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Abstracts Listing

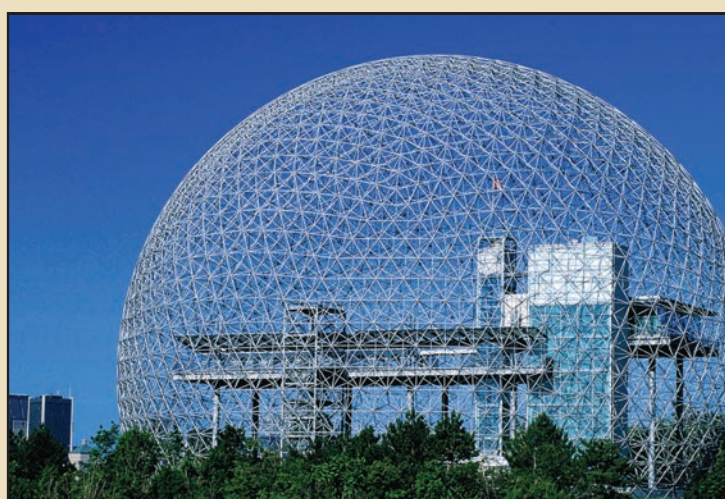

Table of Contents

ATMOSPHERIC SCIENCES

Abstract ID: 34794

Final Number: AS11A-01

Title: Effects of Short-Lived Climate Forcers on Future Warming and Human Health

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Abstract Body: The peak global temperature is largely determined by cumulative emissions of long-lived greenhouse gases. However, anthropogenic emissions include also so-called short-lived climate forcers (SLCFs), which include aerosol particles and methane. Previous studies with simple models indicate that the timing of SLCF emission reductions have only a small effect on the rate of global warming and even less of an effect on global peak temperatures. However, these simple model analyses do not capture the spatial dynamics of SLCF-climate interactions, nor do they consider the additional effects of SLCF emissions on human health. There is therefore merit in assessing how the timing of SLCF emission reductions affects global temperature and premature mortality caused by aerosol emissions, using more comprehensive climate models.

Here, we use an aerosol-climate model ECHAM-HAMMOZ to simulate the direct and indirect climate forcing resulting from realistic aerosol emission scenarios based on the Representative Concentration Pathways (RCPs). From these simulations we produce the effective radiative forcing from aerosol emissions between 1850 and 2100, as well as aerosol concentrations which are used to estimate the premature mortality caused by particulate pollution. We then use the University of Victoria Earth System Climate Model to simulate the spatial and temporal pattern of climate response to these aerosol forcing scenarios, in combination with prescribed emissions of both short and long-lived greenhouse gases. In the RCP scenarios, global anthropogenic aerosol forcing declines during the 21st century from -1.3 W m^{-2} to -0.4 W m^{-2} (RCP8.5) and -0.2 W m^{-2} (RCP2.6). This relatively small difference suggests that within this range of aerosol emission scenarios, the timing of aerosol emission reductions would not have a large effect on global peak temperatures. However, there is the potential for substantially larger regional differences amongst scenarios, which would result important differences in both regional temperature changes, as well as human health impacts associated with aerosol-induced mortality.

Abstract ID: 34702

Final Number: AS11A-04

Title: Measurements of urban, marine and Biogenic Air: VOC measurements during the MUMBA campaign

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Published Material: Some of this work has been presented at Australian scientific meetings.

Abstract Body: The Measurements of Urban, Marine and Biogenic Air (MUMBA) campaign took place in Wollongong, NSW (a city approximately 80 km south of Sydney, Australia) from 21st December 2012 to 15th February 2013. Wollongong is nestled between a steep forested escarpment to the west and the Pacific Ocean to the east, providing an ideal setting for characterising the complex atmospheric environment at the ocean/forest/urban interface. Instruments were deployed to measure the gaseous and aerosol composition of the atmosphere, with the overarching aim of providing a detailed characterisation that could be used to test the skill of regional atmospheric models. Gases measured included ozone, oxides of nitrogen, carbon monoxide, carbon dioxide, methane and many of the most abundant volatile organic compounds. Aerosol characterisation included total particle counts above 3 nm, total cloud condensation nuclei counting; mass concentration, number concentration size distribution, aerosol chemical analyses and elemental analysis. A weather station, a LIDAR (for vertical profiles of aerosols and boundary height measurement) and a MAX-DOAS(for profiles of aerosols and trace gases) were also deployed. Total column amounts of trace gases from the University of Wollongong's ground-based solar remote sensing Fourier transform spectrometer are available for the campaign period.

As part of MUMBA, ambient mixing ratios of common biogenic and anthropogenic volatile organic compounds (VOCs) such as methanol, acetone, isoprene, monoterpenes, benzene and toluene were measured by Proton Transfer Reaction Mass Spectrometry (PTR-MS). A preliminary analysis of these VOC measurements is presented, highlighting the differences in the source regions sampled (marine, urban or biogenic) and the effects of weather patterns on the measurements.

Abstract ID: 35555

Final Number: AS11A-07

Title: Spatial and Temporal Variability of Black Carbon and Particulate Matter in the Vaal Triangle and Highveld Priority Areas in South Africa

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Abstract Body: The presence of aerosols in the atmosphere is of significant concern with regard to climate, the hydrological cycle and human health. Particulate Matter, of which Black Carbon may comprise a considerable portion, is emitted from a large number of combustion and non-combustion sources. Combustion sources such as biomass burning, domestic fuel burning and various industrial processes are of great importance within the context of South African air quality management. The Vaal Triangle and Highveld Priority areas were

established as priority areas for air quality management in South Africa. Particulate Matter concentrations (PM_{10} and $PM_{2.5}$) have been measured at eleven sites in these priority areas since 2007; while Black Carbon concentrations have been measured since 2012 at three of these stations, and at the other five stations since August 2013. The concentrations of Particulate Matter measured during this time period are revealed to be significantly high, often exceeding yearly allowable exceedances within one month. As a result of the adverse effects of Black Carbon and Particulate Matter on human health and climate, this paper explores the spatial and temporal distribution of Particulate Matter in relation to Black Carbon; as well as the impact of meteorology and seasonality in these priority areas. The relationship which exists between Black Carbon and Particulate Matter within the South African context is explored. Trajectory analysis will reveal the impact which foreign airmasses may have on the Particulate Matter and Black Carbon concentrations over these two priority areas. Further, using the data available the potential sources of Black Carbon and Particulate Matter are discussed. Finally, this paper will explore whether the Particulate Matter concentrations over the two priority areas have improved since the onset of measurements.

Abstract ID: 33615

Final Number: AS11B-01

Title: Using Multi-Model Ensembles in Climate Change Projections: Challenges and Opportunities

Presenter/First Author: Claudia Tebaldi, National Center for Atmospheric Research, Boulder, CO

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Published Material: I have presented similar types of talks at several meetings in the past. Some of the illustrations have been published in papers by me and co-authors like Reto Knutti and David Lobell.

Abstract Body: I will talk about approaches to characterizing uncertainties in future climate projections on the basis of MMEs, highlighting the hurdles and challenges in translating characterization into quantification. I will offer an example where some of those obstacles can be overcome, using some recent work that quantified the risk of significant impacts on crop yields from anthropogenic climate change.

My aim is to caution about the statistical oddities that make MMEs difficult to interpret and analyze, but also to highlight circumstances under which I believe those oddities may be less relevant and therefore could be discounted in the quest for probabilistic quantification of uncertainties in climate changes and their impacts.

Abstract ID: 35365

Final Number: AS11B-02

Title: Development of a Bayesian Probabilistic Model for the NARCCAP Regional Climate Model Ensemble Using Information from the Driving GCMs to Formulate Priors and Application to Hydrology Impacts

Presenter/First Author: Linda O Mearns, NCAR, Boulder, CO

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Co-authors: Stephan R Sain, NCAR, Boulder, CO; Seth A McGinnis, National Center for Atmospheric Research, Boulder, CO

Abstract Body: In this talk we will describe the development of a joint Bayesian Probabilistic Model for the climate change results of the North American Regional Climate Change Assessment Program (NARCCAP) that uses a unique prior in the model formulation. We use the climate change results (joint distribution of seasonal temperature and precipitation changes (future vs. current)) from the global climate models (GCMs) that provided boundary conditions for the six different regional climate models used in the program as informative priors for the bivariate Bayesian Model. The two variables involved are seasonal temperature and precipitation over sub-regions (i.e., Bukovsky Regions) of the full NARCCAP domain. The basic approach to the joint Bayesian hierarchical model follows the approach of Tebaldi and Sansó (2009). We will compare model results using informative (i.e., GCM information) as well as uninformative priors. These results will be used in the context of hydrologic model sensitivities to ranges of temperature and precipitation results to determine the likelihoods of future climate conditions that cannot be accommodated by possible adaptation options.

Abstract ID: 35519

Final Number: AS11B-03

Title: On the Level of Agreement Between Climate-Change Projections from Same-Centre Models

Presenter/First Author: Martin Leduc, Concordia University, Montréal, QC

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Co-authors: René Laprise, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Ramón de Elía, Ouranos, Montreal, QC, Canada; Leo Separovic, Environment Canada, Dorval, QC, Canada

Published Material: Leduc M., R. Laprise and R. de Elia, 2014: Investigating structural dependencies between AOGCMs and their impact on regional-scale climate-change projections, 3rd Lund Regional-scale Climate Modelling Workshop: 21st Century Challenges in Regional Climate Modelling, Lund, Sweden, 16 - 19 June 2014.

Abstract Body: Climate models developed by a same research group are prone to share structural similarities. It is also known that such dependencies may induce resembling climatic features in the models' simulations. The "same-centre" hypothesis, which combines these two assertions into a single one, suggests that two models from a same centre should lead to climate-change projections that agree to some extent. We explore this idea throughout an analysis of climate-change projections by considering several groups of same-centre climate models.

With some exceptions, the same-centre hypothesis appears as an efficient rule to filter out non-informative agreements between models and thus clarify the message conveyed by an ensemble of opportunity. Minor modelling differences often lead to non-informative agreements while non-generalized structural differences (e.g. changing the ocean component) may reveal disagreements that are limited to specific regions (e.g. in surface air temperature over the Hudson Bay). However, there are also cases where the same-centre hypothesis fails. One typical example is that of slight iterative changes between two versions of a same model that lead to highly differing climate sensitivities. Maybe more interestingly, major changes in all of the model components may correspond to highly similar projections. The latter result suggests two outcomes. First, the two models may have reach an informative agreement, i.e. a robust result that deserves a high confidence. But conversely, this might also reflect some higher-level dependencies, such as in institutional decisions made in model development or through similar practices for model validation and tuning.

Abstract ID: 34914

Final Number: AS11B-04

Title: Introducing Multi-Model Ensembles to Decision-Makers: The Perception Challenge

Presenter/First Author: David B Huard, David Huard Solutions, Quebec City, QC

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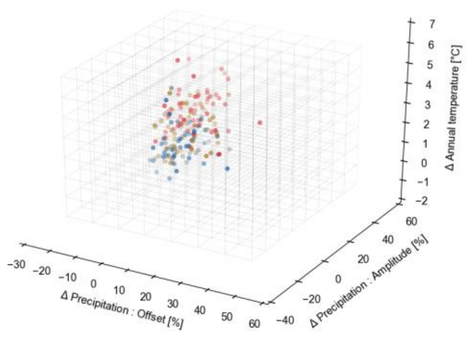
Co-authors: Michael P.H. Vieira, , , ; Nathalie Thiémonge, , , ; René Roy, Ouranos, Montréal, QC, Canada

Published Material: I've just submitted another abstract discussing the same case studies to the 22nd Canadian Hydrotechnical Conference. The point-of-view and audience are however completely different. For the CHC, attended by engineers, I'll focus on the mechanics of the investment analysis and the decision-making tools, whereas here I'll address the perception of climate model ensembles by decision-makers and how to present scenarios to this particular crowd.

Abstract Body: Large infrastructure investments in the hydroelectric sector are planned decades in advance and their economic returns evaluated over periods ranging up to a century. Such long time spans and the sensitivity of hydroelectric productivity to climatic conditions make those investments especially sensitive to uncertainties in climate projections. However, there are very few known examples of hydroelectric investments from private investors using climate projections to assess their robustness to future climate conditions. One explanation may be that typical top-down climate scenarios prepared for impacts and adaptation studies do not give decision-makers a solid footing to evaluate the climate risks, or opportunities, of a given project. Indeed, the large uncertainties around climate projections from multi-model ensembles may either be perceived by non-climatologists as an obstacle to their use in investment planning or as an indication of climate science's immaturity. In collaboration with Hydro-Québec and Manitoba-Hydro, Ouranos is developing decision-making tools for two case studies in the hydroelectricity sector. The aim of these studies is to show-case how climate information from multi-model ensembles can be leveraged by decision-makers. The approach uses the “Robust Decision Making” framework and explores the sensitivity of different investment options to climate projection uncertainty. Of particular interest within this framework is the role played by climate projections, where instead of defining future conditions through top-down scenarios, they play the role of expert advice, weighing in on the likelihood of parameterized climate scenarios. This fundamental switch in the interpretation and perception of climate projections may ease their integration into decision-making process by explicitly acknowledging their conditional nature.



Abstract ID: 34635

Final Number: AS11B-05

Title: APCC Multi-Model Ensemble Forecasting and an Empirical-Dynamical Approach for Summertime Temperature Prediction in South Korea

Presenter/First Author: Hyung Jin Kim, APEC Climate Center, Busan,

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Co-authors: Young-Mi Min, APEC Climate Center, Busan, South Korea; Hae-Jeong Kim, APEC Climate Center, Busan, South Korea; Sang Myeong Oh, APEC Climate Center, Busan, South Korea

Published Material: Parts of this presentation were introduced in the session entitled “Multi-Model Ensembles Predictions for Intrasesonal-to-Interannual Timescales” at the 2014 AGU Fall Meeting.

Abstract Body: The APEC Climate Center (APCC) is a leading climate information service provider and research institute that serves the 21 APEC member economies as well as the broader international community. Currently, 16 operational centers and research institutes from around the world participate in the APCC operational multi-model ensemble (MME) prediction system by routinely providing ensembles of global forecast fields. Various MME methods implemented in APCC's MME system were compared with a simple averaged MME (with equal weightings) to assess one-month lead seasonal mean temperature and precipitation. The results showed that the simple averaged MME is generally superior to the empirically-weighted multiple regression MMEs if all aspects of the predictions were taken into account. On the other hand, the calibrated MME with a step-wise pattern projection resulted in reduced errors and improved forecast skills in a large proportion of cases. Two empirical models, a multivariate regression model and a simple empirical model, were established based on the tropical-extratropical teleconnection patterns and applied to the APCC MME prediction to investigate the predictability of summertime temperature in South Korea. The multivariate regression model outperformed the simple empirical model at all lead times ranging from one to six months. The notably different predictability arguably arose from the higher fidelity of the simulated tropical SST in the Central and Eastern Pacific than in the Western Pacific. In addition, the multivariate model outstripped the one-month lead MME prediction, suggesting that the reproducibility of tropical SST, despite the regional dependency, can pave a promising way for the use of an empirical-dynamical prediction for summertime temperature in South Korea.

Abstract ID: 33668

Final Number: AS11B-06

Title: Bias-corrected Down-scaled Multi-Model Ensemble Prediction of the Indian Summer Monsoon Rainfall using Self-Organizing Map

Presenter/First Author: Nabanita Borah, Indian Institute of Tropical Meteorology, Pune,

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Co-authors: A. K. Sahai, Indian Institute of Tropical Meteorology, Pune, India; Rajib Chattopadhyay, Indian Institute of Tropical Meteorology, Pune, India; S. Abhilash, Indian Institute of Tropical Meteorology, Pune, India; Susmitha Joseph, Indian Institute of Tropical Meteorology, Pune, India

Abstract Body: The probabilistic large scale forecasts though useful for Extended Range Prediction (ERP) of the Indian Summer Monsoon Rainfall (ISMR) over larger regions of Indian subcontinent, it has been found that the regional forecast outlook misrepresents the amplitude of rainfall variability. This is a common problem in a large scale Global Circulation Model. E.g. the rainfall prediction over north-east India, south-peninsular India and the regions with elevated orography show large underestimation of rainfall amplitude and limited forecast skill at fourth pentad lead time.

Hence, bias correction of the large scale forecast and its downscaling to smallest possible regions need to be explored rigorously. In this study, Self-Organizing Map (SOM) has been used to bias-correct and downscale the CFS v2 generated ERP forecast of ISMR. SOM is used to identify the patterns from the low-resolution (1x1, IMD) observed data. Then dynamical model (CFSv2) generated data is projected onto these patterns to generate the bias-corrected forecast and reconstructed using a high resolution observed data (0.25x0.25, TRMM) so that we finally get the bias-corrected downscaled prediction of the ISMR.

Three versions of CFSv2 [T126, T382 and the bias corrected GFS (GFSbc) at T126] is used in this study to generate total 129 [(11 members of CFST126+11 members of CFST382+21 members of GFSbc) x3 different lattices] members. Mean of these are given as the deterministic forecast. The brier skill score and the pattern correlation shows significant improvement in the forecast skill.

Abstract ID: 33542

Final Number: AS11B-07

Title: Improving Multimodel Medium Range Precipitation Forecasts over the Greater Horn of Africa Using the FSU Superensemble

Presenter/First Author: Oliver Kipkogei, IGAD Climate Prediction and Application Center, Nairobi,

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Co-authors: Amit Bhardwaj, Florida State University, Tallahassee, FL 32306, USA, Tallahassee, FL; T N Krishnamurti, Florida State Univ, Tallahassee, FL; Laban Ogallo, , , ; Vinay Kumar, , ,

Published Material: Currently under review by *Journal of Meteorology and Atmospheric Physics*

Abstract Body: Abstract

This study makes use of the WMO's multimodel data set called THORPEX Integrated Grand Global Ensemble (TIGGE) towards the construction of multimodel superensemble forecasts covering a period of 10 days. The goal of this study is to explore the forecast skill for precipitation forecasts over the Greater Horn of Africa (this is a consortium of 11 countries). The multimodels include forecast data set from a suite of models that include: the UK Met office model (UKMO), the US National weather model (NCEP), the European Model (ECMWF), and the Brazilian model (CPTEC). After performing a training phase for the superensemble weights covering the previous 450 days of October, November and December months of 2008 to 2012, forecasts of precipitation were prepared for the multimodel superensemble. These covered Day-1 to Day-10 of forecasts over the region. Various skill metrics were prepared to validate the forecast rainfall against the Tropical Rainfall Measuring Mission (TRMM) observed rainfall data. This study shows that the construction of the multimodel superensemble was a worthwhile effort since it provided the best overall skills for the RMS errors, the spatial correlations and the equitable threat scores and their bias errors for precipitation forecasts from day 1 to day 10 over all of the countries covered by the Greater Horn of Africa. The best among the member model was the UKMO model. This study strongly suggests the usefulness of a product such as the multimodel superensemble for improved precipitation forecasts over East Africa.

Abstract ID: 35386

Final Number: AS12A-01

Title: Towards regional understanding and predictions of tropical cyclone activity and hydroclimate

Presenter/First Author: Gabriel Andres Vecchi, Geophysical Fluid Dynamics Laboratory, Princeton, NJ

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Published Material: Some appeared in Vecchi, G.A., T. Delworth, R. Gudgel, S. Kapnick, A. Rosati, A.T. Wittenberg, F. Zeng, W. Anderson, V. Balaji, K. Dixon, L. Jia, H.-S. Kim, L. Krishnamurthy, R. Msadek, W.F. Stern, S.D. Underwood, G. Villarini, X. Yang, S. Zhang (2014): On the Seasonal Forecasting to Regional Tropical Cyclone Activity. J. Climate. doi:10.1175/JCLI-D-14-00158.1

Abstract Body: Seasonal to decadal prediction systems have demonstrated skill at predicting some aspects of large-scale climate, such as temperatures over the equatorial Pacific and North Atlantic, and even the statistics of some extremes aggregated over large regions, such as the basin-wide number of hurricanes in the Atlantic. However, information at smaller space scales and of more targeted quantities is a more desirable prediction target both for decision support and for testing our understanding of processes controlling regional hydroclimate. Prediction of regional climate depends on both correct simulation and prediction of large-scale climate drivers, as well as of regional processes.

Potential for skillful seasonal prediction at the regional scale is highlighted using two new high-resolution (with 50km and 25km atmospheric/land resolution) global coupled climate models, targeted to the understanding, intraseasonal-to-decadal prediction and near-term projection of regional and extreme climate. Initialized predictions of global hurricane activity show skill on regional scales, comparable to the skill on basin-wide scales, suggesting that regional seasonal TC predictions may be a feasible target. The variation and prediction of regional hydroclimate globally, with a focus on the Caribbean/Gulf of Mexico and surrounding land regions are explored, including methods for maximizing prediction skill. It is shown that mean-state errors are a key constraint on the simulation and prediction of variations of regional climate and extremes, and methodologies for overcoming model biases are explored. Improvements in predictions of regional climate are due both to improved representation of local processes, and to improvements in the large-scale climate and variability from improved process representation.

Abstract ID: 34664

Final Number: AS12A-02

Title: Evaluation of the January-March 2015 Monthly Rainfall Predicted by Taiwan CWB Two-tier MME Forecast System

Presenter/First Author: Mong-ming Lu, Central Weather Bureau, Taiwan, Taipei,

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Abstract Body: Taiwan faced a serious water shortage situation since the commencement of dry season in November 2014. The water shortage is a result of the less active typhoon activity during the preceding typhoon season. Thus, the rainfall prediction for January-March 2015 is of particular importance to the water resources management sector. In this paper, we will use the January-March 2015 monthly and seasonal rainfall prediction to introduce the forecast system, ensemble strategy, statistical downscaling procedure, forecast product, and related forecast tools

developed at the Central Weather Bureau (CWB) of Taiwan. The forecast system TCWB2T-2 is CWB's second version multi-model two-tier forecast system consisting of two atmospheric generation circulation models and two sets of forecast SST. The two AGCMs and two set of forecast SST form 4 suites of two-tier forecast models, namely, CWB-GFS/CWB-OPGSST, CWB-GFS/NCEP-SST, ECHAM5/CWB-OPGSST, and ECHAM5/NCEP-SST. Each suite has 30 members, differentiated by different initial conditions for the atmosphere and ocean occurring on 30 sequential days. Four suites of the models form 120 forecast members. A SVD-type statistical downscaling method applied to five large-scale variables is used to downscale the global forecast to 16 Taiwan stations. The individual and ensemble members can generate 620 monthly and seasonal prediction values at each station. The station rainfall prediction is generated from the difference of the real-time forecast probability distribution formed by 620 prediction values and the background forecast probability distribution formed by historical prediction of the training period from 1982 to the latest global forecast operational runs. The prediction skill of the downscaling method provided to the users is based on the evaluation results of the retrospective forecast of 1982-2011.

Abstract ID: 35673

Final Number: AS12A-03

Title: Multi-Model Ensemble for Seasonal Forecasting at Environment Canada

Presenter/First Author: Bertrand Denis, Organization Not Listed, Dorval,

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Co-authors: William J Merryfield, University of Victoria, Victoria, BC, Canada; Juan Sebastian Fontecilla, , ,

Abstract Body: Environment Canada has been in the business of producing seasonal forecasts using the Multi-Model Ensemble (MME) approach since 1995. Nowadays, the MME approach is widely spread but typically uses model contributions from different producing centres instead of only one center. Current examples of these multi-center MMEs for seasonal forecasting include the WMO, APCC, NMME and EUROSIP MMEs. During that 20 years period, successive versions of the EC's seasonal forecasting system have drawn upon "models of opportunity" that were developed for other purposes by EC's climate and meteorological modeling centers. This talk will describe the origins of this single-center/multi-model approach, and its evolution through configurations consisting of two and subsequently four 2-tier models in the 1990s and 2000s, to the current Canadian Seasonal to Interannual Prediction System (CanSIPS). The latter is based on two global climate models, CanCM3 and CanCM4, that employ common ocean, sea ice and land components coupled to two versions of CCCma's atmospheric model. Lessons learned concerning the efficacy of this multi-model approach will be discussed, focusing on the relative merits of adding more ensemble members versus adding more models, and on methods for combination and calibration.

Abstract ID: 33826

Final Number: AS12A-04

Title: Probabilistic Forecasting in NMME

Presenter/First Author: Emily J Becker, Climate Prediction Center, College Park, MD

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Co-authors: Hugo M Van den Dool, Climate Prediction Center, College Park, MD

Published Material: A preliminary version of this material was presented at the 39th CDPW in October 2014. These findings are currently under review at J. Climate.

Abstract Body: The North American Multi-Model Ensemble (NMME) forecasting system has been continuously producing seasonal forecasts since August, 2011. The NMME, with its suite of diverse models, provides a valuable opportunity for characterizing forecast confidence using probabilistic forecasts. The current experimental probabilistic forecast product (in map format) presents the most likely tercile for the monthly mean value, chosen out of "above normal", "near normal", or "below normal", using a non-parametric counting method to determine the probability of each class. A first-order bias correction is applied when the hindcast based local model climatology is removed (for each model separately) and replaced with the climatology from observations. A 2nd order bias correction is applied when forecasts are expressed in terciles derived from model hindcast data.

The skill of the monthly-mean and three-month-mean probabilistic forecasts of 2 m surface temperature, precipitation rate, and sea-surface temperature is assessed using the 29-year (1982-2010) NMME hindcast database. Skill is assessed on the cross-validated hindcasts using the Brier skill score; forecast reliability and ROC diagrams are also assessed, and the anomaly correlation of deterministic forecasts is shown for comparison. Results of a probabilistic anomaly correlation correction are presented. For all of the fields and regions examined, forecasts for the above and below terciles from the NMME system result in substantially higher BSS than is found for the CFSv2 forecasts alone. NMME forecasts were also found to have greater reliability than those from the CFSv2. Skill relative to model diversity and ensemble size is assessed.

Abstract ID: 33183

Final Number: AS12A-05

Title: Evaluating the Skill of NMME Seasonal Precipitation Ensemble Predictions for 17 Hydroclimatic Regions in Continental China

Presenter/First Author: Feng Ma, BNU Beijing Normal University, Beijing,

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Published Material: This results were submitted to *International Journal of Climatology* at 16-Oct-2014, and are under review.

Abstract Body: There is increasing focus on the usefulness of climate model–based seasonal precipitation forecasts as inputs for hydrological applications. This study reveals that most models from the North American Multi-Model Ensemble (NMME) have potential to forecast seasonal precipitation over 17 hydroclimatic regions in continental China. In this paper, we evaluated the NMME precipitation forecast against observations. The evaluation indices included the correlation coefficient (R), relative root-mean-square error (RRMSE), rank histogram (RH), and continuous ranked probability skill score (CRPSS). We presented the RRMSE-R diagram to distinguish differences between the performances of individual models. We find that the predictive skill is seasonally and regionally dependent, exhibiting higher values in autumn and spring and lower values in summer. Higher predictive skill is observed over most regions except the southeastern monsoon regions, which may be attributable to local climatology and variability. Among the 11 NMME models, CFS, especially CFSv2, exhibits the best predictive skill. The GFDL and NASA models, which are followed by CMC, perform worse than CFS.

The performances of IRI and CCSM3 are relatively worse than that of the other models. The forecast skills are significantly improved in multi-model mean forecasts based on simple model averaging (SMA). The improvement is more obvious for Bayesian model averaging (BMA), which is employed to further improve the forecast skill and address model uncertainty using multiple model outputs, than individual model and SMA.

Abstract ID: 34812

Final Number: AS12A-06

Title: Ensemble Hydrological Forecasts

Presenter/First Author: Dorothy A Durnford, Meteorlogical Service of Canada, Dorval, QC

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Co-authors: Vincent Fortin, Environment Canada Dorval, Dorval, QC, Canada; Etienne Gaborit, Environment Canada Dorval, Dorval, QC, Canada

Abstract Body: There is an increasing demand for sub-seasonal and seasonal hydrological forecasts. Long-range predictions would provide extremely useful guidance for water management practices, fisheries, and shipping companies. The Canadian Meteorological Centre (CMC) is currently developing a modelling system to produce monthly hydrological forecasts. Precipitation is the weakest component of extended range hydrological forecasts. No deterministic model can provide a reliable sub-seasonal forecast of precipitation. Therefore, an ensemble of month-long predictions of precipitation and other atmospheric variables will drive CMC's hydrological modelling system. The variation of key parameters in the streamflow routing model will further increase the number of ensemble members. An ensemble hydrological reforecast of the past 20 years will be combined with the ensemble monthly hydrological forecasts to yield predictions of anomalies of streamflow and water levels. Guidance issued to users will be a probabilistic forecast of the magnitude of the streamflow and water level anomalies over the coming month. The magnitudes will be presented as an index.

Abstract ID: 35667

Final Number: AS12A-07

Title: Developing Operational MME Forecasts for Subseasonal Timescales.

Presenter/First Author: Dan C Collins, Climate Prediction Center College Park, College Park, MD

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Published Material: A fraction of the material was presented at the Climate Diagnostics and Prediction Workshop in October 2014.

Abstract Body: A number of recent international research and operational prediction development projects have focused on bridging the gap between weather and climate forecasts; for example the WMO WCRP/WWRP Subseasonal to Seasonal Prediction Project (S2S). The NOAA Climate Prediction Center (CPC) has a milestone to provide operational subseasonal forecasts before the end of 2015. Environment Canada and U.S. National Centers for Environmental Prediction (NCEP) ensembles from the North American Ensemble Forecast System (NAEFS), currently used in weather forecasts out to two weeks lead time, have been extended to more than four weeks lead time. In addition to the NAEFS models, CPC is evaluating retrospective and real-time ensemble prediction system (EPS) subseasonal forecasts from the European Centre for Medium-range Weather Forecasts (ECMWF) and Japan Meteorological Agency (JMA). The ensemble models of the North American Multi-Model Ensemble (NMME) including the U.S. NCEP Climate Forecast System (CFS) and the Canadian Seasonal to Inter-annual Prediction System (CanSIPS), used in CPC operational seasonal forecasts with one to five months lead time, are now providing data at daily resolution for research on subseasonal prediction. The ensemble models available for subseasonal forecasts are varied in several respects. The NAEFS and JMA EPS are currently uncoupled atmosphere dynamical models, while the ECMWF EPS and NMME models are all coupled to ocean models. Extended weather models also differ from the seasonal forecast systems of the NMME in that they have generally higher spatial resolution and more advanced data assimilation and initialization schemes.

This talk will present preliminary evaluations of the multitude of ensemble model forecasts individually and combined as multi-model ensemble forecasts, compare subseasonal modeling systems, and discuss the prospects for provision of skillful subseasonal forecasts with three to four weeks lead time.

Abstract ID: 34826

Final Number: AS13A-01

Title: Uncertainties on atmospheric aerosol particle emission and deposition fluxes: observation and needs to improve quantification

Presenter/First Author: Philippe Laguionie, IRSN Institut de Radioprotection et de Sûreté Nucléaire, Cherbourg-Octeville,

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Co-authors: Denis Maro, , , ; Olivier Connan, , , ; Didier Hébert, , , ; Geoffrey Pellerin, , , ; Luc Solier, , , ; Marianne Rozet, , , ; Mehdi Morillon, , ,

Abstract Body: Assessing, understanding and predicting the impact of accidental or chronic releases of particulate pollutants (chemical, radioactive, biologic) in ecosystems is a major issue in the context of risk management for the population. In addition, aerosol particles play an important role in global warming by reducing the action of greenhouse gas emissions. Particle concentrations in the atmosphere depend on the particle sources (primary and secondary), particle evolution (coagulation), and the dry and wet deposition processes. Predictive emission, transfer and deposition models, developed and improved from in situ flux measurements, are important tools to better protect population and to understand dynamics of aerosol in the surface layer. For now, experimental data are scarce and gaps between measurements and model results, and between model predictions, are usually huge. For examples, there is several orders of magnitude discrepancy between scavenging coefficients or dry deposition velocities. These uncertainties are due to the lack of accurate experimental data in function of specific parameters such as particle size and atmospheric turbulence. Although there have been recent important progresses in experimental and numerical studies, there remains many challenges before achieving this goal. For example, systematic high frequency measurements of particle concentrations combined with spectral corrections, or use of appropriate surrogates in deposition particle tracing methods, would allow a better quantification of the dry deposition fluxes. It is proposed here to review experimental and data processing techniques used in the environment to estimate aerosol particles fluxes and to discuss some improvements to methodologies for a better quantification. This topic is also being addressed by an international working group whose common goal is to publish recommendations for environmental particle fluxes quantification.

Abstract ID: 35374

Final Number: AS13A-02

Title: Mechanisms Responsible for the Size-dependence of, and Bi-directionality of, Ultrafine Particle Fluxes Over Forest

Presenter/First Author: Sara C Pryor, Cornell University, Ithaca, NY

Presenter/First Author Email: sp2279@cornell.edu

Co-authors: Rebecca J Barthelmie, Cornell University, Ithaca, NY; Ryan Sullivan, Cornell University, Ithaca, NY

Published Material: I presented some very preliminary results in a poster at AGU Fall 2013 meeting

Abstract Body: Given the global importance of forests, there is a specific need to understand aerosol particle removal to, and formation in/above, forests. We present 18 months of size-resolved and total ultrafine particle fluxes (i.e. diameters < 100 nm) over (at 46 m) and in (at 7 m) a deciduous forest and use them to quantify controls on particle uptake. The flux data presented derive from 3 Gill 3-D WindMaster Pro sonic anemometers (deployed at 46 m, in the canopy at 20 m and below the canopy at 7 m), along with data from, an Ultrafine Condensation Particle Counter (UCPC) operated at 10 Hz and a Fast Mobility Particle Sizer (FMPS) operated at 1 Hz. Size-resolved particle profiles during the same period are measured using a separate FMPS scanning at three measurement heights across the canopy (top, middle and bottom). The results are integrated with fluxes of sensible heat, momentum and carbon dioxide derived using a Licor LI-7200. Results for the total number flux concentrations and the size-resolved concentrations derived using micrometeorological flux approaches show a high degree of accord, but relatively high uncertainty. Other results will be described in detail and include the following:

a) Selecting only deposition fluxes, above/below canopy fluxes indicate a median flux ratio of 3 (i.e. total number fluxes above canopy are 3× below canopy) and above versus below canopy deposition velocities implies a median interception fraction of 60%.

b) The net flux of both the total number of ultrafine particles and all size classes in the ultrafine modes are downwards, but a considerable number of the sampling periods are characterized by upward fluxes. Heat fluxes during large magnitude upward particle fluxes do not exhibit different quadrant partitioning than during large downward fluxes. But particle fluxes exhibit an increased role of both ejections and sweeps in upward fluxes that are differentially important in terms of leaf on versus leaf off and phenological stage.

c) Distinctly different flux diurnal profiles for the nucleation versus Aitken mode particles, and a clear link to nucleation events. This indicates differential control mechanisms on fluxes of particles of different sizes and a key role for aerosol dynamics.

Abstract ID: 33232

Final Number: AS13A-03

Title: Variation in Seasonal Deposition of Indoor Carbon, Ionic, Toxic Metalloids and Metal Species in Different Anthropogenic Zones- CMB study

Presenter/First Author: Balakrishna Gurugubelli, Pt.Ravishankar Shukla University, Raipur,

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Abstract Body: Abstract

Different approaches of source apportionment of dust fractions have been reported world-over. Prediction of source categories within receptor chemical profiles using regression and factor analysis using PCA has been reported to evaluate possible source/routes of air pollution mass significantly. The present study is focused on application of all three (regression analysis, PCA and CMB) approaches to investigate higher degree of significance in source apportionment of indoor seasonal deposition of different species in different anthropogenic atmospheric zones. Modeled source categories obtained from regression and factor analysis (using PCA) has shown potential support in the selection of source profiles in CMB. About 75-88% agreement has been obtained between results of source signatures of indoor deposition obtained from three approaches. The application of combined approach has been extended to respirable fine particulates measured indoors. Both fractions have shown different dominance of selected source of emissions.

Practical implications: Major approaches of source signatures has been investigated in combination with the hypothesis that prediction and modeled source profiles will support the selection and inclusion of field based source profiles in source apportionment of indoor dust fractions using CMB. A stratified random sampling plan using longitudinal study design has been adopted for dust fallout source apportionment.

Key words: CMB, regression analysis, PCA, indoor air, anthropogenic zones

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Abstract ID: 34250

Final Number: AS13A-04

Title: Evaluating impact of surface ozone on mortality and crop yields over South Asia

Presenter/First Author: Chinmay Kumar Jena, Indian Institute of Tropical Meteorology, Pune,

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Co-authors: Sachin D Ghude, IITM, Pune, India; Dilip Chate, , , ; Gufran Beig, Indian Inst of Tropical Meteor, Pune, India

Published Material: One paper was publised and another one under review

Abstract Body: Climate change has been shown to increase surface O_3 in many regions of the world and have raised concerns about the O_3 impact on mortality and the magnitude of yield reductions, primarily occurring in the developing nations. Demographically agriculture is the broadest economic sector, rank worldwide second in farm output and principle source of livelihood for more than 58% of 1.2 billion populations which plays an important role in the overall socio-economic fabric of India. For the potential impact of ozone on district-wise cotton, soybeans, rice, and wheat crops in India for the first decade of the 21st century. Wheat is the most impacted crop with losses of 3.5±0.8 million tons (Mt), followed by rice at 2.1±0.8 Mt, with the losses concentrated in central and north India. On the national scale, this loss is about 9.2% of the cereals required every year (61.2 Mt) under the provision of the recently implemented National Food Security Bill by the Government of India. The nationally aggregated yield loss is sufficient to feed about 94 million people living below poverty line in India. Significant portion of human population in India is believed to be regularly exposed to higher surface ozone (O_3) levels. Here, we have also evaluate total, cardiovascular and respiratory mortalities and hospitalizations (COPD) caused by population exposure to surface O_3. Attributable mortalities are quantified using health impact function of long-term relative risk estimates (population attributable-risk proportion) for O_3 from epidemiology literature. We calculated total mortality of about 1125 thousands, 404 thousands by cardiovascular deceases and 176 thousands by respiratory deceases, and COPD cases of about 175 thousands caused by O_3 exposure to population of India in 2005. The highest number of total, cardiovascular and respiratory mortalities and

COPD cases are found in the highly populated Indo-Gangetic region followed by metro-cities and sub-urban and industrial areas.

Abstract ID: 36861

Final Number: AS13A-05

Title: Temporal Trends in Mercury Wet Deposition Across the U.S. and Canada

Presenter/First Author: David Allen Gay, University of Illinois, Champaign, IL

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Co-authors: Mark E Brigham, , Anoka, MN; Matthew Parsons, , , ; Arnout ter Schure, EPRI, PALO Alto, CA

Published Material: some of these early results were reported at the National Atmospheric Deposition Meeting 2014 October, but we have moved well beyond these reported results.

Abstract Body: To assess whether reductions in mercury (Hg) emissions from electrical generation units and other sources in the United States and Canada have translated into changes in Hg concentrations in precipitation, we assessed spatial gradients and temporal trends in mercury (Hg) wet deposition and Hg air concentration data. We obtained wet deposition Hg data from 185 National Atmospheric Deposition Program (NADP) sites across the U.S. and Canada, 128 of which have records of at least 5 years, and 27 of which have complete records from 1998-2013.

Annual rates of change in Hg concentration and Hg deposition rates were calculated using two different methods; (1) the Seasonal Kendall-Mann non-parametric method, and (2) a Fourier transform linear regression parametric method using precipitation depth as an input variable. For this presentation, we will also show results from both methods, where they agree, where they disagree, and potential reasons for this disagreement.

The results from both methods agreed in showing widespread decreasing Hg concentration trends ($p<0.05$) across most regions in the eastern half of the continent (-0.5 to < -3 %/yr) and significant increasing Hg concentration trends (+1.5 to > +3 %/yr), primarily located in the U.S. Great Plains and Rocky Mountain/Desert regions. Some trends are consistent region-wide, while other regions show significant between–site and –season variation. The downward trend in precipitation Hg concentrations observed at many sites with data beginning before 1998 is becoming significantly less steep in recent years. Finally, best estimates of trends over North America will be provided for use by others.

Abstract ID: 35324

Final Number: AS13A-06

Title: A Synthesis of Global Observations on the Air-Surface Exchange of Elemental Mercury Vapor

Presenter/First Author: Che-Jen Lin, Lamar University, Beaumont, TX

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Co-authors: Wei Zhu, Institute of Geochemistry, Guiyang, China; Jonas Sommar, Institute of Geochemistry, Guiyang, China; Xinbin Feng, GIG Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China

Abstract Body: Both the atmosphere and earth surface are transient reservoirs of mercury (Hg) in the environment. Reliable quantification of the air-surface exchange of elemental mercury vapor (Hg^0) is crucial for understanding the global biogeochemical cycling of Hg. There have been extensive measurement and modeling efforts made to estimate the exchange fluxes between the atmosphere and various surfaces (e.g., soil, canopy, water, snow, etc.). However, large uncertainty remains in these estimates due to the complexity of Hg^0 bi-directional exchange, the limitations of flux quantification techniques and the challenges in model parameterization. Due to the semi-volatile nature of Hg^0 and poorly understood redox transformation of Hg in different environmental media, the flux of deposition and re-volatilization of previously deposited Hg exhibits distinct characteristics subject to the influence of environmental variables such as natural surface types, temperature, light, moisture, atmospheric turbulence, presence of reactants that facilitate Hg redox chemistry, and relative levels of Hg in the media where Hg^0 exchange occurs. In this study, we provide an integrated synthesis on the current state of scientific understanding in the air-surface exchange of Hg^0. Specifically, the development of advancement of flux quantification methods, existing field observational data of Hg^0 flux, environmental factors driving the exchange process, and modeling efforts to scale up the measured flux for global assessment are presented. The existing knowledge gap and the associated research need to further understand the air-surface exchange of Hg^0 are discussed.

Abstract ID: 35766

Final Number: AS13A-07

Title: Preliminary Evaluation of Methylmercury Concentrations for Wet Deposition Samples Collected in North America, 2003-2013

Presenter/First Author: Gregory Alan Wetherbee, USGS, Baltimore, MD

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Co-authors: Mark F. Rhodes, , , ; David Allen Gay, University of Illinois, Champaign, IL; Robert C. Brunette, , , ; Eric M. Prestbo, Tekran Instruments Corporation, Toronto, ON, Canada; Martin R. Risch, , ,

Abstract Body: The National Atmospheric Deposition Program /Mercury Deposition Network (NADP/MDN) recently released data for methylmercury (MeHg) concentrations in 5,375 non-filtered samples of wet-only deposition. Samples were collected at 74 locations in the USA and Canada during 2003-2013.

Concentrations are censored at a mass-based RL=0.050 ng in samples collected before April 18, 2007 and at RL=0.0025 ng on or after that date, relevant for samples with a minimum volume of 45 mL. Mean MeHg concentrations for samples pre- and post-April 18, 2007 are statistically different per the Peto-Prentice test. The mean MeHg concentration is 71 percent lower for samples collected after April 18, 2007 due to an increased percentage of low-concentration samples above the RL. Approximately 66% of the MeHg determinations are less than the RLs.

Assigned quality rating codes classify 92.8 percent of the samples as "valid". Associated notes codes qualify the data based on various sample characteristics, including visible debris type (bird, insect/animal, plant, ash/soot, and cloudiness). Consideration of these codes is crucial to proper use of the data. Approximately 63% of valid samples with MeHg concentrations above the RL contained visible debris, indicating a highly significant relation ($p<.001$) between debris presence and quantifiable MeHg as measured by a chi-squared contingency analysis. The mean MeHg concentration in samples noted as containing debris is 1.7 times the mean for samples with no debris per the maximum likelihood estimator comparison test ($p<0.001$) .

A mean MeHg concentration of 0.122 + 0.450 ng/L and median of 0.050 ng/L is calculated by Regression on Ordered Statistics (ROS) for the complete dataset. Exclusion of both samples considered invalid and samples with visible debris shifted the mean concentration to 0.078 + 0.254 ng/L and median of 0.019 ng/L per ROS. Concentrations in the range 0.1 – 1.0 ng/L follow a log-normal distribution on a normal quantile plot, with higher concentrations departing from this distribution at 1 ng/L. Interestingly, 67 percent of MeHg concentrations greater than 1 ng/L were not coded as having observable debris.

Preliminary analysis indicates network-wide temporal variation in concentrations along with regional (spatial) patterns.

Abstract ID: 34196

Final Number: AS13A-08

Title: Dry Deposition of Polycyclic Aromatic Compounds to Various Land Covers in the Athabasca Oil Sands Region

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Co-authors: Irene Cheng, , , ; Zhiyong Wu, Hohai University, Nanjing, China; Tom Harner, , , ; Jasmin Schuster, , , ; Jean-Pierre Charland, Environment Canada, Ottawa, ON, Canada; Derek Muir, Environment Canada, Burlington, ON, Canada

Abstract Body: Dry deposition is an important pathway inputting pollutants to various ecosystems. The present study provides the estimation of dry deposition of polycyclic aromatic compounds (PACs), including polycyclic aromatic hydrocarbons (PAHs), alkylated PAHs, dibenzothiophenes (DBTs) to various land covers in the Athabasca oil sands region. A framework was first developed to estimate dry deposition of individual PAC species making use of monitored ambient concentrations of 18 PAHs species, 20 alkylated PAHs and 5 DBTs at three sites. The gaseous dry deposition scheme of Zhang et al. (2003) was modified to handle gas-phase PACs and the particle dry deposition scheme of Zhang and He (2014) was applied to particulate-phase PACs. Henry's law constant and octanol-air partition coefficient of PACs were used as the basis for choosing model parameters needed in the gaseous dry deposition scheme. Modelled dry deposition velocities for various gaseous PACs and over various land covers were in the range of 0.01-0.1 cm s^{-1}, comparable with literature values obtained from field studies. Annual dry deposition of the sum of PAHs was estimated to range from 610 to 1150 µg m^{-2} over forested canopies surrounding the three sites and from 580 to 670 µg m^{-2} over agricultural lands, grass and shrubs. The corresponding numbers are 1500 to 4200 and 1900 to 2800 for the sum of 20 alkylated PAHs, and are 130 to 1100 and 370 to 690 for the sum of 5 DBTs. The three monitoring sites are situated nearby the Athabasca River, and the direct atmospheric dry deposition to water surface was estimated to range from 830 to 1000, 2200 to 4100, and 160 to 880 µg m^{-2} for PAHs, alkylated PAHs, and DBTs, respectively. In most cases the estimated annual dry deposition is two to four times the measured annual wet deposition. Alkylated PAHs contributed more than the sum of PAHs and DBTs in both dry and wet deposition budget, suggesting the importance of including this parent group of pollutants in atmospheric deposition budget estimation for subsequent ecosystem impact studies.

Abstract ID: 34965

Final Number: AS13B-01

Title: Use of process tendencies to assess regional climate models

Presenter/First Author: Kamel Chikhar, Centre ESCER, Université du Québec à Montréal, Montreal, QC

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Co-authors: Pierre Gauthier, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Published Material: This presentation will summarize findings reported in two scientific papers. The first paper entitled "Impact of analyses on the dynamical balance of global and limited-area atmospheric models" by Chikhar and Gauthier, first published online on 25 FEB 2014 in Quarterly Journal of the Royal Meteorological Society. The second paper entitled "On the effect of boundary conditions on the Canadian Regional Climate Model: Use of process tendencies" by Chikhar and Gauthier, accepted in Climate Dynamics journal. Chikhar, K. and Gauthier, P. (2014), Impact of analyses on the dynamical balance of global and limited-area atmospheric models. Q.J.R. Meteorol. Soc., 140: 2535–2545. doi: 10.1002/qj.2319Chikhar K, Gauthier P (2015) On the effect of boundary conditions on the Canadian Regional Climate Model: Use of process tendencies (accepted in Climate Dynamics)

Abstract Body: Dynamical imbalances can induce spurious variability which can be diagnosed from the physical and dynamical tendencies observed in the first moments of short-term forecasts using as initial conditions analyses obtained from an assimilation system using this model.

This approach is first used to investigate differences in the balance observed in the Global Environmental Multiscale (GEM) model and its limited area version, the Canadian Regional Climate Model (CRCM) when these models are initialized and driven (lam version) with different data (4D-Var analyses from the the forecast–assimilation system of the Meteorological Service of Canada (MSC) and ERA-Interim reanalyses at low and full resolution). Results showed that GEM is best balanced when initialized with MSC 4D-Var analyses and is better balanced when using the higher-resolution reanalyses. Similar results are obtained for the CRCM initially. Moreover, after a few days of integration, we observe imbalances appearing gradually in the interior of the regional domain.

We also used process tendencies to investigate the lateral boundary effects on the CRCM balance for a much longer simulation. The different boundary conditions provided are outputs from the second-generation Canadian Earth System Model (CanESM2) and the Max Planck Institute for Meteorology's Earth System Model (MPI-ESM-LR) and also from ERA-Interim reanalysis. The tendencies are analysed when the regional model is well spun up and is sufficiently affected by the lateral forcing data. The results indicate that the model is very sensitive to those imposed lateral conditions.

Abstract ID: 34864

Final Number: AS13B-02

Title: Assessment of Trend in Drought Propensity across the Globe Using GCM Projections

Presenter/First Author: Kironmala Chanda, Indian Institute of Technology Kharagpur, Kharagpur,

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Co-authors: Rajib Maity, Indian Institute of Technology Kharagpur, Kharagpur, India

Abstract Body: This study aims to assess the global response of soil moisture drought propensity to climate change in the 21st century. The

projected monthly soil moisture data from two Global Circulation Models (GCMs) - Canada's new Earth System Model i.e, CanESM2 and Geophysical Fluid Dynamics Laboratory (GFDL) are obtained for Representative Concentration Pathways 8.5 (RCP8.5) scenario, which represents a scenario of high greenhouse gas emissions in absence of climate change policies. Each of the individual datasets as well as the model averaged data is bias corrected through an appropriate technique using past data from Climate Prediction Centre (CPC) as a reference. In order to capture the slowly-varying changes in soil moisture drought propensity, Drought Management Index (DMI), which is a newly developed probabilistic index for characterization of multi-year droughts, is applied. The intermediate measures – resilience and vulnerability of the soil moisture data are computed at a 2.5° x 2.5° global grid using the local (grid specific) long term monthly mean soil moisture data as thresholds. Subsequently, the DMI series is computed at each grid intersection at the aforementioned spatial resolution for overlapping 5-year periods from 1961 to 2100. The spatio-temporal variation in global drought propensity over 140 years is inspected from temporal snapshots of DMI contour maps. While there are some conflicts in the continent wise trends of drought propensity for the two GCM datasets, statistical analyses of the DMI series using the model averaged data indicate progressive drying over Africa, South America, eastern Australia and most of Asia towards the end of the 21st century. The status remains relatively unchanged in North America and the western part of Australia, while the high latitude regions of Europe tend to become wetter. These findings may be incorporated for global long term water resources planning and timely adoption of drought mitigation strategies.

Abstract ID: 36392

Final Number: AS13B-03

Title: The statistic-dynamical joint approach can predict the decadal hiatus of East Asian Surface Air Temperatures

Presenter/First Author: Shuanglin Li, IAP Insititute of Atmospheric Physics, Chinese Academy of Sciences, Beijing,

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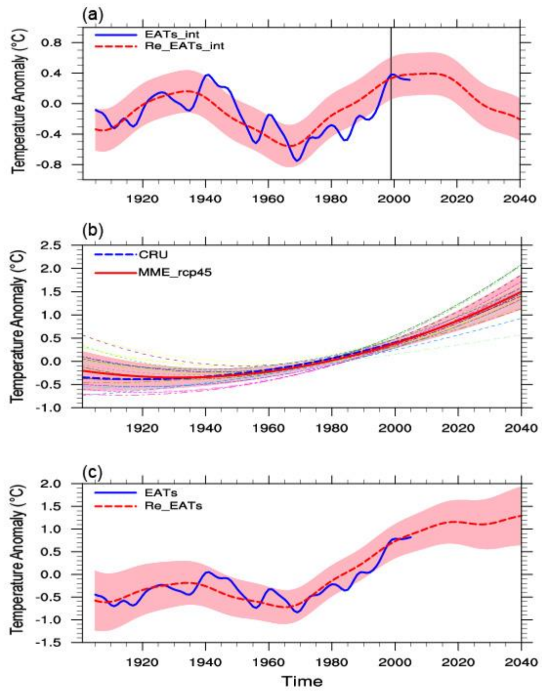
Co-authors: Feifei Luo, IAP Insititute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

Published Material: The primary content was published by a scientific journal, Science China-Earth Sciences, in the December 2014 issue.

Abstract Body: A statistic-dynamical joint method considering both the internal decadal variability and the effect of anthropogenic forcing is developed to hindcast/predict the decadal components of East Asian Surface Air Temperatures (EATs). Since previous studies have revealed that the internal variability of EATs (EATs_int) is mainly influenced by oceanic modes, we first analyzed the lead-lag connections between EATs_int and the three SST multidecadal modes as well as the explained variance rates of EATs_int by the modes. Based on the lead-lag connections, we constructed a multiple linear regression with the three SST modes as predictors. The hindcast for the years from 2000 to 2005 indicated the regression model had a high skill in hindcasting the observational EATs_int. Therefore, the prediction for the EATs_int (Re_EATs_int) was obtained by the regression model based on quasi-periods of the decadal oceanic modes.The external forcing from greenhouse gases is likely to associate with global warming, and ensembles of monthly global land surface air temperature in the experiments with multiple CMIP5 models on historical and projected experiments under RCP4.5 are used to predict the curve of EATs (EATs_trend) by a second-order fit. Then, EATs_int and EATs_trend were combined to the reconstructed or predicted EATs (Re_EATs). Re_EATs shows a fluctuation during 2010-2040 with hiatus or a slight decrease from 2015-2030, and then an gradual increase. Compared with the decadal prediction in CMIP5 models, Re_EATs is in agreement qualitatively with the predictions of most of models and the MME.



Abstract ID: 34827

Final Number: AS13B-04

Title: Spatio-temporal Variability of Rainfall over Central Himalaya, Uttarakhand

Presenter/First Author: Sneh Joshi, , Almora,

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Co-authors: Krushna Chandra Gouda, CSIR CENTRE FOR MATHEMATICAL MODELLING AND COMPUTER SIMULATION, Bangalore, India; Kireet Kumar, G.B. Pant Institute of Himalayan Environment and Development Kosi-Katarmal, Almora, India; Bimal Pande, Kumaun University, Nainital, Nainital, India; Prashant Goswami, CSIR CENTRE FOR MATHEMATICAL MODELLING AND COMPUTER SIMULATION, Bangalore, India

Abstract Body: Simulation and forecasting of the Indian Summer Monsoon (ISM) has remained a major scientific challenge, especially at smaller (regional) scale like Central Himalaya, Uttarakhand region which is situated at a very high altitude. While climate models have gained incomplexity, and hence, scope of the accuracy and reliability have not necessarily increased; this is particularly true at regional scales. An important issue is the appropriate model configuration for regional seasonal forecasting of rainfall simulations. An atmospheric GCM, without interannual variability of SST, can reproduce the important characteristics of the Himalayan regional climate. In the present study, the results show that considerable skill in seasonal forecasting over the central Himalayan region can be achieved with an appropriate model configuration. The
Correlation between the interannual variability (IAV) in multi-source observation and ensemble simulation is significant above 99% level and the phase synchronization (PS) is also about 75%. Together with earlier

results on skill on seasonal forecasting of ISM with the VR GCM (Goswami and Gouda 2009, 2010), the present work provides a forecast configuration with considerable skill over the central Himalaya; an important point is that the skill is considerably higher than that for all-India scale.

Although the seasonal cycles at station scale are generally under predicted over five out of six stations, the seasonal cycles from ensemble simulation and composite observations are significantly (99%) correlated. Thus, even at station scale, the skill in seasonal forecasting is non-trivial. It may be noted that this skill at station scale is somewhat less when considered against station scale observations. We believe that this is because unlike in the case of composite observation, gridded simulation does not correspond well to point (station observation).

Abstract ID: 35421

Final Number: AS13B-05

Title: Skillful seasonal prediction of temperature and precipitation over land in a new GFDL high resolution climate model

Presenter/First Author: Liwei Jia, Princeton University, Princeton, NJ

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Co-authors: Xiaosong Yang, UCAR, Princeton, NJ; Gabriel Andres Vecchi, Geophysical Fluid Dynamics Laboratory, Princeton, NJ; Rich Gudgel, , , ; Thomas L Delworth, NOAA, Boulder, CO

Published Material: Part of these findings were accepted by Journal of Climate, and were presented as a poster in WMO S2S conference, in Maryland, USA, 2014.

Abstract Body: This study demonstrates skillful seasonal prediction of 2m air temperature and precipitation over land in a new high-resolution climate model developed by Geophysical Fluid Dynamics Laboratory, and explores the possible sources of the skill. The impact of atmosphere and land initialization on seasonal predictions is also investigated.

First, we show considerable skill improvement of the high-resolution model over the previous lower-resolution model in seasonal prediction of NINO3.4 index and other aspects of interest. Then, we employ a new statistical optimization approach to identify the most predictable components of seasonal mean temperature and precipitation over land in the high resolution model, and measure the skill of these components for boreal winter and summer, and further diagnose the sources of the skill. Predictions using a few most predictable components are then reconstructed to yield more skillful predictions than the raw model predictions.We find that the two most predictable components of temperature are characterized by a component that is likely due to changes in external radiative forcing in boreal winter and summer, and an ENSO-related pattern in boreal winter. The most predictable components of precipitation in both seasons are very likely ENSO-related. These components of temperature and precipitation can be predicted with significant correlation skill at least 9 months in advance. The reconstructed predictions using only the first few predictable components from the model show considerably better skill relative to observations than raw model predictions. Lastly, we show that by initializing atmosphere and land conditions, the high-resolution model is able to predict NAO with significant correlation skill, which consequently improves predictions of seasonal temperature and precipitation over North America and Europe compared to the predictions without initialization.

This study shows that the use of refined statistical analysis, a high-resolution dynamical model and initialization of atmosphere and land conditions leads to significant skill in seasonal predictions of temperature and precipitation over land.

Abstract ID: 34096

Final Number: AS13B-06

Title: Studies on the Global Morphology of Middle and Upper Atmospheric Fluctuation

Presenter/First Author: Cunying Xiao, Center for Space Science and Applied Research, Chinese Academy of Sciences, Beijing,

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Co-authors: Xiong Hu, , , ; Bo Wang, , , ; Junfeng Yang, , ,

Abstract Body: Current analysis about the middle and upper atmospheric fluctuation often focuses on some certain waves or modes in certain area with observations. Little is known about the global distribution characteristics of the atmospheric fluctuation as a whole. In this paper, a method of global gridding and mathematical statistics in the grids has been developed in order to circumvent the difficulty of characterizing the global atmospheric fluctuation quantitatively. Based on a total of 11 years of TIMED/SABER temperature data from January 2002 to January 2013, temperature means and standard deviations are obtained, which extend 50 ° S ~ 50 ° N latitude, 0 ° ~ 360 °E longitude, 20~100 km altitude on each month from January to December. Quantitative results are derived by analysis on the distribution of the temperature standard deviations, which can be used to characterize the activity of the atmosphere fluctuation. In the lower altitude between 20 km and 70 km, temperature standard deviations are generally 1-10 K. The temperature standard deviations are larger in winter than those in summer and larger in austral winter than in boreal winter. There are some changes with the longitude, showing the structure of the wave 1 or wave 2. In the upper altitude between 70 km and 100 km, the temperature standard deviations are always strong, with typically values of 10-30 K. There are small differences in the winter/summer. The standard deviations are higher in the low-latitude regions than those in high latitudes. Their longitudinal distributions are quite complex, presenting many of small local structures. These statistic results can be used to fulfill the blank of MSIS models in describing the atmospheric fluctuation. They are valuable in modeling the middle and upper atmospheric fluctuation globally. Moreover, some physical processes related to these features are discussed in this paper.

Abstract ID: 34362

Final Number: AS13B-07

Title: Comparison between high-resolution climate simulations using single and multiple nesting.

Presenter/First Author: Dominic Matte, University of Quebec at Montreal UQAM, Montreal,

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Co-authors: René Laprise, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Julie M Theriault, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Abstract Body: Previous studies have shown the importance of choosing appropriate domain size for dynamical downscaling with nested Regional Climate Models (RCM). The domain should not be too large to avoid large departures from the original driving data, and should not be too small to provide sufficient distance from the lateral inflow to allow the

development of the small-scale features permitted by the increased resolution. This latter point has repercussions on the computational cost, and becomes an issue with large jump in resolution between the driving data and the RCM mesh. The use of multiple nesting reduces the spatial spin-up compared to direct nesting, thus allows shrinking the domain size and reducing computational cost.

Our investigation compares direct and double nesting to achieve a grid mesh of 0.15° from driving data at 1.8°, using the perfect-prognostic approach of the Big-Brother protocol. The direct and double nesting appear to produce similar level of accuracy for the stationary components. The large-scale transient components however exhibit some reduction in time correlation. Overall this investigation suggests that multiple nesting may offer benefits compared to the one-step nesting for climate dynamical downscaling.

Abstract ID: 36097

Final Number: AS13B-08

Title: Technical Support for Climate Assessment Data Services

Presenter: Andrew Buddenberg, The Cooperative Institute for Climate and Satellites/NC State University, Asheville, NC

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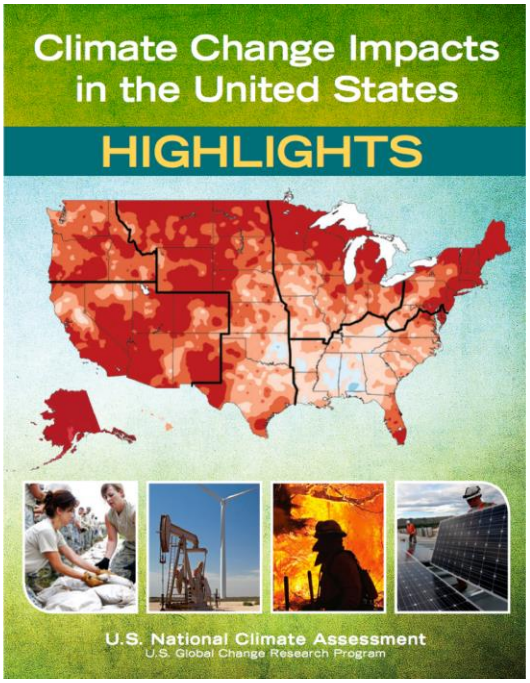
First Author Student?: No

Abstract Body: NOAA's Climate Assessment Technical Support Unit provides critical climate science input and technical coordination support to the National Climate Assessment (NCA), a premier activity of the U.S. Global Change Research Program. The United States Global Change Research Act of 1990, calls for a report to the US President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change every four years. Seeking to establish an ongoing, sustainable assessment process, as well as deliver a timely interim and quadrennial reports, NOAA's Technical Support Unit provides coordination of the scientific input from more than 250 authors and technical expertise to a wide network of interagency and external groups and individuals.

To meet NOAA Information Quality Act requirements and manage the complexity of a large, distributed effort, the TSU adopted a number of technologies and best practices. With so many contributors to the NCA and iterations of code to process scientific datasets and produce figures, version control has been a great asset. Git Annex simplified the problem of versioning large datasets by providing a single common repository of the most up-to-date files with the ability to roll back at will. In addition, Gitlab provided a way to locate code see at-a-glance what program created a given figure. Automated testing verified the configuration of and prevented regressions in data processing code. Traceability and reproducibility of climate analyses were ensured through a massive metadata collection effort and integration with the United States GLobal Change Research Program's Global Change Information System.

These technologies and practices served the TSU well, though none are particularly novel in the greater context of software development. Techincal issues persist:

- Most scientific code is still specific to a particular dataset/analysis. How can we reduce "one-off" analyses and increase code reusability?
- Climate dataset description and metadata collection efforts are largely manual and very time-consuming especially after-the-fact. How can we improve the scientific workflow?
- Version control of the hundreds of submitted figures was difficult. How can the graphical asset management improve?



Abstract ID: 33123

Final Number: AS14A-0001

Title: A Modified Micrometeorological Gradient Method for Estimating O_3 Dry Deposition over a Forest Canopy

Presenter/First Author: Zhiyong Wu, Hohai University, Nanjing,

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Published Material: published in *Atmospheric Chemistry and Physics Disccusion*, under review for *Atmospheric Chemistry and Physics*.

Abstract Body: Small pollutant concentration gradients between levels above a plant canopy result in large uncertainties in estimated air-surface exchange fluxes when using existing micrometeorological gradient methods, including the aerodynamic gradient method (AGM) and the modified Bowen-Ratio method (MBR). A modified micrometeorological gradient method (MGM) is proposed in this study for estimating O_3 dry deposition fluxes over a forest canopy using concentration gradients between a level above and a level below the canopy top, taking advantage of relatively large gradients between these levels due to significant pollutant uptake at top layers of the canopy. The new method is compared with the AGM and MBR methods and is also evaluated using eddy-

covariance (EC) flux measurements collected at the Harvard Forest Environmental Measurement Site, Massachusetts during 1993-2000. All the three gradient methods (AGM, MBR and MGM) produced similar diurnal cycles of O_3 dry deposition velocity ($V_d(O_3)$) to the EC measurements, with the MGM method being the closest in magnitude to the EC measurements. The multi-year average $V_d(O_3)$ differed significantly between these methods, with the AGM, MBR and MGM method being 2.28, 1.45 and 1.18 times of that of the EC. Sensitivity experiments identified several input parameters for the MGM method as first-order parameters that affect the estimated $V_d(O_3)$. A 10% uncertainty in the wind speed attenuation coefficient or canopy displacement height can cause about 10% uncertainty in the estimated $V_d(O_3)$. An unrealistic leaf area density vertical profile can cause an uncertainty of a factor of 2.0 in the estimated $V_d(O_3)$. Other input parameters or formulas for stability functions only caused an uncertainly of a few percent. The new method provides an alternative approach in monitoring/estimating long-term deposition fluxes of similar pollutants over tall canopies.

Abstract ID: 33217

Final Number: AS14A-0002

Title: Assessment of Artificial Intelligence implementation in Delhi addressed to a diagnostic air quality modelling

Presenter/First Author: Dhirendra Mishra, Indian Inst of Technology, New Delhi,

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Co-authors: Pramila Goyal, , ,

Abstract Body: Air pollution forecasting is the most important environmental issue in urban areas as it is useful to assess the effects of air pollutants on human health. It has been observed that the air pollution has been increased above the standard level in the urbanized area of Delhi and will be a major problem in the coming years. Therefore, the main objective of the present study is to develop the models that can forecast daily concentrations of air pollutions in one-day advance through artificial intelligence based models. The concentrations of air pollutants have been forecasted using the available meteorological variables viz. temperature, pressure, relative humidity, wind speed and direction, visibility and the estimated concentrations through air quality dispersion model, AERMOD. The nitrogen dioxide (NO_2) pollutant is chosen for model development and analysis in the present study. The eight and two year's seasonal data are used for training and validation respectively. The evaluation of artificial intelligence based model has been made by comparing its results with observed values in different seasons through statistical parameters, which reveals that the artificial intelligence based model is performing well and can be use for operational use.

Abstract ID: 33894

Final Number: AS14A-0003

Title: A Novel Approach to Measurement of Atmospheric Ultrafine Silica Particulate Matter

Presenter/First Author: Sean Marcus Olson O'Connell, University of Wisconsin Eau Claire, Eau Claire, WI

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Abstract Body: This project entails the establishment of a novel analytical method for quantifying respirable, airborne silicon oxide-containing particles and design of an instrument to perform such an analysis. Many previous studies exploit heteropoly acids via reduction to molybdenum blue, and subsequent visible absorbance analysis for a variety of quantitative environmental analyses, primarily in aqueous media. This approach substantially extends the sensitivity of the analytical procedure and also simplifies the analysis. Applying the molybdenum blue approach to respirable atmospheric silica, NIOSH estimates a limit of detection (LOD) of 10 mg SiO_2. We estimate that our proposed analytical instrument design will have an LOD on the order of 0.5 µg SiO_2, enabling sampling times of less than an hour to reach the newly-proposed OSHA personal exposure limit (PEL) of 0.10 mg/m_3. Potential applications of such a measurement include many environmental applications such as atmospheric monitoring in the vicinity of sand mining operations and other industrial settings ranging from shipbuilding to non-conventional petroleum extraction.

Abstract ID: 34758

Final Number: AS14A-0004

Title: Formation and near-field evolution of fine particles in a plume from a metallurgy plant: Results from the NANO-INDUS project

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Abstract Body: The aim of the NANO-INDUS project was to study the evolution of the physico-chemical properties of industrial fine particles over a short-range distance, after their release from the stacks. First, measurements were performed directly at the stacks of a plant manufacturing iron-manganese alloy near Dunkirk Port, France. Separately, an intensive field campaign was undertaken at a site located close (<1 km) to the stacks. We present results obtained during four specific days, during which the wind direction was favorable for the transport of plumes (detected by Light Detection and Ranging [LIDAR] monitoring), from the stacks to the near-field sampling site, which was under the direct influence of the metallurgy plant emissions, mainly during sea breeze periods. These phenomena promoted a fast vertical dispersion of the plumes, as well as a mixing of pollutants from different sources.

The physico-chemical properties of particles sampled at the stacks were compared to those determined at the near-field site during these four days. Particles sampled at the stacks were characterized by a high Mn/Fe ratio (in the range 2-3). However, the ratios measured at the sampling site were much lower, in the range 0.5-1. The difference was explained by rapid mixing with emissions from a large steelworks close to the metallurgy plant, with specific Mn/Fe ratios < 0.1, which was also confirmed by high concentrations of non-refractory chloride used in the neighboring plant process. Size distribution data showed the presence of a mode around 15 nm, much smaller than during other periods. This result suggests that new particle formation occurred within the few minutes it took for emissions to travel from the stacks to the receptor site. Given that aromatics were by far the most important class of volatile organic compounds (VOCs) emitted at the stacks (60% of the total VOCs), this class of compound is suspected to be involved in the nucleation events observed at the sampling site.

Abstract ID: 34778

Final Number: AS14A-0005

Title: Simulations of Pollutant Dispersal over Nairobi City,Kenya

Presenter/First Author: George Otieno, University of Nairobi, Nairobi,

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Published Material: It is part of the work submitted for publication at journal of Environment and Agricultural Sciences, JEAS 2014, Volume 1, Article No. 10

Abstract Body: The current rapid deterioration of air quality in urban centres can be attributed to urbanization. Poor air quality has been associated with several negative effects on human health, climate and ecosystems. Most cities in developing countries, especially in Africa have poor or in some cases no air quality management systems in place despite having the fastest growing urban populations. City populations have high vulnerability to the impacts air pollution following high density of residents and economic activities as well.

Air pollution is evident in most cities; the case of Nairobi is an illustrative of this. The common air pollutants include carbon monoxide and total suspended particulates among others, the latter being the most widespread and the most serious for human health.

This study simulated air pollutant dispersal over the city using Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT), considering a case for emission of total suspended particles into the environment. The predominant wind speed over the city is 4-6 knots and the wind direction is easterly. The forward trajectory of a pollutant released in the city is generally observed to flow to the western side of the city. The pollutant is observed to be dispersed beyond 100 km from the city reducing the concentration of the same in the city.

The study thus recommends for a consultative planning process of the city that factors in the wind characteristics over the city; most industrial activities should be located to the extreme western side of the city to minimize concentration of pollutants over the city. The study further recommends studies that studies be carried out to ascertain the quality of rain water during the long rain season.

Abstract ID: 36411

Final Number: AS14A-0006

Title: Spheroidal carbonaceous particles (SCPs): Indicator of atmospherically deposited pollutants in Kongsfjorden, Ny-Ålesund, Arctic

Presenter/First Author: Neelu Singh, National Centre for Antarctic and Ocean Research, Vasco,

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Abstract Body: Spheroidal carbonaceous particles (SCPs) are produced during the incomplete high temperature combustion of fossil fuels. Since these particles have no other known natural source, their presence in the snow and soil in such pristine areas as the Polar Regions can serve as proxy indicators for anthropogenic pollution. In this study we have carried out a morphological and chemical characterization of the SCPs extracted from the surface sediments of Kongsfjorden in Ny-Alesund, the Arctic. The characterization was carried out by scanning electron microscope coupled with X-ray spectrometer (SEM-EDX). The prevalent particle types in all the samples studied were granular-spherical, hollow- spherical and irregular shaped carbonaceous particles. Analysis of the elemental composition showed that the particles are mainly composed of C, O, NA, Si, Al, K, Cl, and Ti. Some particles contained heavy metals Fe, Al, Cu, Cr, Zn, Pb and Ni which indicate that the SCPs could have acted as the dominant carriers of the heavy metals deposited in the surface sediments.

Abstract ID: 36560

Final Number: AS14A-0007

Title: Air quality during holy pilgrimage of Hajj- the largest annual human gathering on planet earth

Presenter: Haider Abbas Khwaja, University at Albany, Albany,

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First Author Student?: No

Co-authors: Mirza M Hussain, NYSDOH/Empire State Plaza, Albany, NY; Fida Khatib, NYSDOH/Empire State Plaza, Albany, NY; Jahan Zeb, King Abdulaziz University, Jeddah, Saudi Arabia; Donald Ray Blake, University of California Irvine, Irvine, CA; Omar Siraj Aburizaiza, King Abdulaziz University, Jeddah, Saudi Arabia

Published Material: The preliminary results were presented in AGU fall meeting in a Press conference and poster

Abstract Body: Oil producing countries in Middle East is known to experience severe air pollution including many cities in Saudi Arabia. Each year this situation is intensified during the Hajj, the Holy Pilgrimage of Islam that draws millions of pilgrims to Mecca. Sharply deteriorated air quality during Hajj, exposing pilgrims to very high level of pollutants. Extremely high levels of air pollutants were observed during the intensive measuring periods. For example, the PM_7 , $PM_{2.5}$, O_3 , and BC concentrations of up to 9,433 μg/m³ , 484 μg/m³ , 444 ppb, and 468 μg/m³ , respectively, were observed. Results of this investigation revealed that most routers had on average exceeded the WHO standards for PM_{10} , $PM_{2.5}$, and . The reasons for the high air pollutants concentrations are most probably high volume traffic, fuel quality, poorly maintained vehicular fleets, re-suspension of particles, construction work, and geographical conditions (arid regions). The pilgrim's longer trip duration lead to their highest whole trip exposure to air pollutants, which indicate that they are subject to higher health risk.

Abstract ID: 36576

Final Number: AS14A-0008

Title: Characterization of gas-phase organic acids in ambient air of a developing Megacity

Presenter/First Author: Sumayya Saied, University of Karachi, Karachi,

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Co-authors: Haider Abbas Khwaja, University at Albany, Albany; Mirza M Hussain, NYSDOH/Empire State Plaza, Albany, NY; Azhar Siddique, University of Karachi, Karachi, Pakistan; Celeste Butts, , , ; Syeda Shadia Kamran, , , ; Muhammad Kamran Khan, , ,

Published Material: First phase of the study was presented as poster in AAAR conference in 2012. Further results and interpertatins are compiled to be published in scientific journal

Abstract Body: According to UN estimates over 600 million urban populations in the world are exposed to dangerous levels of air pollutants and ambient air pollution is a significant factor shaping public health. Karachi, a developing Megacity with population over 18 million, served as a great focal point to observe the effects of industrial development on a growing city and how it contributes to the progression of environmental pollution. Results indicate that acetic and formic acids are important components of the Karachi atmosphere. The most abundant acids, by a substantial margin, were acetic acid and formic acid, with concentrations of 0.70 - 14.2 ppb and 0.82 - 11.0 ppb, respectively. On the average acetic acid levels exceeded those of formic acid. Concentrations of propionic acid, pyruvic acid, and glyoxalic acid ranged 0.03 - 1.41, 0.01 - 0.28, and 0.02 - 0.14 ppb, respectively. The gaseous acids showed diurnal cycles, with higher mixing ratios during nighttime. Compared with other metropolitans in the world, the level of acetic and formic acid concentration of Karachi is much higher. The ratio of formic to acetic acid was used to distinguish primary sources from secondary sources. A mean ratio of 0.85 was found. A positive correlation (r = 0.65 - 0.94) was observed between the acid concentrations suggesting that they have similar sources. Carboxylic acid concentrations appear to arise both from direct emissions and from atmospheric oxidation of hydrocarbons.

Abstract ID: 35848

Final Number: AS14A-0009

Title: Next Generation Sequencing Analysis: Impact of Bacteria in Snow and Frost Flowers on the Arctic Ecosystem

Presenter/First Author: Roya Mortazavi, McGill University, Montreal, QC

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Co-authors: Saeid Attiya, McGill University, Montreal, QC, Canada; Parisa A Ariya, McGill University, Montreal, QC, Canada

Abstract Body: During the OASIS 2009 campaign in Barrow, AK, different snow types namely accumulated snow, wind pack, blowing snow, snow hoar, frost flowers and fresh snow were collected on March (4 – 20) close to the Barrow Arctic Research Center (BARC). Microbial community of Arctic snow samples and frost flowers were compared to snow collected in the province of Quebec in Canada. Next Generation Sequencing (NGS) was used to characterize Arctic samples for their bacterial communities. Our results have indicated the existence of heterogeneous population of bacteria with diverse activities that potentially impact the Arctic ecosystem.

Abstract ID: 33435

Final Number: AS14B-0010

Title: Predicting Which 20% to 25% of Thunderstorms Will Develop Tornadoes

Presenter/First Author: Ronald Bryan Hardwig, Retired, Bloomington,

Presenter/First Author Email: rsdatainc@aol.com

Abstract Body:

This paper brings forth new research on predicting which 20% to 25% of thunderstorms will develop tornadoes, tornado genesis. The research was done over 25 years. Over 10,000 thunderstorms and tornadoes were investigated as to how, why, when and where tornadoes form, what is their source of energy and why they dissipate. The thunderstorms and tornadoes were chosen at random. Data was collected as to the relationship of the overhead jet stream and thunderstorms underneath. A definite relationship was noticed. The data showed how a tornado will only form in a thunderstorm which is developing under a jet stream with velocity ≥ 58 knots, the Tornado Threshold. It is thought that a tornado forms under these conditions because of the streamline flow of the jet stream passing over any vortex/mesocyclone created in the thunderstorm has the air entrained per the Bernoulli Effect and Entrainment, just as an atomizer, whenever the thunderstorm is high enough to interface with the overhead jet stream of high velocity. Anywhere in the world that has thunderstorms can have a tornado, if there is a jet stream with a high velocity overhead to energize the mesocyclone within the thunderstorm. Information also obtained, the higher the velocity of the jet stream corresponded to a stronger tornado. Also the higher the thunderstorm intersecting the jet stream the stronger the tornado due to the larger Relative Area of Interface. The tornado will dissipate any time the thunderstorm dissipates or moves out from under the high velocity jet stream. To better predict which thunderstorms will produce a tornado and with what intensity, we need to be looking at the overhead jet streams' velocity between 25,000 feet to 50,000 feet high any time the velocity is 58 knots.

Abstract ID: 35671

Final Number: AS14B-0011

Title: Return times of drought over West African Sahel

Presenter/First Author: Chamani Roméo, University of Yaoundé, Yaoundé,

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Co-authors: Monkam David, University of Douala, Douala, Cameroon

Abstract Body: Using Stationary stationary peaks-over-threshold model (POT), return times (RTs) of drought events are determined in West African Sahel (12-20°N, 17°W-15°E) using seasonal July-September (JAS) rainfall data from Climatic Research Unit for the period 1901-2009.Two metrics are used : the area-averaged precipitation and the fractional area of drought. The analysis revealed that RTs for the dry extremes have increased after 1970, implying that dry extremes (low values of precipitation with high value of fractional area) are higher after 1970 than they were before. The years 1984, 1972 and 1983 have been detected as the extreme years with rainfall amount (fractional area extend) of 167.80 (0.95), 177.17 (0.85) and 180.84mm (0.89), and RTs of 130 (125), 40 (20) and 30 (35) years, respectively. These results are also compared with those found by the most relevant study over the entire Sahel region. A RTs gap of 15 and 4 years were found for precipitation and fractional area respectively, when compared with the values of Greene *et al*. (2009).

Abstract ID: 34127

Final Number: AS14B-0013

Title: Global Warming Stopped in 1998 Because it is Controlled by Ozone Depletion, Not by Greenhouse Gases. The Montreal Protocol on Substances That Deplete the Ozone Layer Took Effect in 1989, Slowing Emissions of CFCs by 1993, Slowing Ozone Depletion by 1995, and Stopping Temperature Increase by 1998.

Presenter/First Author: Peter L Ward, , Jackson, WY

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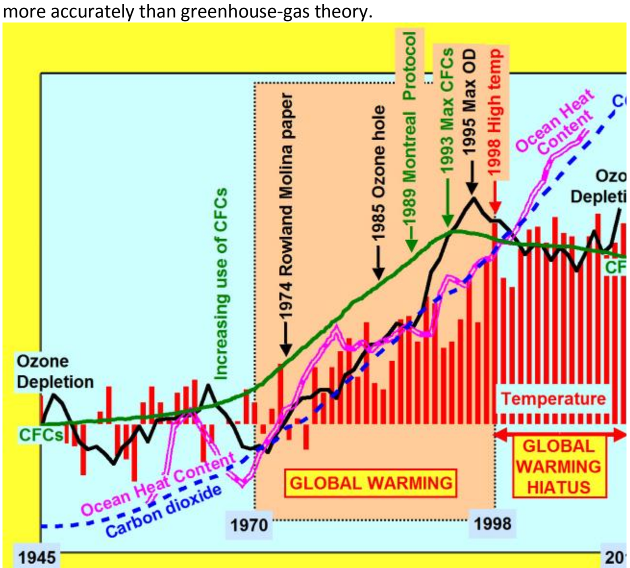
Published Material: Developments leading to these ideas have been reported at the fall AGU meetings from 2008 through 2014 and at the annual meeting of the American Meteorological Society in 2015. Nine scientific papers have been rejected without review as described at ozonedepletiontheory.info/publications-ozone-depletion.html. This work is described in detail at ozonedepletiontheory.info and at www.youtube.com/watch?v=GyZDf3kMvwo, both released on November 18, 2014.

Abstract Body: In the late 1960s, chlorofluorocarbons (CFCs) became popular as spray-can propellants, refrigerants, and solvents. Emissions began increasing by 1970, as did ozone depletion. In 1974 Rowland and Molina showed that CFCs can be broken down by ultraviolet light in the coldest parts of the lower stratosphere to release chlorine that depletes ozone. In 1985, with discovery of the Antarctic Ozone Hole, scientists and politicians began working together to draft the Montreal Protocol that took effect in January, 1989, the first universally ratified treaty in United Nations history. CFC emissions stopped increasing in 1993; ozone depletion stopped increasing in 1995; global surface temperatures stopped increasing in 1998. For the last 17 years, CFC emissions and ozone depletion have been decreasing very slowly; global mean surface temperatures have remained nearly constant. Ocean heat content continues to rise because ozone remains depleted relative to levels before 1970.

Chlorine and bromine emitted by active volcanoes also deplete ozone as much as 6% for more than 5 years. Pinatubo (1991), a major explosive volcano, caused the lowest levels of ozone ever measured in mid-latitudes accompanied by winter warming of northern continents. But Pinatubo also ejected megatons of SO_2 and water into the lower stratosphere forming aerosols that reflected and scattered solar radiation causing net global cooling of 0.5°C for 3 years. Effusive, basaltic volcanoes, on the other hand, common in Iceland and Hawaii, cause net warming by extruding large lava flows, depleting ozone, but not forming aerosols. Major warming and drought in Central North America during 2012 was coincident with 14% ozone depletion caused by CFCs and the largely effusive eruptions of Eyjafjallajökull (2010) and Grímsvötn (2011).

Ozone depletion theory explains the details of global and regional climate change observed in recent decades and throughout geologic time much more accurately than greenhouse-gas theory.



Abstract ID: 35141

Final Number: AS14B-0014

Title: Study of climatology and thermal comfort on Rio de Janeiro City: Preliminary analysis for 2016 Olympic Games

Presenter/First Author: Mariana Pallotta, National Institute for Space Research, Sao Jose dos Campos,

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Co-authors: Dirceu Luis Herdies, Center for Weather Forecasting and Climate Research, Cachoeira Paulista, Brazil; Luis Goncalves, CPTEC/INPE, Cachoeira Paulista, Brazil

Abstract Body: Weather conditions analysis has proven to be an useful tool when directed specifically to sports. For outdoor activities one of the major themes in weather applied to sports comes up: the thermal comfort of the athlete (Perry, 2004). Some studies indicate that the evaluation of bio-climatological conditions and thermal comfort in endurance sports has fundamental importance in training programs, nutritional plan and also for improving evaluation of race strategies (Pezzoli et al., 2012). Hence, the main objective of this study is to develop climatological analysis and thermal comfort assessments directed to sports and applied to Rio de Janeiro city, in Brazil. It is also expected that the results obtained might help the development of products and services to be used on 2016 Olympic Games.

The area of interest for this study is Rio de Janeiro city ,with special focus on the places that will held outdoor competitions of the 2016 Olympic Games. In order to compose the climatology, two weather stations in that area were selected. The period of study was chosen according to the data availability in both stations (2003 to 2014 – 11 years), and also to the months of interest to the Games (July – Acclimation; August – Olympics; September – Paralympics). Different thermal comfort indices were calculated: Effective Temperature and Effective Temperature related to the wind, using equations of the literature (Suping et al., 1992), Physiological Equivalent Temperature, Predicted Mean Vote and Standard Effective Temperature, according to Matzarakis et al. (2007).

Results related to climatological analysis for Rio de Janeiro city, on the period of Olympic Games, show that situations of extreme weather, as storms or extremely low temperatures, are not expected. Thermal comfort assessment for Rio de Janeiro city in average situation did not indicate for the period extreme discomfort both for heat and cold. Just September afternoons are more susceptible to moderate heat stress than the other months, which in case of intense physical activity can even be strong. A climatological analysis similar to that developed in this work, if released in advance to competing delegations of a sport event could contribute to substantial improvement preparation and practice of the athletes.

Abstract ID: 35369

Final Number: AS14B-0015

Title: Analysis of Mesoscale Rapidly Occluding Storm Causing Severe Atmospheric Anomalies in Southern California on February 28th, 2014

Presenter/First Author: Alex A Mundo, California State Polytechnic University Pomona, Victorville, CA

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Abstract Body: There are always good compliments on California's weather because no matter the season of the year a pleasant atmosphere usually prevails, until an alarming event changed the life course of 22 million of Southern Californians. On February 28th, 2014, Southern California experienced the largest thunderstorm since the storms of December 2010. The continuous progressivity of a strong and rapidly-occluding storm off the coast of California roaring from the Pacific Ocean led to flash flooding including mud and debris flows in certain zones. In order to understand the tough effect this storm had upon the zone, time-series of 125 NWS and RAWS weather stations are tested including at least 80% of hourly observations for a period of 72 hours. Analysis show the peak precipitation in the San Diego, Orange, Los Angeles and San Bernardino counties where precipitation reached 6 inches in various parts.

The substantial amounts of extreme precipitation were along the southern slopes of the San Bernardino County mountains, with Yucaipa Ridge reaching 11.11 inches, Lytle Creek with 9.67 inches and Cedar Glen with 9.10 inches. The occluding storm off Southern California's cost led to continuous flash flooding and winds of up to 77mph in different zones. An indication of the strength of the storm was the high amount of GOES-15 sounder Total Column Ozone associated with its circulation, which reached levels as high as 440-450 Dobson Units. These findings imply that the high levels of total column ozone are associated with potential vorticity anomalies and a dramatically lowered tropopause. Additional numerous arc-shaped mesospheric airglow waves in the storm circulation suggest that a 140-knot jet streak propagated them vertically in the southward direction.

Abstract ID: 35050

Final Number: AS14B-0016

Title: A Case Study Of Mesoscale Convective Complexes With Assimilation Of Radar Data

Presenter/First Author: Rute Costa Ferreira, CPTEC Center for Weather Forecasts and Climate Research, Cachoeira Paulista, SP

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Co-authors: Dirceu Luis Herdies, Center for Weather Forecasting and Climate Research, Cachoeira Paulista, Brazil

Abstract Body: Mesoscale Convective Complexes (MCC) are responsible for intense storms in southern region of Brazil. Usually, the MCC events can cause significant damage and are related to strong winds, atmospheric electrical discharges, heavy rain, and, in more extreme cases, even hail. This work presents a detailed study of these events based on radar data assimilation. In numerical weather prediction, an adequate radar data assimilation leads to better representation of the MCC, improving the forecast of this event. Moreover, an accurate forecast model is an important tool for the meteorologist. Thus, in order to demonstrate the importance of data radar assimilation in a correct way, the results of operational models of CPTEC (Center of Weather Forecasting and Climate Research) and the radar data assimilation with WRF are compared for the western of Paraná state and southeastern of Paraguay. The results of this work may contribute to improve the alerting systems of this kind of event with better accuracy and in advance, reducing losses caused by landslides, destruction of plantations, falling trees, and others.

Abstract ID: 34445

Final Number: AS14B-0017

Title: A Climatology of North American 850 hPa Equivalent Potential Temperature and its Extremes in Montreal, Quebec.

Presenter/First Author: Alice Louise Wood, McGill University, Montreal,

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Abstract Body:

Abstract ID: 33684

Final Number: AS14B-0018

Title: Analysis of Strengthening and Dissipating Mesoscale Convective SystemsPropagating off the West African Coast

Presenter/First Author: Abdou Lahat Dieng, Polytechnic School of Dakar (ESP), Dakaar,

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Co-authors: Laurence Eymard, , , ; Saidou Moustapha Sall, , , ; Alban Lazar, , , ; Marion Leduc-Laballeur, , ,

Published Material: This work is published in the Monthly Weather Review Journal Dieng, A. L., L. Eymard, S. M. Sall, A. Lazar, and M. Leduc-Leballeur, 2014: Analysis of Strengthening and Dissipating Mesoscale Convective Systems Propagating off the West African Coast. *Mon. Weather Rev.*, 142, 4600–4623, doi:10.1175/MWR-D-13-00388.1.

Abstract Body: Alarge number of Atlantic tropical depressions are generated in the eastern basin in relation to the African
easterly wave (AEW) and embedded mesoscale convective systems (MCSs) coming from the African continent.
In this paper, the structures of strengthening and dissipating MCSs evolving near the West African
coast are analyzed, including the role of the ocean surface conditions in their evolution.
Satellite infrared brightness temperature and meteorological radar data over seven summer seasons between
1993 and 2006 are used to subjectively select 20 cases of strengthening and dissipating MCSs in the
vicinity of the Senegal coast. With these observed MCSs, a lagged composite analysis is then performed using
Interim ECMWF Re-Analysis (ERA-Interim) and Climate Forecast System Reanalysis (CFSR).
It is shown that the strengtheningMCS is generally preceded by prior passage of anAEWnear the West African
coast. This previous wave trough is associated with a convective cyclonic circulation in the low and middle troposphere,
which enhances the southwesterly flowand then provides humidity to the strengthening MCS, located in
the vicinity of the subsequent AEW trough. This is favored by the contraction of the wavelength associated with
the two troughs. The sea surface contributes to the MCS enhancement through surface evaporation flux. But this
contribution is found to be less important than advection of humidity from the previous wave trough. These
conditions are almost not found in the dissipating MCS cases, which dissipate in a dry environment dominated by
a subsident and anticyclonic circulation, with generally no interaction with a previous wave trough.

Abstract ID: 36704

Final Number: AS14B-0019

Title: What is the Cause of the Ongoing Global-Warming Pause?

Presenter/First Author: S Fred Singer, Science & Environmental Policy Project, Arlington, VA

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Abstract Body: The observed absence of a global-warming trend ("pause"), beginning around Yr 2000 (or perhaps even earlier) contradicts the results of every IPCC climate model – all of them driven by a steady increase in anthropogenic carbon dioxide. This lack of model validation has obvious implications for model-based estimates of future climate. Until the cause of the pause is fully understood and incorporated into existing models, all policies aiming to stabilize climate are useless and nothing more than highly uncertain and hugely expensive undertakings.

Scientific efforts to discover appropriate mechanisms for the cause of the pause may be classified according to Forcing Imbalance (F.I.) at the TOA (top of the atmosphere):

1. FI unaffected and in accord with rising CO2: implies existence of "hidden heat" somewhere (deep ocean?)

2. FI reduced wrt rising CO2 by (internal) negative feedback (from increase in OLW [reduced WV in upper troposphere] or from increase in albedo [low-altitude clouds])
But can such negative feedback cancel nearly all of CO2 forcing?

3. FI reduced by external offsets, like volcanic aerosols or solar irradiance; but this raises many unanswered problems: how to match the steady increase in forcing from rising CO2?

All these proposed mechanisms should also be able to answer two puzzling questions:
Why did pause begin around Yr 2000?
When will it end – as implied by the word "pause"?

Finally, could the pause have started in the 1970s, much before 2000? Only land-surface stations show a distinct warming trend since the late 1970s; other data sets do not. The puzzle continues.

Abstract ID: 33957

Final Number: AS14C-0020

Title: The Operational World Meteorological Organization (WMO) Multi-Model Ensemble

Presenter/First Author: Bertrand Denis, Organization Not Listed, Dorval,

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Abstract Body: This talk will give an overview of the operational WMO Multi-Model Ensemble (MME) for long range forecasts. This MME gets contributions in real-time and on a monthly basis from 12 WMO designated Global Producing Centers (GPCs). It is the role of the WMO Lead Center for Long Range Forecast MME (LC-LRFMME) to process the data into MME forecasts and also to give access to them to National Meteorological and Hydrological Services (NMHS) as well as to Regional Climate Outlook Forums (RCOFs) and Regional Climate Centers (RCC). To ensure high quality standards and to help interpreting the forecast skill coming from the GPCs, a comprehensive set of standard verification measures has been defined. The display of those metrics as well as the technical and scientific support in the domain of long range forecast verification are part of the responsibilities of the WMO Lead Centre for Standard Verification System for Long-Range Forecasts (LC-SVSLRF).

The presentation will give more details about the participating GPCs, the LC-LRFMME web site to view and access the forecasts, the forecast variables and other products, real-time forecast verifications, the forecast schedule and user access restrictions, amongst other things. An overview of its companion LC-SVSLRF web site used to display the expected skill from hindcasts will also be shown. Finally, plans for the future, including the sub-seasonal timescale will be given.

Abstract ID: 34639

Final Number: AS14C-0021

Title: Assessment of APCC Multi-Model Ensemble Prediction in Seasonal Climate Forecasting: Retrospective (1983-2003) and Real-time Forecasts (2008-2013)

Presenter/First Author: Sang Myeong Oh, APEC Climate Center, Busan,

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Co-authors: Young-Mi Min, APEC Climate Center, Busan, South Korea; Vladimir N. Kryjov, , ,

Published Material: Min, Y. -M., V. N. Kryjov, S. M. Oh, 2014, Assessment of APCC Multi-Model Ensemble Prediction in Seasonal Climate Forecasting: Retrospective (1983-2003) and Real-time Forecasts (2008-2013), J. Geophy. Res. Atmos., 119, 12,132-12,150, DOI:10.1002/2014JD022230.

Abstract Body: Since 2007, the Asia Pacific Economic Cooperation (APEC) Climate Center (APCC) has monthly issued multi-model ensemble (MME) seasonal predictions for three months, with one-month lead time, and disseminated it to APEC member economies. This paper gives a comprehensive documentation of the current status of the APCC operational multi-model performance, with a large set of retrospective (1983-2003) and real-time (2008-2013) predictions of temperature and precipitation. In order to investigate the enhancement in seasonal predictability that can be achieved by empirically-weighted MME (using multiple regression) and calibrated MME (by correcting single-model prediction using a step-wise pattern projection method) schemes, operationally implemented at the APCC, we compare them with a simple averaged MME (with equal weightings), for predicting seasonal mean temperature and precipitation one-month ahead. The results indicate that the simple averaged MME consistently outperforms the multiple regression-based MMEs, when considering all aspects of the predictions from operational prediction systems (i.e., in different variables, regions, seasons) whereas the calibrated MME shows the capability to reduce errors and improve forecast skills in a large proportion of cases. The possible causes of the failure and success of the different MME methods implemented in the APCC operations are discussed.

Abstract ID: 36505

Final Number: AS14C-0022

Title: Monthly Ensemble Forecasts from the NCEP GEFS

Presenter/First Author: Malaquias Peña, Environmental Modeling Center, Crofton, MD

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Abstract Body: A series of experiments of 35-days, 20 members ensemble forecasts based on the NCEP GEFS has been carried out to assess the ability to predict atmospheric and precipitation anomalies in current NWP systems. Model integrations initialized every 24 h during periods of regular, strong and weak MJO signal during the months JASO-2011, JFM-2012 and ND-2012, respectively were analyzed. Results indicate a correspondence between the intensity of the MJO signal and the skill of NH atmospheric anomalies. The enhancement of skill during high MJO signal indicates that the teleconnection responses to forcing in the tropical Pacific is to some degree adequately modeled by the GEFS. Another set of experiments with a more recent version of the GEFS was carried out to assess the impact of SST anomalies on the skill of predictions. In this set, three identical configurations of the GEFS that differ only on what SST anomalies are prescribed are compared. The first configuration uses initial

SST anomalies that decay towards observed climatology in a 90-days e-folding time as the forecast is integrated forward. The second configuration uses analyzed SST and a third configuration uses SST forecasts from the CFSv2 coupled model. Results indicate that prescribing realistic SSTs, particularly the analyzed SST, marginally improves the skill of prediction of some variables even during the first two weeks of the forecasts.

Abstract ID: 35085

Final Number: AS14C-0023

Title: Diagnostic Evaluation of Summer Precipitation over West Africa using three of CORDEX-Africa Simulations

Presenter/First Author: Akinsanola Akintomide Afolayan, Federal University of Technology Akure, Akure,

Presenter/First Author Email: mictomi@yahoo.com

Co-authors: Ogunjobi Kehinde Olufunso, , ,

Abstract Body: The study evaluates the ability of three Regional Climate model (RCMs) used in the Coordinated
Regional climate Downscaling Experiment (CORDEX) activity driven by the same initial and
boundary conditions (ERA-Interim) in simulating the characteristics of rainfall pattern over West
Africa from 1998-2008. The seasonal climatology, annual rainfall cycles, interannual variability
and the wind fields of RCMs output have been assessed over three homogenous sub-regions
against ground observed data of 81 meteorological stations in West Africa and TRMM
observational dataset. Furthermore, the study assessed the ability of the RCMs in simulating the
El Nino and La Nina events. Result shows that all the RCMs simulate the main features of the
rainfall climatology and associated dynamics over the three sub-regions (Guinea coast, Savannah
and Sahel) of West Africa. Furthermore, analysis shows significant biases in individual models
depending on sub-region and season. In general, the study shows that the three CORDEX RCMs
simulate West Africa rainfall and extreme events adequately and can therefore be used for the
assessment of future climate projections for the region taking into consideration the degree of
biasness.

Abstract ID: 36204

Final Number: AS14C-0024

Title: Urban Climate Downscaling Processes using Dynamical and Diagnostic Numerical Models Approach: Madrid Case Study

Presenter/First Author: Roberto San Jose, , Boadilla Del Monte,

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Co-authors: Juan Luis Perez-Camanyo, , , ; Julia Pecci, , , ; Antonio Garzon, , , ; Marino Palacios, , ,

Published Material: The 1st International Workshop on Smart City Clouds: Technologies, Systems and Applications in London, Dec. 10, 2014. Oral presentation. Not under review.

Abstract Body: Downscaling techniques are very important to assure the robustness and credibility of climate modelling exercises. Regional climate simulations use boundary conditions and initial conditions from global climate and meteorological models. The regional climate simulations (WRF/chem model) have much higher spatial resolution and using nesting approaches can be used to derive climate indicators at urban level. Dynamical nesting approaches – also known as dynamical downscaling procedures – use a substantial amount of computer power, particularly for urban applications; other alternatives such as CALMET diagnostic model (for meteorological applications) and CMAQ model (with linear chemistry) produce results faster and can be used for climate applications with reasonable required computer power. In this contribution, we are using the European Centre for Medium-Range Weather Forecasts (ECMWF) model data sets to provide boundary conditions for the mesoscale model WRF/Chem (NOAA, US) that has been ran over Europe with 23 km spatial resolution and 33 vertical levels up to 50 hPa. We have used the full nesting approach defined into WRF model to produce simulations centered over the city of Madrid (Spain) with 4.6 km spatial resolution (nesting level 1, l1), 0.92 km spatial resolution (nesting level 2, l2) and 0.184 km spatial resolution (nesting level 3, l3). In l3, we have run the CMAQ (full chemistry) model (EPA, US) to produce chemical pollution data. We have applied both downscaling techniques over Madrid area using Retiro meteorological and air pollution monitoring station as observational station. The comparison between both downscaling techniques shows that CALMET-CMAQL (linear chemistry) model is much faster and the results are good enough (compared with other simulations results) to consider this tool, when the number of simulations for climate purposes is very high (due to many years and several climate scenarios) and the application of the WRF/chem model (dynamical downscaling) is prohibited computationally.

Abstract ID: 33226

Final Number: AS14C-0025

Title: Analyzing future extreme rainfalls changes over the Central Africa using CMIP5 models.

Presenter/First Author: Siewe KAMEGNI André, Organization Not Listed, Douala,

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Co-authors: Chamani Roméo, University of Yaoundé, Yaoundé, Cameroon; Monkam David, University of Douala, Douala, Cameroon; Yepdo Zephirin, , , ; Mkankam Kamga François, , ,

Abstract Body: Abstract

This paper examines future changes in extreme rainfall by using projected daily precipitations from the ensemble mean of 10 state-of-the-art global climate models from the fifth Coupled model inter-comparison project (CMIP5) under the high representative concentration pathways scenario (RCP 8.5) over the Central Africa. To analyze future changes, trends in the 90th and 99th percentiles of daily precipitation distributions were calculated for two sub periods (2035-2065 and 2071-2100). Results show robust signal in the strong rainfall response i.e., increasing amounts in central part of our region and the few areas in the northern and southern part characterized by a reduction of extreme rainfall or no trends.

Abstract ID: 36481

Final Number: AS14C-0026

Title: Impacts of high-end climate change scenarios on the Mediterranean coast

Presenter/First Author: Piero Lionello, University of Salento, Lecce,

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Co-authors: Dario Conte, CMCC Salento, Lecce, Italy; Luca Scarascia, CMCC Salento, Lecce, Italy; Agustin Sanchez-Arcilla, , , ; Joan Pau Sierra, University of Salento, Lecce, Italy; Cesar Mosso, , ,

Abstract Body: This contribution describes the impacts of high end climate change scenarios on the Mediterranean coast. The study is focalized on the maximum water level that will be reached in the future at the coast considering the superposition of waves, storm surge and mean sea level variations. The study compares results based on an ensemble of simulations CMIP5 RCP8.5 emission scenario to previous results based on the A1B emission scenario. The period considered in 1950-2051. Our goal is to analyze the effect of two factors that in the Mediterranean Sea are acting in opposite directions: the increase of mean sea level (due to regional steric effects and water mass addition through the Gibraltar Strait) and the decrease of storminess (due to the northward shift of the storm track across Europe) decreasing surge levels and wave heights. It shows that even a moderate mass addition due to melting of the ice caps will lead to a statistically significant increase of the extreme water level statistics along the Mediterranean coast. Impacts on the management of the coast defenses are discussed. This study is part of the RISES-AM project (FP7-EU-603396).

Abstract ID: 33301

Final Number: AS21A-01

Title: Equatorial stratospheric thermal structure and ozone variations during the sudden stratospheric warming of 2013

Presenter/First Author: Oindrila Nath, National Atmospheric Research Laboratory, Tirupati,

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Co-authors: Sundararajan Sridharan, National Atmospheric Research Laboratory, Gadanki, India

Published Material: This work has been published in Journal of Atmospheric and Solar-Terrestrial Physics in January 2015. Oindrila Nath, S. Sridharan, H. Gadhavi, Equatorial stratospheric thermal structure and ozone variations during the sudden stratospheric warming of 2013, *Journal of Atmospheric and Solar-Terrestrial Physics*, Volume 122, January 2015, Pages 129-137, ISSN 1364-6826, http://dx.doi.org/10.1016/j.jastp.2014.11.003.

Abstract Body: Ozone mass mixing ratio (OMMR) obtained from both European Centre for Medium Range Weather Forecasting (ECMWF) Reanalysis (ERA)-Interim and Sounding of Atmosphere by Broadband Emission Radiometry (SABER) instrument onboard Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) satellite shows large values in the equatorial upper stratosphere during the occurrence of a major stratospheric sudden warming (SSW) in January 2013 preceded by a large reduction of planetary wave activity. However, surprisingly equatorial stratospheric temperature is found to decrease at pressure levels where the ozone mixing ratio is larger. The computed radiative heating rate using Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) model also shows positive heating rate indicating that the temperature should increase in response to the ozone accumulation over equator. In addition to radiative heating due to ozone, heating rate due to other dominant factors, namely, ascending motion and convergence of meridional heat flux, which could influence the thermal structure of the equatorial stratosphere, are estimated. It is found that the observed low temperature during SSW is mainly due to large upward motions. The estimated heating rates agree reasonably well with the observed heating rates at 10-8 hPa indicating the dominance of transport at lower stratosphere. The large discrepancy between the estimated and observed heating rates in the upper stratosphere may be due to the dominance of photochemistry.

Abstract ID: 33586

Final Number: AS21A-02

Title: Quantifying the scales of coherence and causes of spatiotemporal variability of aerosol particle properties and extreme concentrations over eastern North America

Presenter/First Author: Ryan Sullivan, Cornell University, Ithaca, NY

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Co-authors: Paola Crippa, Newcastle University, Newcastle upon Tyne, United Kingdom; Robert C Levy, , Silver Spring, MD; Sara C Pryor, Cornell University, Ithaca, NY

Abstract Body: Aerosol optical depth (AOD) and Ångström exponent (AE) from the MODerate resolution Imaging Spectroradiometer (MODIS) on the Aqua and Terra satellites, and AErosol RObotic NETwork (AERONET) ground-based stations are used to deliver an evaluation of the spatially averaged (Level-3) MODIS aerosol particle products, and to characterize the spatiotemporal scales of variability of the aerosol particle population over eastern North America. Our analyses show (i) a high degree of consistency in AOD retrievals from Terra and Aqua, and between MODIS and AERONET, although larger discrepancies are observed in AE retrievals, and (ii) MODIS data indicate highest mean AOD and lowest day-to-day variability during the summer, but largest scales of spatial coherence in summer and fall. The frequency of co-occurrence of extreme AOD values (> local 90th percentile) decreases to below 50% at ~ 150 km from a reference grid cell in south-central Indiana, but is above that expected by random chance over almost all of eastern North America, indicating supra-regional scale extreme events. In both the MODIS and AERONET observations variability in AOD is manifest primarily on synoptic and annual scales. Conversely, AE variability in MODIS data is primarily focused on seasonal, semiannual, and annual time scales, and there is an additional mode of AE variability at ~ 30 days in the AERONET measurements. The results of these analyses are being used to diagnose the causes of the different spatiotemporal variability of columnar aerosol particle loading (AOD) and aerosol particle size (AE) and in a cross-comparison evaluation exercise of yearlong simulations (for 2008) conducted using WRF-Chem applied at 12 km spatial resolution.

Abstract ID: 35433

Final Number: AS21A-03

Title: Investigation and intercomparison of ozone depletion in the Arctic polar vortex - using ground-based and space-borne FTIR measurements at Eureka between 2006 and 2013

Presenter/First Author: Debora Griffin, University of Toronto, Toronto,

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Co-authors: Kaley A Walker, University of Toronto, Toronto, ON, Canada; Stephanie Conway, University of Toronto, Toronto, ON, Canada; Dan Weaver, University of Toronto, Toronto, ON, Canada; Felicia Kolonjari, University of Toronto, Toronto, ON, Canada; Rodica Lindenmaier, , , ; Lin Dan, University of Toronto, Toronto, ON, Canada; Joseph Mendonca, University of Toronto, Toronto, ON, Canada; Ashley Harrett, University of Toronto, Toronto, ON, Canada; Rebecca Lee Batchelor, National Center for Atmospheric Research, Boulder, CO; Kimberly Strong, University of Toronto, Toronto, ON, Canada; Gloria L Manney, NorthWest Research Associates, Inc, Socorro, NM; Chris D. Boone, University of Waterloo, Waterloo, ON, Canada; Peter F Bernath, Old Dominion University, Gloucester, VA; James R Drummond, Dalhousie University, Halifax, NS, Canada

Published Material: The some initial components of this work were presented recently at an ACE Science Team meeting (Oct. 2014).

Abstract Body: During the Canadian Arctic ACE (Atmospheric Chemistry Experiment) Validation Campaigns from 2004-2014, ground-based measurements have been carried out during the polar sunrise period (from mid-February to mid-April) at Eureka, Nunavut (80.05°N, 86.42°W). As part of this project two ground-based Fourier Transform Spectrometers (FTSs) were used to measure total and partial columns of trace gases important to O_3 depletion, namely, O_3, HCl, and HNO_3, as well as HF. During the same time period, the satellite-based ACE-FTS made measurements over Eureka and provided profiles of the same trace gases.

An intercomparison of the latest version of the ACE-FTS retrieval product (v3.5) has been carried out for these stratospheric gases between 2006 and 2013. Instrument comparisons in the High Arctic during the polar sunrise period are challenging. Trace gas amounts inside and outside the polar vortex can be significantly different. We have used a smoothed partial column methodology for the ground-based to space-borne intercomparison; and selected coincident measurements based on time, distance and scaled potential vorticity (sPV).

Furthermore, we have investigated the springtime Arctic O_3 loss in each year and found significantly lower O_3 columns in 2011 for all instruments. To distinguish O_3 decrease caused by dynamics from that arising from chemical loss, we have applied a HF normalization and tracer-tracer (O_3-HF) correlation method. We used measurements between 2004 and 2013 to estimate the annual amount of springtime chemical O_3 loss. The results of the intercomparison and chemical O_3 loss analyses will be discussed in the presentation.

Abstract ID: 35483

Final Number: AS21A-04

Title: Contribution of Different Ultrafine Aerosol Size Fractions to Ice Nucleation in Clouds

Presenter/First Author: Yevgen Nazarenko, McGill University, Montreal, QC

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Co-authors: Rodrigo Benjamin Rangel-Alvarado, McGill University, Montreal, Canada; Parisa A Ariya, McGill University, Montreal, QC, Canada

Abstract Body: In the upper troposphere, aerosol particles serve as ice nuclei impacting precipitation and weather. The physico-chemical nature of these particles determines the highest temperature at which they nucleate ice crystals. One of these determinant physico-chemical characteristics is particle size. Most research to date suggests that micrometer-scale particles are more efficient ice nucleators than submicrometer particles. However, recent findings show the importance of nanoparticles. Due to previous technical limitations, it has been hard to investigate the role of ultrafine particles in ice nucleation. The recent instrumental advances, however, enable separation of different size fractions of even sub-100 nm particles using differential mobility analyzers (DMAs).

Aerosol particles that nucleate ice crystals in the atmosphere are trapped in the snowflakes. These particles are then present in meltwater that can be obtained from the snow. We designed a novel technique to aerosolize desalinized meltwater from natural snow, followed by subjecting the aerosol to drying and size classification in a DMA. The resulting monodisperse aerosol is collected in an electrostatic precipitator on 3 mm diameter disc substrate and then used in ice nucleation assays on a cold plate. We will present our data from several field campaigns in the Arctic and subarctic sites and discuss their role in nucleation processes.

Abstract ID: 35944

Final Number: AS21A-05

Title: Lagrangian Analysis of Ozone Production in the Baltimore-Washington Metropolitan Area Based on Air Parcel Trajectories and In Situ Airborne Measurements from the 2011 DISCOVER-AQ Campaign

Presenter/First Author: Heather Leigh Arkinson, University of Maryland College Park, Swanton, VT

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Co-authors: Lacey C Brent, NIST, Gaithersburg, MD; Hao He, University of Maryland College Park, College Park, MD; Christopher Loughner, University of Maryland College Park, College Park, MD; Jeff Stehr, University of Maryland College Park, College Park, MD; Andrew John Weinheimer, National Center for Atmospheric Research, Boulder, CO; Russell R Dickerson, University of Maryland College Park, College Park, MD

Abstract Body: Tropospheric O_3 is a reactive trace gas with a short atmospheric lifetime that absorbs infrared energy and thus acts directly as a greenhouse gas that contributes strong radiative forcing on regional scales. It is also the dominant component of summertime photochemical smog, and at high levels, has deleterious effects on human health, ecosystems, and materials. The University of Maryland (UMD) Regional Atmospheric Measurement Modeling and Prediction Program (RAMMPP) strives to improve air quality in the Mid-Atlantic States and to elucidate contributions of such pollutants from regional transport versus local sources. The National Aeronautics and Space Administration (NASA) Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) project investigates the connection between column measurements and surface conditions to explore the efficacy of remote sensing observations in quantifying atmospheric composition and diagnosing air quality at ground level. During the 2011 DISCOVER-AQ field campaign, in situ measurements were performed along the Baltimore-Washington corridor from the NASA P3B aircraft. To provide regional context, measurements were also performed by the RAMMPP Cessna 402B aircraft over nearby airports. This work presents an analysis of O_3 measurements made by the Ultraviolet (UV) Photometric Ambient O_3 Analyzer on the Cessna 402B and by the NCAR 4-Channel Chemiluminescence instrument on the P3B. Spatial and temporal patterns of O_3 data are examined within the context of forward and backward air parcel trajectories calculated from 12-km North American Mesoscale (NAM) meteorological data using the National Oceanic and Atmospheric Administration (NOAA) Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model and from a high resolution Weather Research and Forecasting (WRF) model simulation in order to empirically calculate localized O_3 production rates and distinguish O_3 resulting from regional transport versus O_3 generated from local photochemistry. Preliminary examination of measurements from overlapping flight days and corresponding trajectories identifies 38 cases suitable for Lagrangian analysis, resulting in O_3 production rates ranging up to 14 ppbv hr^{-1} and 4 ppbv hr^{-1} on average.

Abstract ID: 33960

Final Number: AS21A-06

Title: Using land surface information to inform back-trajectory analyses of aerosol measurements

Presenter/First Author: David Doughty, Oak Ridge Associated Universities Inc., Oak Ridge, TN

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Co-authors: Steven C Hill, , ,

Abstract Body: The land surface types that an airmass passes over can influence the trace-gas and aerosol properties observed downwind. The objective of the present study is to determine how particulate matter properties correlate with land surface types upwind of the measurement location. To do this, we combine high-resolution Geographical Information Systems (GIS) data with air-parcel back-trajectories, using a time-weighted residence time analysis, which we refer to as TWRTA. Additionally, we study the influence that changing model resolution has over the determined TWRTAs. Measured aerosol data from a site located near Beltsville, MD, in the mid-Atlantic region of the United States are used. Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) back-trajectories are driven by Global Data Assimilation System data, which has a resolution of approximately 111x85 km at 40°N 77°W, and North American Model 12 km data. We calculate TWRTAs using land surface type data from the North American Land Change Monitoring System, and include coastal and deep waterways, cropland, temperate/subpolar broadleaf deciduous forest, and wetlands, among other land surface types.

Abstract ID: 35655

Final Number: AS21A-07

Title: Features of Limited Organic-Inorganic Miscibility and Their Relation to Aerosol Hygroscopicity

Presenter/First Author: Andreas Zuend, McGill University, Montreal, QC

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Co-authors: Daniel M. Lienhard, , , ; Ulrich Karl Krieger, ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland

Abstract Body: The water content of aerosol particles at atmospheric conditions depends on their chemical composition, which defines their hygroscopicity, and the environmental temperature and relative humidity (RH). Hygroscopicity is therefore an important property affecting aerosol size as well as phase transitions and viscosity of soluble or partially soluble particles. The chemical composition of ambient aerosol particles is complex, often involving hundreds to thousands of multifunctional organic compounds and several types of dissolved inorganic ions. The miscibility of all the chemical species is often limited, which can, e.g., lead to the separation of a particle into two or more liquid phases. The thermodynamics describing organic-inorganic molecular interactions lead to hygroscopicity behavior deviating from simple linear additivity assumptions at given RH. The latter assumptions are employed in the Zdanovskii-Stokes-Robinson (ZSR) mixing rule, which is typically found to describe hygroscopic mass growth well in the RH range of completely miscible liquid aerosol systems and therefore often employed in atmospheric models. We present new thermodynamic calculations based on the AIOMFAC activity coefficient model in comparison to hygroscopic growth factor data from measurements conducted with an electrodynamic balance (EDB). Different hygroscopicity features at relative humidity levels below the full deliquescence of multicomponent systems are found. We will present experiments and detailed model calculations performed for multicomponent systems showing varying degrees of organic-inorganic miscibility, including liquid-liquid phase separation and hysteresis effects between metastable and stable gas-particle equilibria. It is found that depending on the degree of miscibility, the aerosol water uptake prior to deliquescence can be substantial due to partial dissolution of electrolytes. Such behavior is not captured with a traditional ZSR parameterization.

Abstract ID: 33285

Final Number: AS21B-01

Title: Evaluating IPCC and Other Scenarios of Future Climate for Regional-to-Local Water Resource Applications in the US

Presenter/First Author: J R Arnold, US Army Corps of Engineers, Seattle, WA

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Published Material: some general parts of this overview talk were given in the 2014 AGU Fall Annual Meeting session on societal decision-making (GC52A); no formal ms submission has been made or is planned fr it

Abstract Body: Assessments of projected climate change impacts to water resources at regional-to-local scales typically use a combination of numerical models for evaluating the various differences across projected scenarios and impacts. However, the sets of approaches for projecting regional climate and its possible effects - statistical or dynamical models, e.g., to generate the regional-to-local climate and weather - together with the hydrologic models used to transfer changes in these model outputs into changed hydrologic processes most often include only one or a few models, and thisinhibits their depiction of the uncertainty space around the projected climate and impacts. Additionally, inter-model differences are often not constrained to define the uncertainties in the simulations consistently. And more generally, the community performing water-resource impacts assessments (among most others) has focused very intently on characterizing uncertainty across climate projections produced by multiple climate models running several emission scenarios, but have done little work to understand the interacting uncertainties in the driving climate and hydrologic models.

Water-resource managers face a linked series of questions about using these models related to their decision-making for climate-changed futures, including: 1) how do different climate downscaling approaches affect the projection of relevant hydrometeorological variables? 2) how can observational datasets best be used to drive analyses of downscaled climate and hydrology? and 3) how many/which hydrologic model/s can be used, and how can they best be configured and calibrated for these applications?

This talk will summarize some of the methods and results coming from the US Army Corps of Engineers' work with partners to help provide fuller answers to those questions. Two salient points are: 1) different methods for producing gridded meteorological fields can have very different effects on projected hydrologic outcomes, with uncertainties as large as the climate change signal; 2) many popular statistical downscaling methods produce hydroclimate representations with too much drizzle, wrong extreme events representations, and improper spatial scaling characteristics relevant to hydrology.

Abstract ID: 34331

Final Number: AS21B-02

Title: A tool to communicate to the adaptation community: a guidebook on climate scenarios

Presenter/First Author: Isabelle Charron, Ouranos, St-Basile-le-Grand,

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Abstract Body: Climate change is a reality that is forcing decision-makers to assess its related risks, vulnerabilities and opportunities. This requires decision-makers to improve their general understanding of climate information. This guide on climate scenarios constitutes a new tool with the objective of helping users become more familiar with different types of climate information so that this information is increasingly incorporated into adaptation frameworks. The guide is intended to all actors involved in climate change adaptation, from the early stages of general climate change awareness to the implementation of adaptation measures. The document is organised around three main sections. The first section presents a unique way to classify climate information using a decision tree. This tool allows users orient themselves toward one of three large climate information categories, namely basic, intermediate, or detailed, based on several factors such as the use of the information, the climate variables of interest, and the spatial and temporal scales of the information provided. The next section presents a catalogue of numerous different formats that can be used in order to customize and present climate information to various users, according to their expertise and personal preference, among others. This section aims to help users better analyse different climate information products and to better evaluate the usefulness and limitation of the climate information that is presented. Finally, a third section describes many key concepts in climate modeling. The guide highlights the fact that all climate information, regardless of its complexity, can be used to make decisions. It is important to recognize the right information for the right use or purpose.

Abstract ID: 34010

Final Number: AS21B-04

Title: Inter-Variable Dependence in Climate Scenarios at Daily Resolution: Testing a 2D Statistical Adjustment of CMIP5 Simulations at Canadian Arctic Coastal Sites

Presenter/First Author: Fabio Gennaretti, Ouranos, Montreal,

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Co-authors: Lorenzo Sangelantoni, , , ; Patrick Grenier, Ouranos, Montreal, QC, Canada

Published Material: A part of the results were already described in a poster presented at 2 meetings (Arctic Change 2014 and Ouranos Symposium). Currently, we are writing a scientific paper on our findings.

Abstract Body: The interdependence between climatic variables is a critical feature which should be taken into account when developing local climate scenarios for the next decades. For example, in the Arctic the temperature-precipitation interdependence is particularly strong and determines other physical characteristics such as the snow cover extent and duration. However, this interdependence is often misrepresented in climate simulations. Here, we propose a two-dimensional (2D) statistical adjustment of climate model simulation data for the development of plausible local daily temperature and precipitation scenarios with more realistic inter-variable dependence. This method is based on the quantile mapping technique and furthermore it uses temperature time trend removal to obtain a stationary correction procedure and moving windows to adjust the correction to the specificities of each day of the year. This method was tested at 30 Canadian Arctic coastal sites, and was applied to an ensemble of 13 CMIP5 simulations (selected for representativeness of the variability of a larger ensemble). The inter-variable dependence was evaluated in terms of correlation values and with empirical conditional probability distributions of standardized temperature ranks given standardized precipitation ranks. The results show that the proposed 2D statistical adjustment corrects individual distributions of climatic time series as well as a standard one-dimensional (1D) statistical adjustment. Furthermore, the 2D adjustment outperforms raw and 1D corrected simulations in the reproduction of the observed temperature-precipitation interdependence. Where this interdependence is important (e.g. characterization of extreme events and of snow cover extent and duration), the proposed 2D adjustment definitely represents a good alternative for the production of plausible local climate scenarios.

Abstract ID: 34675

Final Number: AS21B-05

Title: High-resolution climate change projections over Australia: producing policy-relevant information

Presenter/First Author: Alejandro Di Luca, University of New South Wales, Sydney,

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Co-authors: Jason Peter Evans, University of New South Wales, Sydney, NSW, Australia; Daniel Argüeso, University of New South Wales, Sydney, Australia; Roman Olson, University of New South Wales, Sydney, NSW, Australia; Lluis Fita, , ,

Published Material: Evans, J. P., F. Ji, C. Lee, P. Smith, D. Argeso, and L. Fita (2014), Design of a regionalclimate modelling projection ensemble experiment NARCliM, Geosci. Model Dev., 7 (2),621–629, doi:10.5194/gmd-7-621-2014.

Abstract Body: °C (CNFD) and the annual minimum temperature (AnnTasmin). Results shows a poleward migration of the suitability of wine-making in the next decades. By 2040-2050, strictly from a climatic perspective, most of the southern part of Québec (Cantons-de-l'est, Montérégie) can expect favorable conditions, as well as the southern shore of the St-Lawrence River. Over those regions, the probability that the climatic indices exceed a suitable threshold for wine-making is over 80%. With respect to the methodology used, we note that the quantile-quantile statistical adjustment is modifying the climate change (CC) signal of the annual minimum value. To what extent this modification of the CC signal is affecting the conclusions related to Anntasmin needs to be determined in future work. The proposed methodology is an example of probabilistic regional climate scenarios that can be produced by large climate simulations ensembles which can be used by the local, regional and national stakeholders.

Abstract ID: 33298

Final Number: AS22A-02

Title: Assessing hydrological impacts from climate change with hourly precipitation using temporal downscaling over South Korea

Presenter/First Author: Taesam S Lee, Gyeongsang National University, Jinju, Gyeongnam,

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Co-authors: Taewoong PARK, Gyeongsang National University, Jinju, South Korea

Abstract Body: The assessment of hydro-climatological variables through climate scenarios from the outputs of Global Climate Model (GCM) is essential for adapting and mitigating the changes. However, GCM outputs are too coarse to apply a basin scale. Temporal downscaling is required to obtain the hourly precipitation for analyzing a small or medium basin since only few or several hours are taken to peak flows after it rains. In the current study, the spatiotemporal distribution of downscaled hourly precipitation for RCP4.5 and RCP8.5 scenarios over South Korea is presented as well as its implications over hydrological responses. The results indicate that the mean of hourly precipitation significantly increases over the southern part of South Korea especially for the morning time and its increase gets lower at the later time of a day in the RCP8.5 scenario. However, the increase cannot be propagated to the mainland due to the mountainous areas in the southern part of the country. Furthermore, the

hydrological responses employing a distributed rainfall-runoff model (Vflo™) show that there is significant increase in peak flow for RCP8.5 scenario while slight decrease for RCP4.5. The current study concludes that the employed temporal downscaling method is suitable for obtaining the hourly precipitation data from daily GCM scenarios. In addition, the rainfall runoff simulation through the downscaled hourly precipitation is useful for investigating the variations of the hydrological responses related with future scenarios.

Abstract ID: 35435

Final Number: AS22A-04

Title: Quantifying Local to Regional-Scale Climate Impacts using Global Mean Temperature Scenarios

Presenter: Anne Marie K Stoner, Texas Tech University, Lubbock, TX

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First Author Student?: No

Co-authors: Sharmistha Swain, Climate Science Center, Texas Tech University, Lubbock, TX

Abstract Body: Assessing the potential impacts of climate change is essential to setting sound targets that minimize the costs and maximize the benefits of both adaptation and mitigation for society. Conventional wisdom, first codified in the UNFCCC's 1992 agreement to stabilize greenhouse gas concentrations at levels that would prevent dangerous anthropogenic interference with the climate system, suggests that impacts are expected to scale with the magnitude of human emissions. Since then, further research has elucidated how the relationship between carbon emissions, global temperature, and impacts may be complicated by non-linear responses of the physical system to global forcing.

We present projected changes in a collection of CMIP5-based climate metrics based on high-resolution downscaled projections for North America that are relevant to climate impacts on infrastructure, natural resources, energy use, and human health. We then explore the extent to which many of these metrics scale with global temperature and hence carbon emissions at the local to regional scale. This novel approach, which combines multiple RCP scenarios and CMIP5 simulations into a single framework based on increases in global mean temperature (GMT) from +1 to +4°C, provides an unprecedented opportunity to connect local and regional impacts directly to global emission targets. With this methodology, we are able to explore the extent to which projected future changes in impact-relevant metrics scale with carbon-equivalent greenhouse gas emissions and global mean temperature, information which can in turn be used to distinguish between the implications of international climate targets under discussion at the UNFCCC Conference of Parties for individual nations, states, and even cities.

Abstract ID: 33882

Final Number: AS22A-05

Title: Improving climate projections using "intelligent" ensembles

Presenter/First Author: Noel C Baker, NASA Langley Research Center, Tempe, AZ

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Co-authors: Patrick C Taylor, NASA Langley Research Center, Hampton, VA

Published Material: Some of the work mentioned in the abstract is under review in Atmospheric Chemistry and Physics. The majority of findings in this presentation are new work building on that previous work.

Abstract Body: Recent changes in the climate system have led to growing concern, especially in communities which are highly vulnerable to resource shortages and weather extremes. There is an urgent need for better climate information to develop solutions and strategies for adapting to a changing climate. Climate models provide excellent tools for studying the current state of climate and making future projections. However, these models are subject to biases created by structural uncertainties. Performance metrics—or the systematic determination of model biases—succinctly quantify aspects of climate model behavior. Efforts to standardize climate model experiments and collect simulation data—such as the Coupled Model Intercomparison Project (CMIP)—provide the means to directly compare and assess model performance. Performance metrics have been used to show that some models reproduce present-day climate better than others. Simulation data from multiple models are often used to add value to projections by creating a consensus projection from the model ensemble, in which each model is given an equal weight. It has been shown that the ensemble mean generally outperforms any single model. It is possible to use unequal weights to produce ensemble means, in which models are weighted based on performance (called "intelligent" ensembles). Can performance metrics be used to improve climate projections? Previous work introduced a framework for comparing the utility of model performance metrics, showing that the best metrics are related to the variance of top-of-atmosphere outgoing longwave radiation. These metrics improve present-day climate simulations of Earth's energy budget using the "intelligent" ensemble method. The current project identifies several approaches for testing whether performance metrics can be applied to future simulations to create "intelligent" ensemble-mean climate projections. It is shown that certain performance metrics test key climate processes in the models, and that these metrics can be used to evaluate model quality in both current and future climate states. This information will be used to produce new consensus projections and provide communities with improved climate projections for urgent decision-making.

Abstract ID: 35452

Final Number: AS22A-06

Title: Regional Estimates of the Transient Climate Response to Cumulative Carbon Emissions

Presenter/First Author: Martin Leduc, Concordia University, Montréal, QC

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Co-authors: Damon Matthews, Concordia University, Montreal, QC, Canada; Ramón de Elía, Ouranos, Montreal, QC, Canada

Published Material: Paper submitted to Journal of Climate (under review).

Abstract Body: The Transient Climate Response to cumulative Emissions (TCRE) is a new metric that quantifies the response of the climate system to anthropogenic CO2 emissions. Defined as the ratio between the global mean temperature change and the amount of CO2 emitted into the atmosphere, the TCRE accounts for interactions between human activity, the climate and the Earth's carbon cycle dynamics.

It is now well known that the TCRE metric is fairly stable in time, that is, approximately independent of the emission pathway. While this has been widely shown in terms of the global mean surface air temperature from observational data as well as in results from state-of-the-art Earth System Models, this study shows that the TCRE stability hypothesis also applies locally in a broad diversity of regions. The largest source of uncertainty affecting the TCRE residing in the sensitivity of the climate-carbon system, we hence attribute a range of confidence to the TCRE spatial pattern based on an ensemble of twelve Earth System Models from the CMIP5 archive. Brought together, the global and regional estimates of the TCRE form a simple but powerful set of tools for synthesizing complex climate models output to non-expert users and hence nourish current discussions for mitigating greenhouse gases emissions.

Abstract ID: 35722

Final Number: AS23A-01

Title: An improved algorithm for trace gas retrieval from satellite measurements

Presenter/First Author: Edward Abram Celarier, NASA Goddard Space Flight Center, Greenbelt, MD

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Published Material: Parts of this work have been submitted, as a paper, to the Journal of Geophysical Research. That paper is currently under review.

Abstract Body: The popular differential optical absorption spectroscopy (DOAS) method
is a "curve fitting" approach to retrieving trace gas slant column densities (SCD) from atmospheric measurements, using a multiparameter, nonlinear least-squares algorithm. A number of problems arise from the sensitivity of the retrieval to (a) "cross-talk" between retrieved species, (b) differences in wavelength registration of the radiance and irradiance measurements, and (c) changes in the performance (noise, throughput, etc.) of the instrument.

We show that a straightforward DOAS calculation may produce systematic biases of up to 30\% in the retrieved NO$_2$ SCDs. We have developed an algorithm in which the radiance/irradiance wavelength registration is carefully refined, and the previously-mentioned error sources are greatly reduced before the final, sequential retrieval of the trace-gas slant columns.

We apply the new approach to the Aura/Ozone Monitoring Instrument (OMI)
data and show that the revised OMI NO$_2$ SCDs are reduced by $15-35\%$,
bringing them much closer to SCDs retrieved from independent measurements and models. The approach described is a major revision to the standard algorithm, and affects both stratospheric and tropospheric NO$_2$
retrieved columns.

Abstract ID: 35579

Final Number: AS23A-02

Title: FTIR measurements of biomass burning species from the 2014 Canadian wildfires

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Co-authors: Stephanie Conway, University of Toronto, Toronto, ON, Canada; Joseph Mendonca, University of Toronto, Toronto, ON, Canada; Kimberly Strong, University of Toronto, Toronto, ON, Canada; James W Hannigan, National Center for Atmospheric Research, Boulder, CO; Eric Nussbaumer, NCAR/ACD, Boulder, CO

Abstract Body: We present time series of the total column amounts of carbon monoxide (CO), hydrogen cyanide (HCN) and ethane (C_2H_6) obtained by Fourier Transform Infrared (FTIR) spectrometer measurements at three sites. Two are located in the high Arctic at Eureka, Nunavut (80.02°N, 86.42°W) and Thule, Greenland (76.53°N , 68.74°W), and the third is at Toronto, Ontario (43.66°N, 79.40°W).

Total column amounts of each target species are obtained from the measured mid-infrared spectra using the SFIT4 retrieval algorithm based on the optimal estimation method, along with spectral line parameters from the HITRAN 2008 spectroscopic database as part of the Network for the Detection of Atmospheric Composition Change (NDACC). Total column amounts of CO are also obtained from near-infrared spectra measured at Eureka as part of the Total Carbon Column Observing Network (TCCON).

The total column time series allow for biomass burning events during July-August 2014 to be identified at both sites by enhancements of the total column amounts above ambient levels. HYSPLIT back-trajectories and MODIS fire hot spot data are used to determine the burning source regions in northern Canada and the travel time durations of the plumes. By accounting for the effect of the aging of the smoke plumes, the measured FTIR enhancement ratios are corrected to obtain emission ratios and emission factors, which are needed to improve the simulation of fire emissions in chemical transport models.

Abstract ID: 35105

Final Number: AS23A-03

Title: Long Distance Pollen Transport to the Canadian High Arctic as a Tracer for Atmospheric Circulation

Presenter/First Author: Elisabeth Levac, Bishop's University, Sherbrooke, QC

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Published Material: Some of the pollen data was presented at the 9th European Palaeobotany-Palynology Conference in Padova, Italy in August 2014. However, none of the results for back trajectories and air mass circulation were available at that time.

Abstract Body: Airborne pollen and spore concentrations were monitored daily at Eureka, on Ellesmere Island in the Canadian high Arctic during the summer seasons 2009-2012. A pollen sampler was installed at PEARL station (Polar Environment Atmospheric research Laboratory) as part of CANDAC (Canadian Network for detection of Atmospheric Change). A volumetric Burkard-type sampler was used to take samples following criteria established by IAAAA. The goal of this project is to quantify how much tree pollen is transported by air masses over long distances, since no trees are growing in the vicinity of this station. The sampler provides hourly pollen concentrations. Pollen counts are generally low, averaging 2-3 pollen grains per day, but a few high-pollen episodes are recorded during the summer season. Pollen grains from conifers are dominant, constituting more than 2/3 of the counts. *Pinus* and *Tsuga* are the most abundant genus, with minor numbers of *Picea*, *Abies*, and *Larix*. In the deciduous

trees, *Ulmus* and *Acer* are the most abundant, but *Juglans*, *Quercus* and *Fraxinus* are also recorded. Other pollen types could be from more regional sources (*Betula*, *Alnus*, *Populus* and *Salix*). Preliminary work has been done to attempt to identify the sources of the tree pollen. Potential sources for the tree pollen are North America and Russia. Back trajectories were performed for large-pollen episodes, to trace the path of air masses and the source of the pollen, but more work is needed to understand the role of weather patterns and determine the altitude of the air mass travel.

Abstract ID: 36187

Final Number: AS23A-04

Title: A Two Beam Cavity-Enhanced Absorption Spectrometer for Atmospheric Trace Gas Sensing

Presenter/First Author: Satheesh Chandran P M, National Institute of Technology Calicut, Calicut,

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Co-authors: Ravi M Varma, NIT Calicut, Calicut, India

Abstract Body: Detection of trace gas pollutants with high temporal and spatial resolution is a key problem in atmospheric science. The new instrumentation for detecting trace pollutants and their laboratory demonstration is a vibrant research area. Cavity-enhanced absorption spectroscopy (CEAS) techniques are widely used in atmospheric pollutant monitoring as a non- invasive way for the in-situ detection of trace species. A two-beam cavity-enhanced absorption spectrometer has been developed with the ability of monitoring sample and reference cavity signals simultaneously. We present the laboratory demonstration this instrument and its feasibility for fast and reliable measurement of trace pollutant NO_2 for a wide concentration ranges.

Abstract ID: 35647

Final Number: AS23A-05

Title: Precipitation Comparison of four datasets over complex topography region

Presenter: Dirceu Luis Herdies, Center for Weather Forecasting and Climate Research, Cachoeira Paulista,

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First Author Student?: No

Co-authors: Daniel A Vila, INPE National Institute for Space Research, Sao Jose dos Campos, Brazil

Published Material: 94th AMS Meeting (Atlanta 2014)

Abstract Body: An overwhelming number of applications depend on reliable precipitation estimations. However, over complex terrain in regions such as the Andes or the southwestern Amazon, the spatial coverage of rain gauges is scarce. Two reanalysis datasets, a satellite algorithm and a scheme that combines surface observations with satellite estimations were selected for studying rainfall Bolivia. The selected reanalyses were the Modern-Era Retrospective Analysis for Research and Applications, which has a horizontal resolution conducive for studying rainfall in relatively small precipitation systems, and the Climate Forecast System Reanalysis and Reforecast, which features an improved horizontal resolution. The third dataset was the seventh version of the Tropical Rainfall Measurement Mission 3B42 algorithm. The fourth dataset utilizes a new technique known as the Combined Scheme, which successfully removes satellite bias. All four of these datasets were interpolated to a coarser resolution. This research aimed to describe and compare precipitation in the two reanalysis datasets, the satellite-algorithm dataset, and the Combined Scheme with ground observations. Two seasons were selected for studying the precipitation estimates: the rainy season (December–February) and the dry season (June–August). The average, bias, standard deviation, correlation coefficient, and root mean square error were calculated. Moreover, a contingency table was generated to calculate the accuracy, bias frequency, POD, FAR, and ETS.

All four datasets correctly depicted the spatial rainfall pattern. However, CFSR and MERRA overestimated precipitation along the Andes' eastern-facing slopes and exhibited a dry bias over the eastern Amazon; TRMM3B42 and the Combined Scheme depicted a more realistic rainfall distribution over both the Amazon and the Andes. When separating the precipitation into classes, MERRA and CFSR overestimated light to moderate precipitation (1–20 mm/day) and underestimated very heavy precipitation (>50 mm/day). TRMM3B42 and CoSch depicted behaviors similar to the surface observations; however, CoSch underestimated the precipitation in very intense systems (>50 mm/day)

The statistical variables indicated that CoSch's correlation coefficient was highest for every season and basin.

Abstract ID: 34792

Final Number: AS23A-06

Title: Assimilation of Doppler weather radar data and their impacts on the simulation of squall events during pre-monsoon season

Presenter/First Author: Mohan Kumar Das, SAARC Meteorological Research Centre (SMRC), Dhaka,

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Published Material: under review in Natural Hazards Journal

Abstract Body: The quantitative data such as Doppler Weather Radar (DWR) radial winds and reflectivity are useful for improvement of the numerical prediction of weather events like squalls. Mesoscale convective systems (MCS) are responsible for majority of the squall and hail events and related natural hazards that occur over Bangladesh and surrounding region in pre-monsoon season. In this study, DWR observations (radial winds and reflectivity) of Bangladesh Meteorological Department (BMD) are used during May 2011 squall events in order to update the initial and boundary conditions through three-dimensional variational assimilation (3DVAR) technique within the Advanced Research Weather Research and Forecasting model (WRF ARW). The simulated sea level pressure, thermodynamic indices, 850 hPa wind fields, cloud hydrometeors from eight experiments are presented in this study in order to analyze the observed and simulated features of the squall events that occurred in the month of May 2011. The model results are also compared with the Kalpana-1 satellite imagery and the India Meteorological Department (IMD) observations. Further, the intensity of the events, generated from the simulations is also compared with the in-situ meteorological observations in order to evaluate the model performance.

Keywords Squall, MCS, 3DVAR assimilation, DWR radial winds, reflectivity.

Abstract ID: 34772

Final Number: AS23A-07

Title: Investigations on Water Vapor, Total Column Ozone and Aerosol Optical Thickness over Western Sites of India

Presenter/First Author: Som Kumar Sharma, Physical Research Laboratory, Ahmedabad,

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Abstract Body: Atmospheric water vapour, ozone, and aerosols play important role in various atmospheric processes and impact human life in several ways. Water vapor, Ozone and aerosols modulate Earth's radiation budget and play important role in weather and climate. In the Total Column Ozone (TCO) the contribution is mainly from the stratosphere while in case of water vapour (WV) and aerosols, major contribution is from the troposphere. For the present study the measurements of TCO, water vapour and aerosol optical thickness (AOT) were made using MICROTOP II instrument. It utilizes five wavelengths viz., 380, 440, 500, 675, 870 nm for measuring AOT. The TCO is measured using three channels at 305.5, 312.5 and 320.0 nm, and the column WV at two wavelengths of 940 and 1020 nm. Observations were taken at Ahmedabad and at Mt Abu during 2013-14. Ahmedabad is an urban polluted site while Mt. Abu is a cleaner high altitude free tropospheric site. Variability of TCO,WV and AOT have been studied using diurnal, daily and monthly observations over Ahmedabad and over Mt. Abu. Correlations between TCO-WV, TCO-AOT, WV–AOT for daily observations are analyzed. Observation during 0900 to 1700 hrs on 6 and 8 March 2013 which were clear sunny days showed significant variability. On 6 March, the TCO varied from 256-268 DU, water vapour 0.73-0.86 cm, and AOT 0.13-0.21 with a peak at ~1500 hrs. On 8 March TCO varied from 252-261 DU, WV 0.75-0.95 cm, and AOT 0.22-0.31 with an abrupt decline at ~1330 hrs. On 11 March, sky was visibly hazy and it is found that AOT and WVwere much higher than the measurements on clear sky days . A set of observations during 6-7 April 2013 at Abu Road (MSL~0.2 km), Mt. Abu (MSL ~1.1 km) and at Gurushikhar (MSL ~1.7 km) provided the relative contributions of planetary boundary layer in the total column measurements of Ozone, WV and AOT. These results and other observed features during pre-monsoon and monsoon seasons over the western sites of India will be presented.

Abstract ID: 33167

Final Number: AS24A-0027

Title: ANALYSIS OF RAIN DROP SIZE DISTRIBUTION AND THEIR EFFECT ON RADIOWAVE PROPAGATION IN AKURE SOUTH – WEST, NIGERIA.

Presenter/First Author: Adewumi Oluwatoyin Ayo, Organization Not Listed, Akure,

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Published Material: No

Abstract Body: Understanding the detailed structure and behavior of rainfall parameters estimated from radar is very important for improving the efficiency of space borne satellite sensors as well as ground based stations. Attenuation due to rain has been recognized as one of the major causes of unavailability of radio communication systems operating at frequencies above 10 GHz for space-Earth links. In order to design radio links for telecommunication and evaluate the attenuation due to rainfall, it is important to have a good model for the rain Drop-Size Distributions (DSD). Two years of rainfall data obtained using the vertically looking low power micro rain radar at the Department of Physics, the Federal University of Technology, Akure, (7˚15'N, 5°15'E) has been analyzed to develop empirical model of raindrop size distribution (DSD) and their effects on radio wave propagation in Akure South-West, Nigeria. The rain rate was observed within the height range of 0 – 160 m up to 4800 m. For all the heights considered, rain drop size of diameter 0.246 mm had the largest concentrations in the height range 0 – 4800 m. Empirical relations in the form of vertical profile of Z –R relation were also obtained for different rainfall types in order to understand the variability of the relationship at this location.

KEYWORDS: RAINRATE, RAIN DROP SIZE, RAIN ATTENUATION, RADAR REFLECTIVITY.

Abstract ID: 33616

Final Number: AS24A-0028

Title: The climate impact of short wave upwelling radiative flux on the global energy budget using GENSPECT synthetic model along with Argus 1000 spectrometer.

Presenter/First Author: Rehan Siddiqui, York University, Mississauga, ON

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Co-authors: Brendan M Quine, , , ; Rajinder K Jagpal, York University, Toronto, ON, Canada; Naif Al Salem, , , ; Sanjar Abrarov, , ,

Abstract Body: The integrated absorption technique is applied to develop a synthetic model to determine the magnitude of Shortwave upwelling Radiative Flux (SWupRF) by O_2, H_2O, CO_2 and CH_4. This new synthetic model is used to estimate the magnitude and expected magnitude variation over spectral range of 900nm to 1700nm by varying surface temperature to assess effect on outgoing (upwelling) forcing term. In this work we employ satellite real observation of space orbiting Argus 1000 especially for O_2, H_2O, CO_2 and CH_4 together with synthetic model by using line by line GENSPECT radiative transfer model. All the radiative transfer simulations have been performed by varying over a different range of percentages of water vapor contents and carbon dioxide with the fixed concentration oxygen and methane. This large scale results of synthetic and observed spectrums have been used to develop an algorithm for SWupRF of given greenhouse gases. We calculate and compare both the synthetic and real measured observed data set. The minimum and maximum range of SWupRF are 0.235 [0.13 to 0.34] W/m^2 and 0.835 [0.05 to 1.62] W/m^2 of the few selected set of week per pass of the ARGUS observed data. The simulated range of synthetic model also represents 1 to 32 K rise of temperature within the different concentration of water vapor and other gases. The authors concluded that the satellite observed data of week 2 pass 94 with packet number 98 & week 71 pass 27 with packet 17 showing maximum 1.62 W/m^2 and minimum 0.05 W/m^2 SWupRF respectively.

Abstract ID: 34780

Final Number: AS24A-0029

Title: Signature of Greenhouse Cooling in the Earth's Middle Atmosphere Observed by Lidar and Satellite over Sub-tropical Locations

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Co-authors: Harish Chandra, , , ; Shyam Lal, Physical Research Laboratory, Ahmedabad, India; Y B Acharya, , ,

Abstract Body: Lidar is a versatile atmospheric probe for providing height profile of temperature in the middle atmospheric region. A Nd:YAG laser based Rayleigh Lidar was set up, at a high altitude observatory near Mt. Abu (24.5° N, 72.7° E, altitude 1.7 km), in the Indian sub-tropical region. Temperature climatology in the middle atmosphere has been studied using about 17 years (1997 to 2014, with some data gaps) lidar observations. Consistently good data series has been used for deriving long term trends in the middle atmosphere. A multivariable analysis is used to consider natural variability (Solar Cycle and QBO) and similarly the changes in stratospheric ozone concentration due to anthropogenic activity have also been taken into account in trends estimations. We have selected different height regions 30-40, 40-50 and 50-60 km for trends analysis. Linear Regression analysis is applied to calculate temperature trend in different altitude regions. Considering the signature of seasonal, QBO and solar cycle variability, a linear decreasing temperature (cooling) has been found. Observed temperature trend is the strongest (-0.38 ± 0.15 K/year) at stratopause level (45 km) and the weakest (-0.13 ± 0.28 K/year) at 55 km during April. Seasonally, stronger temperature trends are found during winter -4.4 ± 2.8, -5.1 ± 2.1 and -2.3 ± 1.9 K/decade at 35, 45 and 55 km, respectively. The temperature trends during summer months are -2.2 ± 1.8, -2.8 ± 1.4 and -2.5 ± 1.6 K/decade at 35, 45 and 55 km, respectively. Lidar observed temperature trends over Mt. Abu are also compared with HALOE (onboard UARS) and SABER (onboard TIMED) temperature observations.

Abstract ID: 34691

Final Number: AS24A-0030

Title: Mass-dependent (MDF) and mass-independent (MIF) sulfur isotope compositions of aerosols in the atmosphere of Montréal (Canada)

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Abstract Body: We report improvements for the simultaneous determination of multiple sulfur isotope compositions for both $\delta^{33}S$, $\delta^{34}S$ and $\delta^{36}S$ on the SF_6 molecule (m/z: 127, 128, 129, 131) for quantities down to 0.4 micromoles, and $\delta^{33}S$, $\delta^{34}S$ for quantities down to 20 nanomoles. Multiple analyses of two international Ag_2S standards, IAEA-S1 and IAEA-S3, yield a narrow range of $\delta^{34}S$ values vs CDT, with a standard deviation of ± 0.2‰. This ultimately allows the determination of the $\Delta^{33}S$ with an accuracy of ± 0.03‰ (1σ), $\Delta^{36}S$ from IAEA-S3 measurements still show larger variations with a standard deviation of ± 1‰ (1σ).

The sulfur multi-isotope analysis of atmospheric emissions from the major sources in the urban environment (road traffic, waste incinerators, heating, thermal plants and cement factories) shows that they can unambiguously be discriminated when coupling their S MDF-MIF isotope compositions. We are currently analyzing PM_{10} (aerodynamical diameter <10µm) samples collected by the *Ville de Montreal* within the Montreal island since 1969 at 6 stations typical of distinct environments including road traffic, harbor, downtown, and natural background.

This temporal recording will allow us 1) to characterize the sources and processes controlling the atmospheric sulfur budget and 2) to evaluate potential variations with time resulting from the implementation of the Canadian and Quebecoise air regulations regarding sulfur.

Abstract ID: 34696

Final Number: AS24A-0031

Title: Characterising VOC emissions from Australian forest fires on the ground: results from field and laboratory measurements

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Published Material: Part of this work has been presented at Australian scientific meetings.

Abstract Body: Australia's climate is hot, dry and fire-prone. Average gross annual emissions of total carbon from fires actually exceed those from burning fossil fuels, although net emissions are lower due to rapid regrowth [*Haverd et al.*, 2013]. An estimated 12 Mha of southern Australian forests were burnt in bushfires between 2001 and 2010, undoubtedly impacting atmospheric composition and regional air quality, yet measurements of emissions from Australian forest fires are scarce and include very few volatile organic compounds.

Emissions from dry sclerophyll forest fuels were measured at prescribed burns in Australian temperate forest during the 2012 and 2013 controlled burn seasons and at a combustion wind tunnel facility in 2014. VOCs were characterised in grab samples collected at the fires using a Selected Ion Flow Tube Mass Spectrometer and a White cell Fourier Transform Infrared (FTIR) system. The FTIR system also yielded mixing ratios for CO_2 and CO, enabling the determination of emission ratios for the VOCs measured in the grab samples. An open-path FTIR system was also deployed at some of the prescribed fires [*Paton-Walsh et al.*, 2014] and at the combustion wind tunnel facility. This open-path system provided continuous measurements of CO_2, CO, methane and some VOCs from which whole-fire emission factors were derived. Emission factors for the VOCs measured in the grab samples were then calculated from their emission ratio to CO (or CO_2) and the open-path emission factors. The emission ratios from the grab samples are compared to those obtained by open-path FTIR when possible (i.e. when a species was measured by both methods) and to values listed in the literature for similar ecosystems. The relationship between combustion efficiency and emissions is discussed.

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Paton-Walsh, C., T. E. L. Smith, E. L. Young, D. W. T. Griffith, and É. A. Guérette (2014), New emission factors for Australian vegetation fires measured using open-path Fourier transform infrared spectroscopy – Part 1: Methods and Australian temperate forest fires, *Atmos. Chem. Phys.*, *14*(20), 11313-11333.

Abstract ID: 34713

Final Number: AS24A-0032

Title: Mineralogical study of Particulate Matter in the Urban environment of Pune

Presenter/First Author: Suman Yadav, Department of Chemistry, Savitribai Phule Pune University, Pune , India, Pune,

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Published Material: Some part had been published in IJEST

Abstract Body: The study of toxic metals and mineral components in atmospheric particulate matter is important in discerning and improving air quality in terms of both climate and health aspects. Present study reports quantification of PM bound metals, morphology of PM and their associated minerals. PM_{10} samples were collected by Mini-Vol TAS sampler at an urban site of Pune. In the present study Ca was highest (3.1 µg m^{-3}) followed by Fe > K > Al > Mg > Ni > Zn > Cr > Co > Cu > Cd > Mn > Pb > Ba. The morphology and mineralogical composition of the PM samples was studied by scanning electron microscopy–energy dispersive spectrometer and X-ray diffraction (XRD). Quantitative image analyzer (Image J) was used to study 620 individual particles and found that value of roundness (R) varies from 0.26 to 1.0 (mean 0.72) which suggests that particles vary in shape from nearly irregular to perfectly spherical shape. Various shaped particles such as spherical, cube, needle shaped, rectangular, irregular and agglomerates types were observed. Based on the morphology of the particles, the analyzed particles are classified into various groups such as crust originated particles, fuel and biomass burning associated particles, biological particles and unidentified particles. The XRD results showed that minerals in the PM were dominated by silicates (quartz, wollastonite, vermiculite, kaolinite and calcium aluminum silicates) followed by oxides (calcium iron oxide, magnetite and wuestite), sulfates (gypsum, koktaite), phosphates (magnesium and silicon phosphates) carbonate (dolomite), iron–zinc and halite.

Abstract ID: 34753

Final Number: AS24A-0033

Title: A Two Beam Cavity-Enhanced Absorption Spectrometer for Atmospheric Trace Gas Sensing.

Presenter/First Author: Satheesh Chandran P M, National Institute of Technology Calicut, Calicut,

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Abstract Body: Detection of trace gas pollutants with high temporal and spatial resolution is a key problem in atmospheric science. The new instrumentation for detecting trace pollutants and their laboratory demonstration is a vibrant research area. Cavity-enhanced absorption spectroscopy (CEAS) techniques are widely used in atmospheric pollutant monitoring as a non- invasive way for the in-situ detection of trace species. A two-beam cavity-enhanced absorption spectrometer has been developed with the ability of monitoring sample and reference cavity signals simultaneously. We present the laboratory demonstration this instrument and its feasibility for fast and reliable measurement of trace pollutant NO_2 for a wide concentration ranges.

Abstract ID: 33638

Final Number: AS24A-0034

Title: Deforestation in Cameroon and its Consequences to the Natural Environment

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Abstract Body: The 17 million hectares of humid forest covering the southern part of Cameroon have received much attention in recent years, including its estimated annual loss of forest cover of 129,000 hectares or 0.6% of total forest between 1990 and 1995. Shifting cultivation and population growth are the main causes of deforestation in Cameroon. Through shifting cultivation farmlands are repeatedly burnt down leading to exposure of forests and soil erosion. Bush burning also produces carbon dioxide which impacts climate by destroying the ozone layer. Other factors contributing to deforestation are the cutting down of tress for timber, road construction, and cultivation of cash crops like coffee and cocoa.

The rapid deforestation process in Cameroon has consequences, such as global warming, loss of biological and genetic diversity, land degradation, soil erosion, watershed destruction, flooding and siltation, loss of income from timber and non timber forest products, loss of wildlife especially Some important species of animals like the chimpanzees and gorillas. Cameroon is blessed with a variety, of climate and ecosystems, harboring some 8260 plant species of which 156 are endemic, about 2000 animal species, and is 5th in Africa in terms of biodiversity. The soil can be exploited only one to three years before the nutrients are exhausted and farmers are forced to move to sites thereby destroying more forest.

Plantation agriculture, which covers extensive areas in southern Cameroon, plays a vital role in its economy. To reduce the rate of deforestation in Cameroon, the government needs to encourage mechanized agriculture that will occupy a particular piece of land for continuous cultivation. By so doing, shifting cultivation which is the main cause of deforestation will eventually reduce.

Abstract ID: 34215

Final Number: AS24A-0035

Title: Role of metal induced free radical generation by ambient particulate matter in Pune, India

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Co-authors: Suman Yadav, Department of Chemistry, Savitribai Phule Pune University, Pune , India, Pune, India; Ritwika Roy, , , ; Rohi Jan, , ,

Published Material: Abstract Free radical generation in particulate matter has been cited as potential contributors to particle toxicity leading to large number of health effects. In this present study the association between the metals, free radical and DNA damage was assessed in Pune. ICP-AES was used to examine the metal composition, EPR technique for free radical detection and plasmid DNA assay was utilized to study the oxidative potential of ambient PM. The results of ICP-AES analysis showed that Fe was the metal present in the highest concentrations followed by Zn and Pb. EPR analysis shows 'g' value for free radicals ranging from 2.002 – 2.003 in PM samples of Pune. PM contains both purely C-centered (g = 2.0023) and C- centered radical with vicinal oxygen atom (g = 2.003). The indirect assays (DTT and DPPH) were performed for ensuring the existence of specific free radicals (such as superoxide and hydroxyl radical) which supported the presence of higher redox activity in PM. The assays performed for assessing oxidative stress showed significant correlation with transition metals such as Fe (r= 0.67) and Cu (r= 0.63), suggesting that these metals play an important role in generation of free radicals and its related toxicity. Toxicity of collected samples was evaluated by gel electrophoresis technique and results showed 70% of DNA damage in collected PM. Key words: Toxic metals, free radicals, DNA plasmid assay, DPPH

Abstract Body: Abstract

Free radical generation in particulate matter has been cited as potential contributors to particle toxicity leading to large number of health effects. In this present study the association between the metals, free radical and DNA damage was assessed in Pune. ICP-AES was used to examine the metal composition, EPR technique for free radical detection and plasmid DNA assay was utilized to study the oxidative potential of ambient PM. The results of ICP-AES analysis showed that Fe was the metal present in the highest concentrations followed by Zn and Pb. EPR analysis shows 'g' value for free radicals ranging from 2.002 – 2.003 in PM samples of Pune. PM contains both purely C-centered (g = 2.0023) and C- centered radical with vicinal oxygen atom (g = 2.003). The indirect assays (DTT and DPPH) were performed for ensuring the existence of specific free radicals (such as superoxide and hydroxyl radical) which supported the presence of higher redox activity in PM. The assays performed for assessing oxidative stress showed significant correlation with transition metals such as Fe (r= 0.67) and Cu (r= 0.63), suggesting that these metals play an important role in generation of free radicals and its related toxicity. Toxicity of collected samples was evaluated by gel electrophoresis technique and results showed 70% of DNA damage in collected PM.

Key words: Toxic metals, free radicals, DNA plasmid assay, DPPH

Abstract ID: 35270

Final Number: AS24A-0037

Title: Facilitating JPSS-1 algorithm development using EPL review process

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Abstract Body: The NOAA/NESDIS Center for Satellite Research and Applications (STAR) Algorithm Integration Team (AIT) provides technical support of the Joint Polar Satellite System (JPSS) algorithm development and integration tasks. STAR AIT is well-integrated in the algorithm change process, coordinating between science algorithm developers and operational engineers to smooth the transition of a code from research to operation. AIT facilitates the development of JPSS-1 algorithms by implementing a review approach based on the Enterprise Product Lifecycle (EPL) process. Building on relationships established during the Suomi-NPP algorithm development process and coordinating directly with science algorithm developers, the AIT has implemented structured reviews with self-contained document suites. We have completed multiple reviews for Sensor Data Record (SDR) and Environmental Data Record (EDR) algorithms, ensuring that all stakeholders are kept apprised of development decisions and that our delivered algorithm packages are functional and complete. STAR AIT also maintains configuration management on the algorithm and documents and has developed tools to more efficiently manage parallel content between the existing requirements and review documents. The process has supported algorithm improvements for products such as ozone, active fire, vegetation index, and temperature and moisture profiles. The review process, its implementation, and the content management shall be discussed.

Abstract ID: 34007

Final Number: AS24A-0038

Title: Development of the Novel Green Hybrid Bio-Reactor-Oxyfuel-Nano/Micro Interface

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Co-authors: Christian Wilde, , , ; Parisa A Ariya, McGill University, Montreal, QC, Canada

Abstract Body: Carbon dioxide is one of the main greenhouse gases, known to contribute to global warming. A major source of anthropogenic CO_2 is from the combustion of fossil fuels, hence the application of mitigation techniques on combustion processes to capture CO_2 are of great importance to reduce emissions being released to the atmosphere. We proposed development on a novel green algal bioreactor-oxyfuel system coupled with natural nano- and micro-particle interfaces containing magnetite, hematite and alumina. Two systems were considered: a semi-continuous oxygen production system, and a batch oxygen enrichment system. We will present our results and discuss the cost-effectiveness of the newly developed system with a potential to couple it to existing industrial setups.

Abstract ID: 36738

Final Number: AS24A-0039

Title: Optical and physical characteristics of biomass-burning aerosols over Alberta

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Co-authors: Zaher Hashisho, University of Alberta, Edmonton, AB, Canada; Long Fu, AEMERA, Edmonton, AB, Canada; John C Gille, NCAR, Boulder, CO

Abstract Body: Aerosol emissions from biomass burning have a large effect on the atmospheric composition and climate change. In summer (June-August) 2012, Alberta faced the highest number of fire events in the last decade as indicated by MODIS fire count (~9,000 fire counts) and total CO column derived from the Atmospheric InfraRed Sounder (AIRS) instrument (> 3×10^{18} molecules cm^{-2}). The present study examines the impact of these fire events on aerosol properties, as well as the long-range transport of smoke plumes, and altitude characteristics using satellite data and AErosol RObotic NETwork (AERONET) measurements. During July 2012, Moderate Resolution Imaging Spectroradiometer (MODIS) images show a thick smoke/hazy aerosol layer covering northern Alberta. The increased number of fire counts is associated with severe aerosol-laden atmosphere as indicated by the high values of aerosol optical depth (AOD) (> 1.0), high values of Angstrom exponent (>1.2), and enhanced Ozone Monitoring Instrument (OMI) UV Aerosol Index (AI) (> 4.0) which are significantly higher than monthly means. Good agreement with linear correlation of ~95% was found for MODIS and AERONET AOD at Fort McMurray station. The AERONET aerosol size distribution is shifted toward the fine-mode fraction which is corroborated by the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) depolarization ratio, indicating dominance of smoke aerosols. The air mass trajectories originating from northern Alberta regions with biomass-burning sources together with CALIPSO backscatter profiles at 532 nm reveal a potential aerosol transport pathway from west to east of Alberta, resulting in a strong AOD gradient with a maximum plume top height of 5 km. These results show that the synergistic use of several remote sensing instruments, results in a more comprehensive view of potential atmospheric impacts of long-range transport of smoke emissions.

Abstract ID: 34461

Final Number: AS24A-0040

Title: Extreme Cases of Tropospheric Convergence of Moisture Transport and their Relationships to Precipitation for the US Midwest

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Abstract Body: The Midwest US is prone to receiving heavy precipitation events, including Mesoscale Convective Systems (MCSs), during the warm season. These MCSs may produce rainfalls, in a 1-2 day period, with amounts well above the monthly climatology. The ability to recognize the patterns and mechanisms that accompany these convective systems is crucial for forecasting their timing and location. Convergence of moisture transport (CMT) is a useful tool in short-term prediction of convection since it contains information on the low-level forcing and the amount of moisture available. However, if there is no support in the upper levels then the likelihood of thunderstorm development is significantly diminished. Using the NARR (North American Regional Reanalysis) data set, the column integrated CMT was computed every 3 hours during a 36-year period (1979-2014) through the months of May to August. A 24-hour running mean was applied to the 3-hourly column-integrated CMT, and the 99th percentile of events were selected. An additional criterion ensuring synoptic independence (five days before/after the largest event) was applied, yielding 65 cases. The low-level moisture transport (1000-700hPa) was analyzed for each case, facilitating the classification of cases. Classifications include 1) southwesterly, 2) high amplitude, 3) low amplitude, 4) cold surge, and 5) southeasterly flow. The overall atmospheric circulation structures differ substantially among the categories. Perhaps surprisingly, there were several cases that actually showed very little precipitation. Further analyses of these light precipitation cases are being studied.

Abstract ID: 36256

Final Number: AS24A-0041

Title: Does the helium isotope composition of air vary with latitude ? A new high precision study.

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Abstract Body: Crustal, mantle and atmospheric sources have characteristic helium isotope signatures. Compared to the atmosphere, crust derived volatiles are enriched in radiogenic helium-4, while gases of mantle origin are enriched in primordial helium-3. The atmospheric helium isotope ratio, $(1.39 \pm 0.01) \times 10^{-6}$, is conventionally considered to be constant on a global scale [2]. This convention is questionable, however, since Sano et al. (1988) [3] reported a lower ratio of $(1.343 \pm 0.013) \times 10^{-6}$ from Tokyo, Japan. In 2010, a further study showed an increase of $(0.16 \pm 0.08) \times 10^{-5}$ R_{HESJ}/degree of latitude, where R_{HESJ} is the $^3He/^4He$ ratio of the Helium Standard of Japan [5]. This could be linked to release of crustal helium into the atmosphere from mining and burning of fossil fuels on short timescales, which is more prevalent in the northern atmosphere [3, 4; see also 1]. Thus, fluxes and retention of anthropogenic CO_2 in the atmosphere could be traced by helium isotope variations in air [3]. Nevertheless, others parameters could explain the reported variations in atmospheric $^3He/^4He$ such as local natural or anthropogenic phenomena at the sampling sites, weather patterns or experimental/analytical problems. Since the variation seems to be less than one ppm, substantial refined statistical analysis is essential in order to discern the accuracy of analyses. Ten samples from different latitudes around the world were repeated analysed by the multi-aliquot measurement method (based on [6]). No evidence of a systematic variation in the atmospheric $^3He/^4He$ ratio at the three permil level is found in air samples from Tokyo (35.69°N), Yellowstone (45.28°N), Svalbard (78°N), Hawaii (21.31°N), Sicily (37.48°N), Djibouti (11.57°N), South Africa (25.79°S) and Tasmania (40.68°S).

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Abstract ID: 34191

Final Number: AS24A-0042

Title: The Relevance of Aerosols to Ice Formation in Clouds

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Abstract Body: Clouds contribute to the total radiative forcing that drives climate change. However, one of the major causes of uncertainty of the total radiative forcing is related to aerosols and their interactions with clouds. It is known that ice clouds can form spontaneously from pure water, but the temperatures at which this happens are extremely low, around -38°C. The presence of aerosols facilitates ice cloud formation by providing a nucleus, on which ice can start growing at temperatures closer to the melting point of water in a process called heterogeneous ice nucleation. The process of heterogeneous ice nucleation exhibits dependency on the size of participating aerosols. Furthermore, it has been demonstrated that many aerosols that are smaller than 800 nm in diameter, start nucleating ice at very low temperatures, close to the temperatures of ice nucleation of pure water. Thus, they are not considered in cloud modelling. Additionally, aerosols efficient at higher temperature ice nucleation with low number densities are disregarded. In summary, many models of cloud formation do not take into account the possible contributions of a fraction of aerosols. We herein show the existence of aerosols from < 100 nm to ~ 1 µm in diameter within snow that could be responsible for the nucleation of ice clouds where the snow formed. We will present our data on number density, size distribution and ice nucleation of the detected particles and will discuss their impact on atmospheric processes.

Abstract ID: 35983

Final Number: AS24A-0043

Title: Assessing U.S. Embassy in Beijing's measurements of $PM_{2.5}$

Presenter/First Author: Anondo D Mukherjee, University of Colorado at Boulder, Boulder, CO

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Abstract Body: The United States Embassy in Beijing, China, has been measuring mass concentrations of particulate matter of particle diameters 2.5 micrometers and smaller ($PM_{2.5}$) since 2008. Results were initially reported in near-real time on Twitter and, more recently, archived results have been made available at the U.S. Embassy website. Here, we combine the U.S. Embassy $PM_{2.5}$ measurements with other concurrent observations recorded nearby from several sources, including visibility index available from the U.S. National Climatic Data Center and a recent paper by J. K. Zhang et al, (Atmospheric Chemistry and Physics, vol. 14, 2887-2903, 2014) to examine the validity of the U.S. Embassy measurements. We find a good relationship between $PM_{2.5}$ and visibility, with a strong dependence of the latter on relative humidity as expected. The slope of a plot of $PM_{2.5}$ to the inverse of visibility length is consistent with values expected from Koschmieder's equation. Embassy $PM_{2.5}$ values measured from January 1st to February 1st 2013 agree well with values reported form a nearby site using the techniques of TEOM $PM_{2.5}$ and aerosol mass spectrometry PM_1, with important deviations between $PM_{2.5}$ and PM_1 during periods of likely enhanced transport of larger particles (e.g., dust) from nearby and distant sources. We conclude that the U.S. Embassy observations could represent a useful historical dataset for studies of improvements in air quality in Beijing as China implements measures to reduce emissions of particles and their precursors. Preliminary comparisons of similar data sets from other cities in China with similar U.S.-installed instruments also appear to be valuable in this regard.

Abstract ID: 36809

Final Number: AS24B-0045

Title: Characterizing the role of natural and forced air temperature variability in the Labrador region of northeastern Canada

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Published Material: Some materials were published in:Way, R.G. and Viau, A.E. (In press). Natural and forced air temperature variability in the Labrador region of Canada during the past century. Theoretical and Applied Climatology.

Abstract Body: Air temperatures in the Labrador region of northeastern Canada are particularly sensitive to ocean-atmospheric telleconnections due to the region's proximity to the Labrador Current and its position near the Canadian Polar Trough. Instrumental and paleoclimate reconstructions show pronounced multidecadal variability in regional air temperatures over the past several centuries highlighting the importance of unforced and forced variations in the region's climate. Throughout much of the past century, air temperatures in Labrador remained fairly stable albeit with multidecadal variations. However, over the past 20 years regional warming has accelerated rapidly according to both instrumental and satellite datasets. Recent winter positive anomalies, in particular, have had negative impacts on the region's aboriginal populations who rely on ice and snow for accessing traditional grounds. Coupled with the strains of living in an isolated northern environment, recent warming has challenged the adaptive capacity of communities to cope with recent environmental change.

Expanding upon recent work by Way and Viau (*in press* - Theoretical and Applied Climatology) this paper provides a detailed examination of the main drivers of regional climate variability over both long and short timescales. We show that rapid regional warming over the past two decades is linked to both natural and anthropogenic factors with several anomalously warm years related to recent anomalies in the Arctic Oscillation (AO) and North Atlantic sea surface temperatures (AMO). This contribution also provides a comparison with another recent climate analysis of Labrador by Finnis and Bell (*in press* - Canadian Geographer) showing that certain data selection choices in the latter study exaggerated the role of natural variability in recent warming. In comparing with future climate scenarios, our results suggest that the anomalously warm conditions observed in 2006 and 2010 are similar in magnitude to climate conditions projected for the mid-21st century under high emissions scenarios (i.e. RCP 8.5). The largest sources of uncertainty in projecting regional climatic changes appear to result from differences between the various emission scenarios and the variability in North Atlantic sea surface temperatures.

Abstract ID: 36391

Final Number: AS24B-0046

Title: Projection of late 21st century (2071–2100) fine-scale climate changes over the Korean Peninsula using RegCM4 based on four RCP scenarios

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Abstract Body: In this study, we projected late 21st century (2071–2100) fine-scale climate changes over the Korean Peninsula using RegCM4 based on the four Representative Concentration Pathway (RCP) scenarios (2.6, 4.5, 6.0, and 8.5). HadGEM2-AO data provided by the National Institute of Meteorological Research was used as the lateral boundary conditions for RegCM4 with a horizontal resolution of 12.5 km. The simulation skills of RegCM4 for the spatio-temporal variations of current climate (1981-2010) over Northeast Asia are evaluated using CRU data. The annual mean temperature over South Korea in the late 21st century is expected to increase by about +1.62°C, +2.71°C, +2.76°C, and +4.53°C, respectively, compared with the present climate under the RCP scenarios. Annual precipitation is projected to increase by about +0.24 mm/day and +0.40 mm/day under the RCP2.6 and RCP8.5 scenarios, respectively. Interannual variability (IAV) of temperature is projected to increase and decrease significantly under RCP6.0 and RCP8.5 and RCP2.6 and RCP4.5, respectively. The significant increase in IAV of temperature under RCP6.0 and RCP8.5 indicates the possibility that abnormal temperatures may be increased in the late 21st century. Additionally, the IAV of summer precipitation is also projected to clearly increaseunder RCP6.0. The portion of heavy rainfalls (> 50 mm/day) is also expected to increase irrespective of scenarios, which indicates the possibility that extreme droughts and heavy rainfalls may be increased.This is considered to be related to the fact that destabilized atmospheric environmentsby the combined effects of increased temperature and mixing ratio at the lower troposphere and the increased cold advection at the upper troposphere.

Abstract ID: 36403

Final Number: AS24B-0048

Title: Simulation skills of RegCM4 forced by HadGEM-AO for the diurnal variations of temperature and precipitation over South Korea

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Abstract Body: In this study, we assessed the simulation skills of RegCM4 for the diurnal variations of temperature and precipitation over South Korea using the 30-year (1981-2010) fine-scale simulation results over North-East Asian region. The simulations performed by RegCM4 with 12.5 km of horizontal resolution driven by the Hadley Center Global Environmental Model version 2 coupled with the Atmosphere–Ocean (HadGEM2-AO). The model configuration is same as the study of Hong *et al.*(2013) and simulation skills of RegCM4 were evaluated with the hourly observations of Korea Meteorological Administration (KMA). In general, the simulations skills of RegCM4 for the diurnal variations of temperature and precipitation vary depending the geographic locations and seasons. RegCM4 well simulated the diurnal variation of temperature as compared with KMA observation, with better skills during morning and significantly less skills during afternoon, regardless of months. The less skills of RegCM4 during afternoon are mainly caused by the significant under-simulation of temperature over inland areas without regard to seasons. As the results, the magnitude of diurnal range of temperature strongly underestimated in inland areas. However, the simulations skills for diurnal variations of precipitation are not so promising, in particular, during summer, with relatively better skills during afternoon and significantly less skills during early morning. The significant underestimation of precipitation during early morning at the western area of the Korean peninsula resulted in the low spatial correlations and underestimation of variance compared to the observations.

Abstract ID: 36448

Final Number: AS24B-0049

Title: Climate Change and Climate Variability Effects on Agricultural Food Production in Kieni East District, Nyeri County, Kenya.

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Abstract Body: Kenya like the rest of the world is experiencing climate change and climate variability and the associated adverse effects with significance on food security. Rainfall trends and temperature variance are evidence of climate change and variability through heat stress, droughts, rainfall variations, distribution changes and flooding leading to crop failure and reductions in yields. The purpose of the study is to assess the effects of climate change and variability on agriculture, estimate rainfall amounts, distribution, trends, temperature variance, vegetation health and vigor of the study area, crop yields per crop type over a continuous period of time. The target population is eco-climatic variables Rainfall amounts, distribution and trends, Temperature variance, vegetation cover, vegetation health and vigor, and crop yield. The sampling technique will be purposive sampling for vegetation index, rainfall amounts, temperatures and crop yields. Research instruments for data collection are Satellite Data Analysis using GIS/Remote Sensing Techniques, interviews with agricultural officers and local farmers, Questionnaires and Field Surveys. Datasets to be used will include SPOTVGT 1Km, climate data from satellite measurements of FEWSNETRFE 1Km and KMD, temperature using MODIS and Crop Yields from KNCPB and the collection procedure for satellite imagery acquisition, preprocessing, interpretation, analysis scheduled interviews, Questionnaires and field observation and validation and acquire information impossible to obtain from satellite data. Data processing will use GIS/RS Software ArcGIS, Erdas, Envi, Ilwis and Microsoft Access. Supervised Classification of Landsat image to identify agricultural landextent and crop type. Vegetation Index will be derived from SPOTVGT NDVI and a temporal analysis to illustrate trends of vegetation vigor using Erdas/ ILWIS/ ENVI. Cumulative Rainfall amounts trendsanalysis distribution and Yields data will be generated. The time frame for the study will be 25yrs. This study looks forward to improving community livelihoods through sustainable utilization of available resources and reduce food shortage and insecurity.

Abstract ID: 33156

Final Number: AS24B-0050

Title: Assessment of South-West and North-East Monsoon over Indian continent using CMIP5 models

Presenter/First Author: Dipti Swapnil Hingmire, Indian Institute of Tropical Meteorology, Pune,

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Abstract Body: India is benefited by two distinct Monsoons. One is the South-West Monsoon (SWM), spanning from June to September, covering almost entire country and bringing about 75% of annual rainfall to India. Another is North-East Monsoon (NEM), commencing from October to December, confined to southern peninsular region and bringing about 11% of annual rainfall to India.

This study compares the present-day skill of 36 state-of-the-art coupled global climate models (GCM) taking part in Coupled Model Intercomparison Project 5 (CMIP5) in simulating NEM and SWM of India. Our analysis uses the simulations from historical runs of CMIP5 models during 1979-2005. The performance of 36 coupled models for the present-day climate is assessed using Taylor diagram, based on the consensus in simulating climatology and interannual variability of NEM and SWM rainfall. The Global Precipitation Climatology Project (GPCP) monthly precipitation dataset is used as reference data. Our analysis reveals large model spread in simulating the observed climate statistics for NEM and SWM rainfall. Considering this large model spread, the selection of best performing models are performed using the following criteria: (1) the pattern correlation in seasonal climatology is above 0.6 (2) the normalized standard deviation of seasonal climatology is between 0.75 and 1.25 (3) the pattern correlation in the interannual standard deviation is above 0.5 and (4) the normalized spatial standard deviation of interannual standard deviation is between 0.75 and 1.25. Out of 36 models, 5 models (BNU-ESM, IPSL-CM5A-MR, GFDL-ESM2G, CNRM-CM5, MRI-CGCM3) are qualified as optimally best performing models in simulating NEM. In contrast for SWM, none of the CMIP5 models satisfies the prescribed criteria, indicating that the models show better skill in simulating NEM compared to SWM. The process studies focusing on systematic errors at regional scale are performed to understand the differences in model skills. Our study has huge implications for useful regional projections as downscaling of the local precipitation is subjected to this inherent uncertainty.

Abstract ID: 34529

Final Number: AS31A-01

Title: Sensitivity of snow crystal habit on the formation of winter precipitation types

Presenter/First Author: Julie M Theriault, University of Quebec at Montreal UQAM, Montreal, QC

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Published Material: Some of the preliminary findings have been presented as a poster presentation at the CMOS congress in 2014. The submitted abstract to AGU presents new updated results.

Abstract Body: During winter storms, it is common to observe several types of precipitation, in particular, when the temperature is near 0°C. These can be on the form of supercooled liquid, solid and a mixture of both solid and liquid water. For example, wet snow and freezing rain are the most damaging. They are formed when a warmer layer (T> 0°C) is located above a sub-freezing layer (T<0°C) near the surface. The precise prediction of the type of precipitation at the surface is critical because it affects the severity of the storm. The goal of this study is to assess the impact of the snow crystal habit on the formation of winter precipitation types aloft and at the surface. To address this, a one dimensional cloud model coupled with a bulk microphysics scheme is used. Different crystal habits have been added to a bulk microphysics scheme to account for many types of winter precipitation. Note that this microphysics scheme originally accounted for only an average type of snow. The results will show how the terminal velocity of these types of snow varies with the liquid fraction. Based on this assumption, systematic studies on, for example, the link between the vertical temperature profile characteristics, the thickness of the warm layer aloft, precipitation rates, initial snowflake types and the production of surface precipitation types will be conducted. Overall, this study contributes to a better understanding of winter precipitation type formation mechanisms, which can lead to catastrophic weather events.

Abstract ID: 35921

Final Number: AS31A-02

Title: A Comparison of the Winters of 2013-2014 and 2014-2015

Presenter/First Author: Eyad Atallah, McGill University, Montreal, QC

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Published Material: Early results were presented at the WWOSC in Montreal this past August.

Abstract Body: Observations since the 1940’s have shown that the preferential formation zones for the coldest air masses in the Northern Hemisphere are generally located near the Northwest Territories and Yukon of Canada as well as the Siberian regions of Russia. However, considerable inter-annual and decadal variability exists with recent decades (the past 30 years) indicating that the coldest air masses have been more commonly found over northwestern Canada and/or Greenland. The winter of 2013-2014 however deviated significantly from climatology in that the coldest air masses consistently formed over Canadian provinces that are east of the usual formation zones, in association with a polar vortex that generally resided in the vicinity of Hudson Bay. In fact, the persistence of the cold pool in the vicinity of Hudson Bay was unprecedented in the 66 year record of the reanalysis. Meanwhile, most of the rest of the Northern Hemisphere was experiencing near record warmth associated with similarly persistent flow regimes. The persistence of the flow regime over North America was seemingly related to an extreme warm pool over the east portion of the North Pacific which served as an anchor for a strongly diffluent jet exit region at the end of an abnormally retracted Pacific basin jet. The warm pool in conjunction with extremely favorable dynamics for ascent in the poleward jet region resulted in persistent storminess and diabatic heating that in turn was responsible for developing and anchoring a strong ridge along the western seaboard of North America. As this warm pool has propagated eastward toward the North American coast-line for this winter, we will investigate whether there is a corresponding phase shift in the pattern relative to 2013-2014. We will also investigate an apparent warm bias in medium range weather prediction in the vicinity of Hudson Bay for the winter of 2014-2015.

Abstract ID: 36008

Final Number: AS31A-03

Title: Identifying synoptic-scale sources of short-term (3-10 day) zonal available potential energy generation

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Co-authors: John R Gyakum, McGill University, Montreal, QC, Canada; Eyad Atallah, McGill University, Montreal, QC, Canada

Abstract Body: Available potential energy (APE) is an estimate of the amount of potential energy in the atmosphere available for conversion to kinetic energy, providing a good proxy for the overall strength of the general circulation. In previous studies, estimates of total hemispheric APE, APE generation, and conversion to kinetic energy have been used to explain the annual APE cycle as well as shortterm APE depletion events by midlatitude cyclones. Here, we focus instead on how APE can be built up on short time scales (3-10 days). Using a standardized-anomaly based criteria, we identify a climatology of continuous build-up events of zonal APE in the Northern Hemisphere. These are divided into two subsets based on the final value of APE anomaly, either anomalously high or neutral. Several case studies are conducted to identify synoptic features in the Northern Hemisphere general circulation that help contribute to the generation of zonal APE. These include, but are not limited to, the filling of low-latitude low pressure systems, and collapses of high-latitude high pressure systems. Using a thermodynamic budget, we further explore sources of heating and cooling in the atmosphere in association with these changes to the mass fields. By exploring the changes to the thermodynamic structure of the troposphere, we will be able to assess the roles of static stability and horizontal temperature gradients, the two contributing terms in the zonal APE equation.

Abstract ID: 33282

Final Number: AS31A-04

Title: Experimental Characterization of Turbulence in the Arctic Lower Troposphere Using Aircraft Measurements

Presenter/First Author: Amir Abbas Aliabadi, Environment Canada Dorval, Toronto, ON

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Abstract Body: It is known that atmospheric turbulence persists even in statically stable conditions. Such conditions are prevalent above the Planetary Boundary Layer (PBL) and also within the nocturnal or polar PBL. Characterization of turbulence under statically stable conditions is difficult since eddies form and disintegrate in an intermittent fashion. Due to the coarse grid resolutions and computational limits in Numerical Weather Prediction (NWP), turbulence modeling is typically treated in the form of vertical diffusion using the concept of eddy diffusivity. Thus, modeled turbulent fluxes of atmospheric quantities only depend on local diffusivities and are always directed in the opposite direction of the gradient of mean atmospheric quantities; i.e. they are proportional to the vertical gradients of mean momentum, temperature, or atmospheric constituents multiplied by a diffusivity term. This approach becomes less valid when prevalent eddies are large enough to cause transport of turbulent fluxes that appears counter-gradient on a local scale. Such is the case in statically stratified conditions.

The main effort of this study is to quantify such behavior in the Arctic lower troposphere, which is typically statically stable, and to further parameterize 'counter-gradient' transport of turbulent fluxes without compromising NWP model grid resolutions. Data was collected in the Canadian Arctic around Resolute, Nunavut, in the summer of 2014 using the Polar 6 aircraft equipped with a 40Hz meteorology sensor and other analyzers measuring atmospheric constituents including gases and particles. We have determined, experimentally, turbulent fluxes and diffusivities of momentum and heat, turbulent kinetic energy, mixing length, turbulent Prandtl number, local Richardson number, cross spectra, structure functions, and other local/non-local quantities which are essential parameters in atmospheric modeling. Functional dependencies are investigated among the measured quantities. This analysis further elucidates physical processes and may suggest improvements to parameterizations of turbulence within NWP algorithms.

Abstract ID: 35885

Final Number: AS31A-05

Title: Characterizing the Structure and Behavior of Extreme Weather Events over the United States

Presenter/First Author: Robert X Black, Georgia Inst Tech School EAS, Atlanta, GA

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Co-authors: Taewon Park, Georgia Institute of Technology, Atlanta, GA; Yi Deng, Georgia Institute of Technology Main Campus, Atlanta, GA

Abstract Body: Regional climate includes extreme weather events such as cold air outbreaks, heat waves, floods and droughts, all with substantial societal impacts. Such events are most commonly studied in terms of a station-based or ad hoc regional approach. We present a pilot study focusing on the objective isolation of the typical spatial structure and synoptic time evolution of extreme temperature events (ETEs) having a widespread impact over the continental United States. Using reanalysis data, segregated by season, we define ETEs using a threshold crossing procedure applied to local time series of surface air temperature. More specifically, we isolate uncommon, large amplitude events with anomaly magnitudes greater than 1.5 standard deviations. Simple point-wise statistical analyses are first performed. On any given day a certain fraction of the continental US will be affected by either anomalous cold or warm air anomalies satisfying the above criterion. To restrict attention to those ETEs having widespread impact, we then set an additional criterion: a minimum threshold for the percentage areal coverage (of the continental US) by such cold (or warm) anomalies. We then group together all days falling within the same event category (e.g., the cold threshold is exceeded over a sufficiently large fraction of the US). Each subgroup is then separately subjected to a cluster analysis to identify the most commonly occurring regional patterns. Once the clusters are identified, we then use the cluster occurrence as a basis for more fully characterizing the spatial structure and synoptic evolution of the different categories of ETEs. Results are presented for both cold and warm events occurring during the extended boreal warm and cool seasons, respectively. Each category of ETE event (e.g., cold air outbreaks during the cool season) is typically characterized by 4-5 distinct clusters. Events typically form and decay on synoptic time scales (3-4 days). The synoptic evolution contains dynamical elements at both synoptic and planetary spatial scales. Cold and warm events are found to sometimes coincide as high amplitude Rossby wave patterns can lead to their simultaneous (albeit regionally distinct) occurrence. Implications of the results for our physical understanding, simulation and prediction of ETEs are discussed.

Abstract ID: 36036

Final Number: AS31A-06

Title: WRF and MM5 Modeling of the 1999 North American Monsoon Onset and the Las Vegas Flood

Presenter/First Author: Dorothea Ivanova, Embry-Riddle Aeronautical University, Prescott, AZ

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Co-authors: David L Mitchell, Desert Research Institute Reno, Reno, NV

Published Material: The Arizona/Great Basin onset of the 1999 North American monsoon (NAM) was simulated using the WRF and MM5 models. This onset also produced a major flooding event in Las Vegas, Nevada. Our working hypothesis states that sea surface temperatures (SST) in the northern Gulf of California (GC) may play a critical role in the timing and amount of summer rainfall over the U.S. southwest. In particular, the onset of relatively heavy rainfall occurs after these SSTs exceeded 29°C. This study explores the impact of GC SSTs on factors affecting deep convective precipitation: the regional atmospheric circulation, water vapor mixing ratio, convective available potential energy (CAPE) and convective inhibition (CIN). The impact of GC SSTs on rainfall is also addressed. The results generally reproduce the observations under “local scale mechanism”, with the removal of the Gulf of California marine boundary layer inversion as SSTs in the northern GC approach 30°C. This increased the water vapor mixing ratio at lower levels over the GC and over the southwestern United States, as low-level winds over the northern GC were from the southeast. This in turn increased thunderstorm activity and rainfall amounts over the Southwest. The northern GC SST-rainfall relationship shown under “local scale mechanism” was reproduced in this modeling study. This study indicates that in order to capture the physics that is mechanistically related to NAM rainfall, high vertical resolution of the boundary layer and good boundary layer physics is a must. Also critical is the use of reliable SST data.

Abstract Body: The Arizona/Great Basin onset of the 1999 North American monsoon (NAM) was simulated using the WRF and MM5 models. This onset also produced a major flooding event in Las Vegas, Nevada. Our working hypothesis states that sea surface temperatures (SST) in the northern Gulf of California (GC) may play a critical role in the timing and amount of summer rainfall over the U.S. southwest. In particular, the onset of relatively heavy rainfall occurs after these SSTs exceeded 29°C. This study explores the impact of GC SSTs on factors affecting deep convective precipitation: the regional atmospheric circulation, water vapor mixing ratio, convective available potential energy (CAPE) and convective inhibition (CIN). The impact of GC SSTs on rainfall is also addressed. The results generally reproduce the observations under “local scale mechanism”, with the removal of the Gulf of California marine boundary layer inversion as SSTs in the northern GC approach 30°C. This increased the water vapor mixing ratio at lower levels over the GC and over the southwestern United States, as low-level winds over the northern GC were from the southeast. This in turn increased thunderstorm activity and rainfall amounts over the Southwest. The northern GC SST-rainfall relationship shown under “local scale mechanism” was reproduced in this modeling study. This study indicates that in order to capture the physics that is mechanistically related to NAM rainfall, high vertical resolution of the boundary layer and good boundary layer physics is a must. Also critical is the use of reliable SST data.

Abstract ID: 36014

Final Number: AS31A-07

Title: Acoustic imaging of thunder from rocket-triggered lightning

Presenter/First Author: Maher A Dayeh, Southwest Research Institute San Antonio, San Antonio, TX

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Co-authors: Neal Evans, Southwest Research Institute, San Antonio, TX

Published Material: Partially presented at the Fall AGU

Abstract Body: Acoustic signatures from rocket-triggered lightning are measured by a 15m long, one-dimensional microphone array consisting of 16 receivers situated 95 meters from the lightning channel. Measurements were taken at the International Center for Lightning Research and Testing (ICLRT) in Camp Blanding, FL during the summer of 2014. The linear array was oriented in an end-fire position so that the peak acoustic reception pattern can be steered vertically along the channel with a frequency-dependent spatial resolution, enabling us to sample the acoustic signatures from different portions along the lightning channel.

We report on the characteristics of acoustic signatures associated with several return strokes in two measured flashes comprising 2 and 7 return strokes. Results show a significant high frequency component measured in the near-field of the channel that enables acoustic imaging along the vertical profile of the channel and for individual return strokes, thus inferring the radiated acoustic energy as a function of altitude.

Abstract ID: 34643

Final Number: AS31A-08

Title: Hilbert transform over the upper half-plane and its high accuracy quadrature scheme: technique renovation of the gravity wave reconstruction

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Abstract Body: Abstract. In our previous study [1], it's found that a couple of Hilbert transform exists there between the gradient components of potential field within a plane circular. The self ad-joint and symplectic characteristics of this linear integral operator have successively been applied to the solving of the problem, i.e., the ill-posedness for the essential Grad-Shafranov (GS) reconstructions. Then in another work [2], we extend it to a plane rectangular region, and a modified Hilbert transform (MHT) operator is deduced, which keeps the same properties as the one within a unit circle. The MHT operator has also been used to solve the inverse boundary problem for the GS reconstruction. Benchmark results highlight its efficiency and robustness of the proposed method. In this work, we report our new results in technique renovation of the mountain gravity wave reconstruction. Firstly, we extended the Hilbert transform within the plane unit circle to the upper half-plane. In contrast to the MHT for a plane rectangle, the new Hilbert transform operator is essentially a Cauchy Principle (CP) integrator except the point at infinity, where it shows a singularity in Hadamarda sense. Secondly, with some variable transforms the MHT for upper half-plane has been reduced to the sum of a Hadamarda Finite Part (HFP) integral and a CP integral within the half-infinite real axis, with an end-point singularity at zero. Thirdly, high accuracy quadrature scheme is developed for these two improper integral operators, and it is also applied to the inverse boundary value problem in solving the Long equations for the stationary structure of the mountain gravity waves. Lastly, reconstructed wave structures are compared with the MHT in the plane rectangle and the one in this study.

References.

(1) Li, H. J., et al. (2013), J. Geophys. Res. Space., 118, 2876—2881, doi:10.1002/jgra.50367.

(2) Li, H. J.,et al. (2014), 2014 AGU Fall Meeting, SH43B-4218, San Francisco, America.

Acknowledgments. The work is jointly supported by the National Natural Science Foundation of China (40904048, 41174164, 41275029, 41275113, 41375045), the General Financial Grant from the China Postdoctoral Science Foundation (2011M500151) and the Special Financial Grant from the China Postdoctoral Science Foundation (2014T70965)

Abstract ID: 33495

Final Number: AS31B-01

Title: Land-Surface-Cloud-Climate Coupling on the Canadian Prairies

Presenter/First Author: Alan K Betts, Institute of Global Environment and Society Calverton, Pittsford, VT

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Co-authors: Ray Desjardins, Agriculture Canada, Ottawa, Canada; Ahmed Tawfik, , ,

Published Material: This is an update on an on-going series of papers: four were published in JGR in 2013, 2014. Two more are in preparation: these are the main focus of this talk. Some preliminary results were presented at the AGU Dec 2014 meeting in 2 invited presentations.

Abstract Body: The long-term hourly Canadian Prairie data set (1953-present) is transforming our understanding of land-atmosphere coupling and hydrometeorology, because the opaque/reflective cloud observations can be calibrated to give daily mean SWCF and LWCF using BSRN data. An ongoing series of papers (see http://alanbetts.com) is mapping the coupling between the diurnal climate of temperature, humidity, precipitation and cloud from the daily to annual timescales. Sub-stratifying by wind-speed, precipitation anomalies and day-night cloud symmetry gives observational insight into the physical processes driving the fully coupled surface diurnal cycle in the warm season, as a baseline for model evaluation.

Abstract ID: 35032

Final Number: AS31B-02

Title: Stubble Height Effects on Canola Microclimate on the Canadian Prairies.

Presenter/First Author: Michael Cardillo, University of Manitoba, Winnipeg, MB

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Co-authors: Paul Bullock, University of Manitoba, Winnipeg, MB, Canada; Aaron J Glenn, Agriculture and Agri Food Canada, Brandon, MB, Canada

Abstract Body: Previous research in the most arid region of the Canadian Prairies indicated that alteration of the early season microclimate using tall stubble from the previous year can create more favorable conditions which improve the performance of the following crop. Research on large-scale plots with canola seeded into either tall stubble (50 cm) or short stubble (20 cm) showed the canola yield was significantly higher in the tall stubble across 6 site-years where the stubble remained intact (i.e. not damaged or flattened). The yield advantage was not a result of additional snowcatch or higher spring soil moisture in the tall stubble because the sites all experienced higher than normal spring precipitation and wet spring moisture conditions across both tall and short stubble. However, the mid-season was warm and relatively dry for all the site-years. It is hypothesized the intact tall stubble slowed down evapotranspiration (ET) sufficiently compared to the short stubble to confer both reduced soil moisture stress to the canola as well as a yield advantage At each site, air temperature was measured 50, 20 and 5 cm above the soil surface and soil temperature 5 cm below the surface in all plots. Meteorological data was recorded by weather stations adjacent to the plots or obtained from the nearest provincial or Environment Canada stations. Following early season rainfall events, surface soil moisture at a site should be similar between treatments. If the hypothesis is correct (tall stubble reduced the rate of ET), the surface soil moisture in the days following rainfall at a site should remain higher in the tall stubble than the short stubble. If this is the case, then the soil temperature near the surface should warm more rapidly in the short stubble over the days following the rainfall. Initial analysis suggests this was occurring. Further analysis will attempt to quantify the effect across the range of site-years and for various days following rain in the early season.

Abstract ID: 33097

Final Number: AS31B-03

Title: Global Carbon Cycle and Temperature Impacts of Future Changes in Fire Regime

Presenter/First Author: Jean-Sébastien Landry, McGill University, Montreal, QC

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Co-authors: Damon Matthews, Concordia University, Montreal, QC, Canada; Navin Ramankutty, McGill University, Montreal, QC, Canada

Published Material: Our study is currently under review with Climatic Change.

Abstract Body: Changes in the current fire regime would directly affect carbon cycling, land–atmosphere exchanges, and atmospheric composition, and could therefore modulate the ongoing climate warming. We used a fully coupled climate–carbon model to quantify the effect of different non-deforestation fire scenarios from 2015 to 2300. When considering only CO_2 fire emissions, the impacts from changes in fire frequency were limited for the global carbon cycle, and almost negligible for the global atmospheric surface temperature. The net fire emissions were only a fraction of the CO_2 directly emitted during combustion due to vegetation regrowth and climate–CO_2 feedbacks, and the albedo increases caused by changes in vegetation cover countered the effect of increased atmospheric CO_2 on global temperature. When employing a simplified approach based on global-mean radiative forcings in order to account for non-CO_2 fire emissions, the effect of increased fire frequency on global temperature depended critically on the uncertain net aerosol forcing. Overall, our results do not support the hypothesis of a strong positive climate–fire feedback for the coming centuries, and suggest that more frequent non-deforestation fires may even represent a net negative feedback to ongoing global warming.

Abstract ID: 34815

Final Number: AS31B-04

Title: Investigation of the Sensitivity of Snow and Energy-Flux Conditions to Surface and Vegetation Parameters for Forest Sites Using the Multi-Energy Balance Option in SURFEX

Presenter/First Author: Patrick Samuelsson, Swedish Meteorological and Hydrological Institute, Norrköping,

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Co-authors: Aaron anthony Boone, Météo-France Toulouse, Toulouse Cedex 01, France; Stefan Gollvik, , , ; Christer Jansson, , , ; Adrien Napoly, , ,

Published Material: A more limited and earlier version of this study was presented at the 3rd International Lund Regional-scale climate modelling workshop, Sweden. International Baltic Earth Secretariat Publication No. 3, June 2014

Abstract Body: Interaction between vegetation and snow is usually modelled in a quite simplified manner in most Numerical Weather Prediction (NWP) and climate models. This simplified manner may have a few consequences for the model performance: (i) wrong timing in spring snow melt and river discharge peaks (usually too early in forest dominated regions). (ii) wrong energy flux exchange between surface and atmosphere (radiation and sensible and latent heat fluxes). (iii) wrong soil temperatures (too much cooling of soil in autumn and winter, too much warming in spring and summer). (iv) wrong snow area fraction (usually underestimated in forest regions). Here we will illustrate a few of these issues.

We do that by the introduction of explicit canopy energy balance in the externalized surface model SURFEX where turbulent and radiation fluxes within the canopy layer are parameterized. This Multi-Energy Balance (MEB) parameterization is part of latest release of SURFEXv8.

The snow accumulation is related to the height of the canopy (forest, shrubs, grass,…). The simulated turbulent and radiation fluxes, the snow accumulation and the soil heat flux will all be sensitive for surface and vegetation characteristics as e.g. Leaf-Area Index, surface albedo, surface roughness, vegetation extinction coefficient, vegetation heat capacity. We optimise the values of these parameters by setting up SURFEX offline for a number of flux-tower sites for which we correlate observed and simulated variables. Also, since SURFEX makes it easy to switch between different physical options we can quantify how the classical ISBA land-surface option performs compared to MEB.

We show that with the MEB option in SURFEX we get quite a good correspondence between simulated and observed snow depth and heat fluxes at forest sites. However, with the classical ISBA option it is not possible to get both snow depth and heat fluxes to correspond well with observations.

Abstract ID: 33551

Final Number: AS31B-05

Title: Playa Soil Moisture and Evaporation Dynamics in an Arid Intermountain Basin

Presenter/First Author: Daniel F Nadeau, INRS - ETE, Quebec City, QC

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Published Material: Most of these findings are under review for publication in Boundary-Layer Meteorology.

Abstract Body: The Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) program was designed to better understand atmospheric fluid dynamic processes across a large range of scales over mountainous terrain. As part of MATERHORN, a large field campaign was conducted in May 2013, which is typically one of the most synoptically active months in the western Utah desert (USA). This study focuses on one of the main field sites, a desert playa, characterized by a shallow water table and significant soil moisture spatial heterogeneity. Recent studies have shown that soil moisture plays a critical role in the dynamics of boundary-layer flows over desert playas. Thus, the objective of this study is to better understand the temporal and spatial evolution of soil moisture and evaporation dynamics under contrasting conditions. During a total of 10 intensive observation periods, soil moisture was monitored with the gravimetric method at 20 sites evenly spread on a 240 x 180 m grid. Near-surface standard meteorological variables, atmospheric fluxes as well as ground heat flux and soil heat transfer properties were also measured. The data analysis reveals that decreasing surface albedo, decreasing Bowen ratio and increasing net radiation with increasing soil moisture all promoted large evaporation rates immediately following rain events. Additionally, it was found that while nocturnal evaporation was negligible during dry periods, it was quite significant (up to 30% of the daily cumulative flux) during nights following rain events. Our results further show that the highest spatial variability in surface soil moisture is found under dry conditions. Finally, we report strong spatial heterogeneities in evaporation rates following a rain event. The cumulative evaporation for the different sampling sites over a five-day period varied from ~0.1 mm to ~6.6 mm. Overall, this study allows us to better understand the mechanisms underlying soil moisture dynamics of desert playas as well as evaporation following occasional rain events.

Abstract ID: 33727

Final Number: AS31B-06

Title: Climate sensitivity and modeling of vegetation distribution through trait-climate relationships in China

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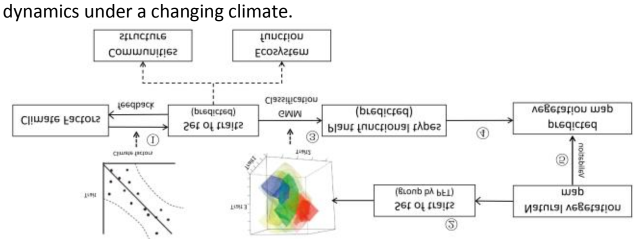
Published Material: this paper has not submitted in any journal

Abstract Body: As a part of ongoing development of plant functional traits (FTs) hybrid model, Gaussian Mixture Model (GMM) has been applied for predicting the vegetation distribution and investigating the sensitivity of vegetation to changing climate conditions based on trait-climate relationships in China. Firstly, we have collected three key plant functional traits (FTs) including leaf mass per area (LMA), area-based leaf nitrogen (N_{area}), mass-based leaf nitrogen (N_{mass}) from published papers and available literatures as well as one structural trait of plant community - leaf area index (LAI) extracted from MODIS products across China. Secondly, we have derived and developed the trait-climate relationships and used different trait combinations to train GMM for vegetation classification. Finally, the GMM trained by LMA-N_{mass}-LAI combination was applied to investigate the climate sensitivity of vegetation under different climate scenarios in China. The results showed that (1) all four traits are well captured the relationships between climate variables and traits and work well in predicting the vegetation distribution and analyzing the environmental sensitivity; (2) the LMA-N_{mass}-LAI combination with a accuracy of 72%, which could provide more parameters information about communities structure and ecosystem function was selected to train GMM for predicting the vegetation distribution; (3) Sensitivity analysis indicated that increasing temperature shifted boundaries of most vegetation northward and westward; for the reason that forest is more suitable for growing in rainy conditions, increasing precipitation expanded the boundaries of forest to a larger area compared with baseline vegetation distribution. Despite limitations and uncertainties in using plant trait-climate relationships to predict future vegetation dynamics under different climate conditions, it laid a good foundation and demonstrated a great potential for constructing the next generation of DGVMs based on FTs and would provide more flexible approaches in modeling global vegetation dynamics under a changing climate.



Abstract ID: 34113

Final Number: AS32A-01

Title: Ecological dimension of 21st century land-atmosphere interactions in the Arctic

Presenter/First Author: Ben Smith, Lund University, Lund,

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Co-authors: Wenxin Zhang, Lund University, Lund, Sweden; Paul A Miller, Lund University, Lund, Sweden

Abstract Body: Structural and compositional changes in the vegetation cover of the Arctic land surface have been documented in many areas and attributed to recent decades' climate trends, in particular a warming-driven increase in growing season length, enhancing net primary production (NPP) and potentially resulting in greener, denser, higher stature vegetation with a greater representation of woody elements. Vegetation trends like these are relevant to consider in climate models as they will affect energy, water and momentum fluxes, potentially modifying simulated climate trends. Findings are presented from simulations across the Arctic and high boreal zone using a regional Earth system model, RCA-GUESS, that couples a detailed individual-based model of climate-driven vegetation dynamics to a regional climate model, accounting for albedo and evapotranspiration-mediated feedbacks to climate. Forced by RCP radiative forcing scenarios for the 21st century, the model simulates poleward expansion of the boreal forest treeline, increased coverage of shrub tundra and a shift in phenology favouring evergreen over deciduous trees. These effects are more pronounced the higher the radiative forcing level assumed. The vegetation changes feed back to climate by lowering albedo particularly in the late snow season, promoting an earlier, warming spring. By contrast, increased evapotranspiration dampens peak season warming, resulting in a longer growing season with lower temperature amplitude compared to the climate predicted in the absence of vegetation-mediated feedbacks. Summer precipitation is also projected to increase in conjunction with vegetation changes. Ecological implications are discussed.

Abstract ID: 34789

Final Number: AS32A-02

Title: A stand-alone demography and landscape structure module for Earth system models: integration with forest inventory data, and impact on land-atmosphere exchange.

Presenter/First Author: Vanessa Elizabeth Haverd, CSIRO Canberra, Canberra, ACT

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Co-authors: Benjamin Smith, Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden; Lars Peter Nieradzik, CSIRO Marine and Atmospheric Research Hobart, Hobart, Australia; Peter Briggs, CSIRO, Canberra, Australia

Published Material: These findings were partially reported at the AGU Fall Meeting (2014) and in the following journal article: Haverd, V., Smith, B.; Nieradzik, L.; Briggs, P. R. (2014) A stand-alone tree demography and landscape structure module for Earth system models: integration with inventory data from temperate and boreal forests *Biogeosciences* ,11(15): 4039-4055.

Abstract Body: Poorly constrained rates of biomass turnover are a key limitation of Earth system models (ESM). In light of this, we recently proposed a new approach encoded in a model called Populations-Order-Physiology (POP), for the simulation of woody ecosystem stand dynamics, demography and disturbance-mediated heterogeneity. POP is suitable for continental to global applications and designed for coupling to the terrestrial ecosystem component of any ESM. POP bridges the gap between first generation Dynamic Vegetation Models (DVMs) with simple large-area parameterisations of woody biomass (typically used in current ESMs) and complex second generation DVMs, that explicitly simulate demographic processes and landscape heterogeneity of forests. The key simplification in the POP approach, compared with second-generation DVMs, is to compute physiological processes such as assimilation at grid-scale (with CABLE or a similar land surface model), but to partition the grid-scale biomass increment among age classes defined at sub grid-scale, each subject to its own dynamics. POP was successfully demonstrated along a savanna transect in northern Australia, replicating the effects of strong rainfall and fire disturbance gradients on observed stand productivity and structure. (Haverd et al. 2013)

Here, we extend the application of POP to a range of forest types around the globe, employing paired observations of stem biomass and density from forest inventory data to calibrate model parameters governing stand demography and biomass evolution. The calibrated POP model is then coupled to the CABLE land surface model and the combined model (CABLE-POP) is evaluated against leaf-stem allometry observations from forest stands ranging in age from 3 to 200 years. Results indicate that simulated biomass pools conform well with observed allometry. POP represents an ecologically plausible and efficient alternative to large-area parameterisations of woody biomass turnover, typically used in current ESMs.

Further, we use CABLE-POP to investigate the sensitivity of modeled land-atmosphere exchanges to incorporation of vegetation structure into a land surface model.

References

Haverd et al. 2013, Geophysical Research Letters, 40: 1-6.

Haverd et al. 2014, Biogeosciences, 11: 1-17.

Abstract ID: 35093

Final Number: AS32A-03

Title: Exploring interflow – soil moisture – climate linkages: Case study for northeast Canada

Presenter/First Author: Oleksandr Huziy, University of Quebec at Montreal UQAM, Montreal, QC

Presenter/First Author Email: guziy.sasha@gmail.com

Co-authors: Laxmi Sushama, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Published Material: Some results from this work were presented at AGU 2014 Fall meeting.

Abstract Body: Several of the recent interflow studies looked at the combined effect of adding interflow and baseflow processes to a land surface or river routing schemes. Although these modifications improve simulated streamflow, it is still not clear what is the contribution of the interflow parameterization to the combined effect, or to the regional climate as these simulations were run offline. In this study, using experiments performed with the fifth generation of the Canadian Regional Climate Model (CRCM5), which includes Canadian Land Surface Scheme (CLASS) and a river routing scheme (WATROUTE modified), the impact of interflow process on regional climate is assessed. The analysis of results from high-resolution (10km) current climate simulations with and without interflow, over northeast Canada, shows modest streamflow increase for majority of the rivers, and some impacts on the land atmosphere interactions via modified soil moisture.

Abstract ID: 35233

Final Number: AS32A-04

Title: Snow-atmosphere coupling over North America in the fifth generation of the Canadian Regional Climate Model (CRCM5)

Presenter/First Author: Gulilat Tefera Diro, University of Quebec at Montreal UQAM, Montreal, QC

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Co-authors: Laxmi Sushama, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Oleksandr Huziy, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Abstract Body: In this study, two sets of CRCM5 simulations were carried out, with and without interactive snow, to investigate the role of snow-atmosphere coupling in modulating climate variability during cold season over North America. In the coupled simulation, snow interacts freely with the atmosphere at each time step, while in the uncoupled simulation, snow related model variables (i.e. snow mass, snow density and snow depth) are replaced with climatological values, derived from the coupled simulation, to suppress the snow-atmosphere interactions. Results indicate that a strong land–atmosphere coupling (mainly via snow cover variability) is noted in winter and spring over northern US and most parts of central Canada including the prairies. Over these regions, snow plays an important role in amplifying winter and spring surface air temperature variability through its influence on surface albedo.

Abstract ID: 35226

Final Number: AS32A-06

Title: Implementation of Dynamic Rooting Depth and Phenology into a Land Surface Model: Evaluation of Carbon, Water, and Energy fluxes for the High Latitude Ecosystems

Presenter/First Author: Atul K Jain, University of Illinois at Urbana, Urbana, IL

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Co-authors: Bassil El Masri, University of Illinois at Urbana, Urbana, IL

Abstract Body: Ecosystem models are important tools to understand and assess the impact of environmental change on northern high latitude ecosystems (NHLEs), but many lack processes that are essential for modeling the ecosystem dynamics important for NHLEs. In this study, we implement NHLE-specific dynamic phenology schemes and dynamic rooting distribution in a state-of-the-art land surface model, the Integrated Science Assessment Model (ISAM), to improve the estimated carbon, energy, and water fluxes for the NHLEs. These schemes account for light, water, and nutrient stresses while allocating the assimilated carbon to leaf, stem and root pools. To evaluate model performance related to these processes, we use measured data from more than 15 sites representing the dominant NHLE. To quantify the implication of these processes on the carbon water and energy fluxes, we performed a number of modeling experiments. Our data-modeling analyses indicates that after accounting for dynamic processes ISAM is able to capture the seasonal variability in leaf area index (LAI), and root distribution in the soil layers and the root response of soil water uptake and transpiration. In addition, without accounting the dynamic processes, modeled growing season length for NHLEs were almost two times higher as compared to measurements. The results also show that the model is better able to capture the seasonal variability in GPP and energy and water fluxes.

Abstract ID: 36808

Final Number: AS33A-01

Title: Sedimentation for 2-moments microphysics models: How to make it fast, interactive, and avoid excessive size sorting.

Presenter/First Author: Frederick Chosson, McGill University, Montreal,

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Published Material: Under review. Journal of Atmospheric Research.

Abstract Body: We present a new sedimentation scheme for 2-moments microphysical models that mimic Eulerian or Lagrangian
classical approaches with three major advantages. First, it is much faster and numerically efficient than
classical Eulerian/Lagrangian methods and it is easy to implement. Second, it allows the microphysical
processes to take into account the sedimenting particles during sedimentation; and vice versa. That is to
say that sedimentation and microphysical processes are computed at the same time. Third, it manages the
sedimenting fluxes of the two moments (particles number concentration and mass content) together to excessive size sorting, accordingly to a minimum and a maximum mean mass particle size observable in nature. In contrast to currently used sedimentation approaches, these characteristics also allow
much longer time step for the microphysics model with a satisfying precision, and total conservation of both
mass and concentration of hydrometeor particles, paving the way toward the use of 2-moments microphysics
schemes within operational numerical weather prediction from regional to global scales and climate models.

Abstract ID: 34796

Final Number: AS33A-02

Title: Wind and sea waves analysis for the Greek area with application to renewable energy.

Presenter/First Author: George Emmanouil, , Athens,

Presenter/First Author Email: george.emmanouil@yahoo.gr

Abstract Body: Wind and sea waves energy seem to be promising solutions for the production of renewable energy in coastal and island countries, like Greece. In this presentation, results of a study in which *an integrated, high resolution system is developed for exploring and monitoring the wind and sea waves patterns in the region of Eastern Mediterranean Sea, with special emphasis to the Greek area, are presented.*

The models for the wind and sea waves simulation, will be discussed. Moreover, atmospheric (WRF) and sea wave (WAM) numerical models will be evaluated. Then, high resolution maps *for the coastal and offshore areas of Greece will be produced,* in which se*a wave and wind climatological characteristics* will be monitoring.

Abstract ID: 36053

Final Number: AS33A-04

Title: Occurrence of scintillation over Lagos within equatorial anomaly

Presenter/First Author: Oladayo Olayiwola Afolabi, Ladoke Akintola University of Technology, Ile ife,

Presenter/First Author Email: oladayo.afolabi@yahoo.com

Abstract Body: This work examines the statistical analysis of occurrence of scintillation index over Lagos Nigeria within the equatorial Anomaly region (6.45^0N, 3.40^0E) for the year 2009. The variation of occurrence of scintillation varies with local time, Season, magnetic activity, pre-midnight, post- midnight and day time. The occurrence of scintillation was found to be maximum in equinox month and minimum in December solstice. Different levels of occurrences in some months were found with moderate Scintillation ($0.4<S_4\leq0.6$) being dominant throughout the period examined.

Abstract ID: 34130

Final Number: AS33A-05

Title: Application of Recurrence Quantification Analysis (RqA) to Climatic Studies

Presenter/First Author: Samuel Toluwalope Ogunjo, Federal University of Technology Akure, Akure,

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Co-authors: Ibiyinka A Fuwape, , , ; Joseph B Dada, , ,

Abstract Body: Scientists generally agree that climate change is real but there is no consensus on the cause. Statistical tools such as correlation, averaging are generally used to detect causes of climate change. However, this will not give a true picture since atmospheric parameters is nonlinear and chaotic. Poincare introduced recurrence in 1890 to investigate fundamental characteristics of dynamical systems. It has been used by researchers in fields such as astrophysics, neurosciences, earth sciences, amongst others to detect structures in time series data. Over the years, the field has extended to include Recurrence Quantification Analsysis (RQA), which has led to the introduction of indicators such as Recurrence rates (RR), Determinisim (DET), e.t.c. The applications of RQA to atmospheric sciences include detection of change points in time series e.g. when did significant changes occur in time series data. Complex relationship such as effect of global warming indicators (e.g carbon(iv) oxide) on atmospheric parameters (e.g. rainfall) can be investigated through phase, lag, generalized or complete synchronization. RQA can also be used to analyse spatial data for relationship. This technique can be used to validate results using other techniques. Examples will be presented using NCEP Reanalysis data for selected locations across the world to show the efficiency of the technique.

Abstract ID: 33531

Final Number: AS33A-07

Title: Causative Mechanisms of Low-Latitude Mesospheric Inversion Layers

Presenter/First Author: K Ramesh, Sri Venkateswara University, Chittoor,

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Co-authors: S Sridharan, National Atmospheric Research Laboratory, Gadanki, India; S Vijaya Bhaskara Rao, Sri Venkateswara University, Tirupati, India

Published Material: Published onlline in Journal of Geophysical Research: Space Physics on 19 May 2014. doi:10.1002/2013JA019750.

Abstract Body: ABSTRACT

Mesospheric Inversion Layer (MIL) refers to the inversion of temperature gradient from negative to positive superposed upon the characteristically decreasing mesospheric thermal structure. Though morphological characteristics of MIL events have been known for several decades, their causative mechanisms are still unknown. Gravity wave breaking, panetary wave critical level interaction, Gravity wave tidal interaction and chemical heating have been suggested as possible causative mechanisms of the MIL events. However, their relative importance and seasonal and altitude dependences are relatively unknown. Considering several case studies, all the dominant causative mechanisms for the occurrence of MILs over a low latitude region, Gadanki (13.5°N, 79.2°E) are investigated using mainly the Rayleigh lidar temperatures over Gadanki, MF radar winds over Tirunelveli (8.7°N, 77.8°E), TIMED-SABER temperature, volume mixing ratios of O, H, O_3 etc and the chemical heating rates of various exothermic reactions. Based on the detailed investigation, it is found that the lower MILs (~70 km) are due to planetary wave-critical level interaction, the middle MILs (~80-85 km) are dominantly caused either by chemical heating due to $H+O_3 \rightarrow OH+O_2$ or by gravity wave breaking. The upper MILs (above 90 km) are found to be due to the exothermic chemical reaction, $O+O+M \rightarrow O_2+M$.

Abstract ID: 33744

Final Number: AS33A-08

Title: Changes in the stratospheric composition during the major stratospheric warming of 2013

Presenter/First Author: Oindrila Nath, National Atmospheric Research Laboratory, Tirupati,

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Co-authors: Sundararajan Sridharan, National Atmospheric Research Laboratory, Gadanki, India

Abstract Body: Volume mixing ratios (VMR) of different chemical components obtained from Microwave Limb Sounder onboard Aura satellite show distinct variations at high and low latitudes in the upper stratosphere (30-50 km) during the occurrence of a major stratospheric sudden warming (SSW) in January 2013. Zonally averaged ozone VMR as well as chlorine monoxide (ClO) VMR are found to increase over higher latitudes (60-90°N) whereas hydrogen chloride (HCl) VMR shows decrement as the warming proceeds. At higher latitudes, as O3/O partitioning controls the ClO/Cl ratio, the increase of ozone during SSW shifts the ClO/Cl partitioning in favour of ClO, thereby decreasing Cl which indirectly results in decrease of HCl. In the equatorial stratosphere, the ozone VMR is found to increase because of weakening of Brewer-Dobson circulation (BDC) due to reduction in planetary wave activity with the onset of warming. However, methane is expected to decrease due to weakening of upwelling branch of BDC resulting in decrease of HCl VMR. Cl i.e. active chlorine converts to ClO by reacting with ozone molecule and this active Cl comes from the reaction of HCl and water vapour (H2O). As both HCl and water vapour are found to decrease during the SSW, the production of active Cl is also getting reduced. As a result, the amount of ClO also reduces during the SSW thereby partly decreasing the depletion of ozone. The decrement of ClO persists for quite a long time even after the end of the stratwarm event.

Abstract ID: 33587

Final Number: AS33B-01

Title: Effects of Increased Horizontal and Vertical Grid Spacing on Mixing in a Simulated Continental Squall Line

Presenter/First Author: Zachary J Lebo, National Center for Atmospheric Research, Westminster, CO

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Co-authors: Hugh Morrison, National Center for Atmospheric Research, Boulder, CO

Abstract Body: The sensitivity of an idealized squall line to horizontal (and vertical) grid spacing is investigated using a new approach. Simulations are first performed at a modest horizontal resolution. Once the storm reaches a quasi-steady state, model output is interpolated to a higher resolution domain and the model is restarted using the interpolated state. This framework allows for investigating both the response *and* sensitivity of the simulated squall line to horizontal grid spacing (Δ). The results demonstrate that there are two resolution-dependent regimes; the transition between regimes occurs for Δ between 250 and 500 m. This transition is found to be independent of the vertical resolution. Mixing in the context of varying resolution is also investigated via passive tracers that are initialized 1 hr after restarting the simulations at higher resolution. The state of the tracer field at the end of the simulations reveals that entrainment and detrainment at mid-levels are suppressed in the simulations with $\Delta \geq 500$ m. For smaller Δ, entrainment and detrainment at mid levels become substantially more important, limiting the flux of low-level tracer to the upper-troposphere, which has important implications for modeling studies of atmospheric transport from the boundary layer to the free-troposphere.

Abstract ID: 34811

Final Number: AS33B-02

Title: Data Assimilation and Simulation of Mesoscale Convective Systems Associated with Squalls

Presenter/First Author: Mohan Kumar Das, SAARC Meteorological Research Centre (SMRC), Dhaka,

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Co-authors: Md. Abdul Mannan Chowdhury, Jahangirnagar University, Savar, Bangladesh; Someshwar Das, India Meteorological Department, New Delhi, India

Abstract Body:
Improving the simulation of the squall events is important as such events routinely result in strong gusty wind, hails, rain and significant loss of life and property over Bangladesh, Indian eastern, northeastern region and neighbourhood. Performance of the mesoscale models is sensitive to the quality of initial conditions. This study deals the improvement of numerical simulation of squall events during pre-monsoon season with improved initial condition through mesoscale data assimilation system. Advanced Research Weather Research and Forecasting model (WRF ARW) along with three dimensional variational (3DVar) data assimilation (DA) technique are used to improve the simulation of these intense events. Pre-monsoon squalls and tornado are studied employing observations from ground based radar, TRMM and synoptic stations. Subsequently, an attempt is made to simulate the storms using WRF model at 4 km and 1 km horizontal resolution, and 40 vertical levels.

Several sensitivity experiments were conducted with different combinations of cloud microphysics schemes, planetary boundary layer schemes and cumulus parameterization schemes to examine the RMSE of forecasts.

Abstract ID: 34225

Final Number: AS43A-01

Title: A Comparison of GCM and RCM resolution Climate Projections in the Great Lakes - Effort, Efficiency, Uncertainty Considerations

Presenter/First Author: Neil Comer, Risk Sciences International, Ottawa,

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Abstract Body: High-resolution output is a necessity for the Great Lakes region as conditions vary significantly in this heterogeneous environment. The procedures to obtain this spatially precise information are largely determined by financial resources of the end-user, whether a large well-funded municipality or a smaller community with no dedicated climate adaptation funding or staff. The latter better describes the majority of these stakeholders. In an ideal case, all users would have access and expert interpretation of many high-resolution RCM model runs, but this is not realistic.

This has led to many different approaches from high-resolution customized approaches, to much simpler delta approaches where multi-model GCM ensemble values are applied to a high resolution observed historical baseline climate. Both of these approaches generate high-resolution future projections, but a balance of many factors must be weighed. Often these factors are not fully appreciated by the non-expert end users of the information. Generally projections are practically limited by many GCM-scale projections (over 40 models in the last IPCC assessment) which can provide more comprehensive information on uncertainty versus a single (or few) high-resolution RCM projections which provide greatly reduced uncertainty estimates – and if one model run – no estimate at all. The fundamental question is: Do simpler approaches provide valuable guidance within accepted uncertainty bounds in these heterogeneous environments?

Given the obstacle of financial resources available for climate adaptation in most locations, it is crucial that such studies go forward without the hurdle of cost, yet of course still be scientifically defensible. The comparative accuracy of final output of these two approaches is considered vis-à-vis the costs and benefits through a specific example location in Ontario.

Abstract ID: 34906

Final Number: AS43A-02

Title: Dynamically Downscaled Projections of Lake-Effect Snow in the Great Lakes Basin

Presenter/First Author: Michael Notaro, University of Wisconsin-Madison, Madison, WI

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Co-authors: Val Bennington, UW - Madison, Madison, WI; Stephen J Vavrus, Univ Wisconsin, Madison, WI

Published Material: Publication: Journal of Climate (2015)Conferences: Adaptation in the Great Lakes Region Conference; NOAA GLERL seminar; DOE Oak Ridge National Lab seminar; UW-Madison CPEP seminar; University of Illinois seminarMedia: Syracuse Post-Standard

Abstract Body: Projected changes in lake-effect snowfall by the mid- and late 21st century are explored for the Laurentian Great Lakes Basin. Simulations from two state-of-the-art global climate models within the latest Coupled Model Intercomparison Project Phase Five (CMIP5) are dynamically downscaled according to the representative concentration pathway 8.5 (RCP8.5). The downscaling is performed using the Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climate Model Version Four (RegCM4) with 25-km grid spacing, interactively coupled to a one-dimensional lake model. Both downscaled models produce atmospheric warming and increased cold-season precipitation. Great Lakes' ice cover is projected to dramatically decline and, by the end of the century, become confined to the northern shallow lakeshores during mid-late winter. Projected reductions in ice cover and greater dynamically-induced wind fetch lead to enhanced lake evaporation and resulting total lake-effect precipitation, although with increased rainfall at the expense of snowfall. A general reduction in the frequency of heavy lake-effect snowstorms is simulated during the 21st century, except with increases around Lake Superior by the mid-century when local air temperatures still remain low enough for wintertime precipitation to largely fall in the form of snow.

Abstract ID: 33367

Final Number: AS43A-03

Title: Probabilistic Climate Change Projections for the Great Lakes Basin Using a High-Resolution Regional Climate Model Ensemble

Presenter/First Author: Xiuquan WANG, University of Regina, Regina, SK

Presenter/First Author Email: xiuquan.wang@gmail.com

Co-authors: Gordon Huang, University of Regina, Regina, SK, Canada

Abstract Body: Current observations in the Laurentian Great Lakes demonstrate that some changes in climate are already occurring, including increases in surface water and air temperatures and decreases in the extent and duration of ice cover. These changes have a significant influence on the surrounding region by affecting local temperature, precipitation, water vapor, cloud coverage, cyclones and anticyclones, as well as other important aspects of regional climate. Planning of appropriate mitigation and adaptation strategies against these changes in

the context of global warming, which requires a better understanding of possible future climate outcomes over the Great Lakes basin, is of great interest to local policy makers, stakeholders, and development practitioners. Therefore, a high-resolution regional climate model ensemble based on the PRECIS regional climate modeling system will be developed in this study to help explore the possible outcomes of future climate over the Great Lakes basin. A Bayesian hierarchical model is then proposed to quantify the uncertain or unknown parameters involved in the modeling results. Probabilistic projections of changes in temperature and precipitation at grid point scales are obtained by feeding the ensemble simulations into the Bayesian model. The high-resolution probabilistic projections developed in this study can provide direct inputs for climate impact researchers to study the possible impacts of global warming on the Great Lakes basin, meanwhile the results are potentially helpful for assessing the risks and costs associated with climatic changes as well as for planning the appropriate mitigation and adaptation strategies.

Abstract ID: 33058

Final Number: AS43A-04

Title: Seasonal and Interannual Variability of Great Lakes Climate and Ice Cover: From Research to Forecast

Presenter/First Author: Jia Wang, NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI

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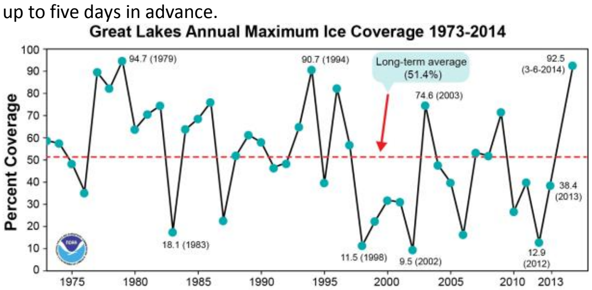
Co-authors: Xuezhi Bai, CILER, University of Michigan, Ann Arbor, MI; Haoguo Hu, CILER, University of Michigan, Ann Arbor, MI; Ayumi Fujisaki, NOAA/GLERL, Ann Arbor, MI

Abstract Body: Over the past six years (since 2007), GLERL and CILER team has studied Great Lakes ice and regional climate in response to global climate changes and how to transfer scientific research results into predictions of lake ice on the scales of several days to several months. It was found that both NAO and AMO have a linear impact on lake ice, while ENSO and PDO have nonlinear (quadratic) impacts on lake ice, but none of them solely dominates the Great Lakes regional climate and lake ice cover. The combined effects of NAO, ENSO, AMO, and PDO on lake ice provide high predictability skills using statistical regression models. The new findings were incorporated into a statistical regression model, which can project medium-range lake ice cover only using projected indices of NAO, Nino3.4, AMO, and PDO one to several months ahead of time. For the first time, fully-coupled Great Lakes Ice-circulation Models (GLIM) with both dynamics and thermodynamics have been developed at GLERL/CILER to simulate and investigate the lake ice variations on the synoptic, seasonal, interannual, and decadal time scales. The hindcast results were validated using in situ, airborne, and satellite measurements. The validated GLIM has been used since the 2010-2011 ice season to forecast Great Lakes ice cover concentration, thickness, velocity, and associated air-ice-sea variables for up to five days in advance.



Abstract ID: 33464

Final Number: AS43A-05

Title: Development of a reference potential evapotranspiration climatological dataset for the Great Lakes region

Presenter/First Author: Jeff Andresen, Michigan State University, East Lansing, MI

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Co-authors: Michael T. Kiefer, Michigan State University, East Lansing, MI; Dana Doubler, , ,

Abstract Body: This study describes the development of a gridded historical climatological dataset of reference potential evapotranspiration (ET0) for the Great Lakes region using the Penman-Monteith methodology following Allen et al. 1998. The rate of ET0 is dependent on meteorological conditions including the intensity of solar radiation, air temperature, humidity and wind speed. Following international convention, we calculate ET0 assuming a flat, unshaded, 12 cm-tall grass-covered surface with no soil water limitations. Although ET0 is a primary input variable for most irrigation scheduling systems, little is known regarding its temporal and spatial variability.

Given the limitations of objectively analyzing single site station data (e.g., incomplete station records, heterogeneous station density), we used the North American Land Data Assimilation System (NLDAS) gridded analysis as a source of weather information for computing ET0. Before calculation, adjustments were made to the NLDAS solar radiation field to reduce bias and correct for a tendency of NLDAS to be too conservative in the tails of the distribution. NLDAS fields were then used as input to generate hourly ET0 estimates at each grid point in a domain covering the entire Great Lakes watershed over the 30-year period from 1983-2012.

Preliminary analysis of the NLDAS-derived dataset shows a pronounced influence of the lakes on ET0 spatial and seasonal patterns, distinct links with drought years in 1988 and 2012, and a general increasing trend of ET0 with time over the 1993-2012 period of record. Future efforts planned include coupling the ET0 dataset to a precipitation dataset, evaluating the sensitivity of ET0 to its individual components, developing future climate projections, and linkage to an operational irrigation scheduling decision support system.

Abstract ID: 36486

Final Number: AS43A-06

Title: Quantifying Uncertainties in Wind Atlases

Presenter/First Author: Paula Doubrawa, Cornell University, Ithaca, NY

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Co-authors: Rebecca J Barthelmie, Cornell University, Ithaca, NY; Sara C Pryor, Cornell University, Ithaca, NY; Merete Badger, , , ; Hui Wang, , ,

Abstract Body: The Great Lakes present a large potential for offshore wind development due to the abundant wind resource and the proximity to large population centers. With low water depths, Lake Erie has been a focus of wind energy projects for the past few years. In this study, observed winds from 12 coastal stations, 4 buoys, and ESA's Synthetic Aperture Radar during 2002-2012 are used to generate an observational wind atlas for Lake Erie. The in situ data provide temporally consistent data at various heights and at point locations. The satellite data represent equivalent neutral winds at 10 m, provide spatial information at a relatively high resolution but are temporally sparse. Each data set is treated separately to take advantage of their respective strengths and address their weaknesses. A methodology is presented to correct for the

consistent temporal gaps introduced in offshore observations when the buoys are removed from the lake and the satellite platforms cannot estimate the wind stress due to ice formation. A method of ratios is applied on the mean wind and power density to correct the buoy generalized wind climates. The wind class method is used to address the disjunction in the available satellite scenes. All processing steps reduce the uncertainty in the results. A method is presented that integrates the individual wind climates into a wind atlas for the region, under the common assumption of neutral stratification offshore. The final area-averaged RMSE is 0.1 m/s and the mean predicted resource is < 314 W/m2 at 90 m in the center of the Lake. To test the neutral stratification assumption, observations over Lake Erie were obtained during a one-month measurement campaign from a buoy, a sonic anemometer, a profiler lidar and a scanning lidar. These data are used to investigate in detail the local characteristics of the wind flow and quantify the impact of stability on the wind climate of the region and the uncertainty in the wind atlas estimation.

Abstract ID: 35019

Final Number: AS43A-07

Title: Best Practices for Data Management to Enhance Binational Availability: GLOS and GEOSS-GL

Presenter: John D Lenters, LimnoTech, Ann Arbor, MI

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First Author Student?: No

Co-authors: Kelli Paige, , ,

Published Material: AWRA, Latornell - both Fall 2014

Abstract Body: A barrier to effective decision support using today's wide array of research and monitoring data is the difficulty of discovery. There are many potentially useful data collections whose existence is not widely appreciated. One way of increasing the discoverability (and transparency) of datasets is to develop and publish standard-compliant metadata that describe the who, what, when, where, why, and how for each collection. Metadata publication through portals like the Global Earth Observation System of Systems (GEOSS) provides the opportunity to find datasets and evaluate their utility. Interoperability - furnishing the data as well for standards-compliant direct access - is another best practice that makes use of data easier. Examples of standards-based discoverability, transparency and interoperability will be presented from the Great lakes Observing System (part of NOAA's Integrated Ocean Observing System) and GEOSS-GL (the Great Lakes node of GEOSS. The examples define a vision for data management that, although not inexpensive, may be the right approach for supporting complex decisions in an international context.

Abstract ID: 33890

Final Number: AS44A-0023

Title: A new Approach to Interpret Multi-Angle Spectral Reflectance of Dense Vegetation

Presenter/First Author: Yuri Knyazikhin, Boston University, Boston, MA

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Co-authors: Jian Bi, Boston University, Boston, MA; Sungho CHOI, Boston University, Boston, MA; Taejin Park, Boston University, Boston, MA; Ranga B Myneni, Boston University, Boston, MA

Abstract Body: Monitoring of dense vegetation represents the most complicated case in optical remote sensing because reflectances saturate and are weakly sensitive to changes in canopy properties. A new approach to interpret such data based on analyses of relationships between forward and adjoint radiative transfer equations is discussed in this presentation. This approach was applied to monitor seasonality in phenology of Amazonian rainforests using data from Terra MODIS, MISR and Aqua MODIS sensors. These three independent satellite datasets consistently show higher greenness level during the dry season relative to the wet season. This result is consistent with the light limitation hypothesis, i.e., light is the limiting factor for productivity of well-hydrated equatorial Amazonian rainforests.

Abstract ID: 36465

Final Number: AS44A-0024

Title: High Spatial Resolution Three Dimensional Atmospheric Radiative Transfer in SASKTRAN

Presenter/First Author: Daniel Zawada, University of Saskatchewan, Saskatoon, SK

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Co-authors: Seth Dueck, University of Saskatchewan, Saskatoon, SK, Canada; Adam E Bourassa, University of Saskatchewan, Saskatoon, SK, Canada; D A Degenstein, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: Parts of this work were presented at the 2013 AGU Fall Meeting and are currently under review in Atmospheric Measurement Techniques.

Abstract Body: The SASKTRAN radiative transfer model has been used successfully for more than a decade to simulate Odin-OSIRIS measurements of vertically resolved profile of limb scattered sunlight. These radiance simulations are used, along with OSIRIS measurements, within a Multiplicative Algebraic Reconstruction Technique in order to retrieved vertically resolved profiles of atmospheric constituents including ozone, nitrogen dioxide and sulphate aerosol within the stratosphere. The original SASKTRAN is a fully spherical model that accurately accounts for the three-dimensional nature of the incoming sunlight but had the limitation of only modelling a one dimensional, vertical, distribution of the atmospheric state. For example the first version of SASKTRAN only allowed the atmospheric density, temperature, ozone, nitrogen dioxide and bromine monoxide profiles to vary in the vertical dimension and homogeneity was assumed across the other dimensions. Recent modifications have been made to the SASKTRAN model that have eliminated this homogeneity constraint allowing for a more accurate simulation of OSIRIS and other scattered sunlight measurements. An adaptive integration technique has been introduced to handle areas of high extinction (e.g. cirrus clouds) and regions with large horizontal inhomogeneity. In addition, the capability to compute analytic weighting functions in one and two dimensions for inversion purposes has been added. This poster details these changes and their expected benefits to the data products retrieved from OSIRIS measurements. The use of the new High Resolution SASKTRAN within a two-dimensional tomographic retrieval technique that can be used with measurements made by microCATS, an OSIRIS follow-on mission, is also discussed.

Abstract ID: 36488

Final Number: AS44A-0025

Title: Monte-Carlo SASKTRAN for Stratospheric Radiative Transfer

Presenter/First Author: Seth Dueck, University of Saskatchewan, Saskatoon, SK

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Co-authors: Daniel Zawada, University of Saskatchewan, Saskatoon, SK, Canada; Adam E Bourassa, University of Saskatchewan, Saskatoon, SK, Canada; D A Degenstein, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: Parts of this work were presented in a poster at AGU Fall Meeting 2013, and are under review in Atmospheric Measurement Techniques (High Resolution and Monte Carlo Additions to the SASKTRAN Radiative Transfer Model, D.J. Zawada, S.R. Dueck, L.A. Rieger, A.E. Bourassa, N.D. Lloyd, and D.A. Degenstein).

Abstract Body: The SASKTRAN radiative transfer model is a spherical, successive orders, discrete ordinates model used for operational processing of the OSIRIS limb scattered sunlight measurements for one dimensional profile retrievals of stratospheric ozone, nitrogen dioxide and stratospheric aerosol extinction. In this work, we study the effects of two and three dimensional structures in the retrieved fields and in clouds within and near the line of sight using a Monte Carlo version of the model. This version uses identical atmospheric state, optical property parameters and ray tracing to facilitate direct comparison to the one dimensional discrete ordinates model. A speed improvement using variance distributed orders of scattering is presented, as well as effects of polarization and the finite size of the solar disk.

Abstract ID: 36588

Final Number: AS44A-0027

Title: Ground-Based Multi-Angle Imaging Network for 3D Atmospheric Sensing

Presenter/First Author: Amit Aides, Technion Israel Institute of Technology, Haifa,

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Co-authors: Dmitri Veikherman, , , ; Aviad Levis, Technion Institute of Technology, Haifa, Israel; Yoav Y Schechner, Technion Institute of Technology, Haifa, Israel

Published Material: This work was presented in part in the 12th Asian Conference on Computer Vision (ACCV 2014), Nov 2014.

Abstract Body: There is much to benefit from 3D recovery of clouds and aerosol distributions, in high spatio-temporal resolution and wide coverage. Algorithms are developed for such tasks, including stereo triangulation (clouds) and tomography (aerosols). However, existing remote sensing instruments may lack the spatio-temporal resolution desired to properly exploit these algorithms. There is a need to capture frequent samples of the atmospheric radiance field from many viewpoints. To help achieve this, we develop a new imaging system, based on a wide, dense, scalable network of wide-angle cameras looking upward. The network uses low-cost units, to enable large scale deployment in the field. We demonstrate high-resolution 3D recovery of clouds based on data captured by a prototype system. We use space carving to recover the volumetric distribution of clouds. This method leads directly to cloud shapes, bypassing surface triangulations that are based on image correspondence. Furthermore, network redundancy solves various radiometric problems that exist in monocular or stereoscopic systems.

Abstract ID: 36483

Final Number: AS44A-0028

Title: A new Approach to Cloud Optical Depth Estimates from Sky Images based of SHDOM Simulations

Presenter/First Author: Felipe Alejandro Mejia, University of California San Diego, San Diego, CA

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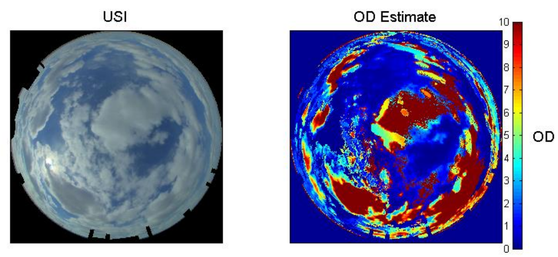
Co-authors: Jan P Kleissl, Univ of California, San Diego, San Diego, CA

Abstract Body: A method for retrieving cloud optical depth (OD) using a ground-based sky imager (USI) developed at the University of California, San Diego is presented. Using data from images taken by a USI in the Oklahoma ARM site over the course of 220 days, as well as synthetic images produced by a 3-D Radiative Transfer Model (SHDOM) the basic parameters affecting an image were identified as the solar zenith angle (SZA), OD, solar pixel angle (SPA), pixel zenith angle (PZA), and 3-D radiative effects. The effects of these parameters are described in this paper as well as the algorithm used to retrieve OD. Comparison between OD retrieved from the USI and a microwave radiometer (MWR) is presented as well as DNI estimates from the USI and actual measurements.



Abstract ID: 34959

Final Number: AS44A-0029

Title: 3D radiative effects on UV, VIS and NIR cloud reflectance

Presenter: Tamas Varnai, University of Maryland Baltimore County, Greenbelt, MD

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First Author Student?: Yes

Co-authors: Alexander Marshak, NASA Goddard Space Flight Center, Greenbelt, MD

Abstract Body: This work explores the three-dimensional (3D) nature of the radiative processes that take place in partly cloudy scenes. While, until now, most studies focused on visible (VIS) and near-infrared (NIR) wavelengths, this study extends the analysis to ultraviolet (UV) wavelengths and examines the way 3D processes change with wavelength, spatial resolution, cloud type, solar and viewing geometry.

With this aim, 3D and 1D-IPA (Independent Pixel Approximation) simulations were carried out for UV, VIS and NIR wavelengths and for a variety of solar and viewing geometries. The differences between the 1D and 3D model outputs show that 3D effects on average reflectances are smaller for UV wavelengths. Moreover, 3D effects for this wavelength show a weaker dependence on solar and viewing geometry.

Additionally, 1D-IPA simulations have been carried out at various spatial resolutions, and their differences from the 3D simulations have been analyzed. The results show that for UV wavelength, the 1D-IPA approximation is most accurate at the highest resolution. This is also true for VIS and NIR wavelengths in back scattering directions, but not in forward scattering directions.

The same analysis has been performed for two different scenes: a cumulus and a stratocumulus cloud field used in the Intercomparison of 3D radiation codes (I3RC) project. It is observed that 3D effects on scene average reflectances are much stronger for cumulus than for stratocumulus. Taking into account that the mean optical thickness of the analyzed scenes are similar, the differences are attributed to differences in the spatial distribution of clouds.

This analysis helps identify situations where the interpretation of satellite-based cloud observations can be most affected by 3D radiative processes. Additional studies using other wavelengths and cloud fields are expected to further improve the understanding of 3D radiative effects.

Abstract ID: 35974

Final Number: AS44A-0030

Title: Statistics About Shortwave 3D Radiative Effects in Cloudy Scenes

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Co-authors: Alexander Marshak, NASA Goddard Space Flight Center, Greenbelt, MD; Guadalupe Sanchez, University of Extremadura, Badajoz, Spain; K Franklin Evans, University of Colorado, Boulder, CO

Abstract Body: This study aims at helping better understand, in which situations it is important for remote sensing applications to consider the three-dimensional nature of solar radiative processes. For this, the presentation compares statistics from 1D and 3D radiation simulations performed for a large number of scenes. Some cumulus and stratocumulus scenes are specified by Large-Eddy Simulations, other scenes are from a global dataset of satellite images. The study examines the way 3D effects vary with wavelength in the ultraviolet-to-near infrared range, and puts their impact in perspective through comparisons with other remote sensing uncertainties. The study also examines the way 3D effects depend on view direction when looking down from above or looking up from below. Finally, the presentation will discuss the statistical influence of relevant scene parameters on 3D effects, and highlights the type of situations in which 3D effects are most or least important to consider.

Abstract ID: 34806

Final Number: AS44A-0031

Title: Effects of Clouds Inhomogeneities on LIDAR and Doppler RADAR Observations : Application to A-train and EarthCARE Space missions

Presenter/First Author: Frédéric Szczap, Organization Not Listed, Aubière,

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Co-authors: Alaa Alkasem, , , ; Céline Cornet, University of Lille 1, Villeneuve d'Ascq, France; Olivier Jourdan, , , ; Valery Shcherbakov, , ,

Published Material: Some prelimenary results presented during AGU Joint Assembly were reported during the French scientific meeting EECLAT (Expecting EarthCARE, Learning from A-Train)

Abstract Body: Clouds show complex tridimensional (3D) variabilities in their horizontal/vertical geometrical, optical, microphysical and dynamical properties at different averaging scales. Effects of cloud and wind inhomogeneities on LIDAR and Doppler RADAR observations, such as the backscatter coefficient, the depolarization ratio, the reflectivity factor, the Doppler velocity, have to be considered in direct radiative transfer calculations (i.e. simulation of LIDAR and RADAR observations from mesoscale models outputs) as well as in the inverse problems (i.e. retrievals of cloud parameters from LIDAR and RADAR observations). Generally and for practical reason, clouds are assumed to be horizontally homogenous and plane parallel in LIDAR and Doppler RADAR signal calculation algorithms (direct problem) and in cloud-property retrieval algorithms (inverse problem).

A study has been undertaken to quantify the effects of high resolution 3D cloud inhomogeneities on the LIDAR and Doppler RADAR observations of A-train and EarthCARE space mission. These investigations are performed using numerical simulations and the classical approach of the radiative transfer community. For direct problem, this approach consists in comparison between the mean of the 3D cloud LIDAR and Doppler RADAR observations and those of the homogenous and plan parallel equivalent clouds with the same mean cloud properties. We have to develop two numerical tools for these purposes. The first one is the 3D multiple scattering polarized LIDAR and Doppler RADAR simulator, which is based on the 3D polarized Monte Carlo model (Cornet et al., 2010). It will be compared to the DOMUS model (Battaglia and Tanelli, 2011) and to the Hogan's model (Hogan et al., 2008). The second tool is the high-resolution synthetic 3D cloud and wind field generator. It will be based on the 3DCLOUD model (Szczap et al., 2014) that is now in use for stratocumulus, cumulus and cirrus clouds cases.

Abstract ID: 35534

Final Number: AS44A-0032

Title: 3D Cloud Observations: Synergy Between Scanning Radars and Shortwave Radiation Measurements

Presenter/First Author: Jui-Yuan Christine Chiu, University of Reading, Reading,

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Co-authors: Mark D. Fielding, , , ; Robin James Hogan, ECMWF, Reading, United Kingdom; Graham Feingold, NOAA Boulder, Boulder, CO

Published Material: published in JGR in 2014.

Abstract Body: Ground-based cloud observations have been primarily made from a vertically pointing view in the past. Consequently, cloud evolution and 3D structures must be derived based on certain assumptions, making it difficult to tackle cloud problems in a fully 3D situation. The new scanning cloud radars from the Atmospheric Radiation Measurement (ARM) Climate Research Facility provide an excellent opportunity for characterizing detailed 3D cloud macrophysical and microphysical properties. In this paper, we will introduce a new ENsemble ClOud REtrieval method (ENCORE) that combines scanning cloud radar and shortwave zenith radiances, using an iterative Ensemble Kalman Filter with a 3D radiative transfer forward model. Based on large eddy simulations and real data collected from the Azores in the northeast Atlantic, we will

show examples from relatively easy stratocumulus to challenging shallow cumulus that tends to have a strong 3D radiative effect. These new cloud observations open the door to many new lines of research, helping unravel the influence of aerosol on clouds, as well as giving insight to the 3D radiative properties of boundary-layer clouds.

Abstract ID: 34240

Final Number: AS44A-0033

Title: *Cirrus cloud heterogeneity effects and their implications for MODIS-like retrievals using solar and IR observations*

Presenter/First Author: Thomas Fauchez, Oak Ridge Associated Universities Inc., Greenbelt, MD

Presenter/First Author Email: thomas.j.fauchez@nasa.gov

Co-authors: Steven Platnick, NASA Goddard Space Flight Center, Greenbelt, MD; Zhibo Zhang, University of Maryland Baltimore County, Baltimore, MD; Céline Cornet, University of Lille 1, Villeneuve d'Ascq, France; Philippe Dubuisson, Lab. d'Optique Atmosphérique, Villeneuve D'Ascq, France; Frédéric Szczap, Organization Not Listed, Aubière, France

Published Material: Fews results are already presented in Fauchez et al., 2014, AMT, accepted.

Abstract Body: Cirrus clouds are important actors in the Earth radiation budget but an accurate assessment of their role remains highly uncertain. Cirrus optical properties such as Cloud Optical Thickness (COT) and ice crystal effective particle size are often retrieved with a combination of Visible/Near InfraRed (VNIR) and ShortWave-InfraRed (SWIR) reflectance channels. Alternatively, Thermal InfraRed (TIR) techniques, such as the Split Window Technique (SWT), have demonstrated better accuracy for thin cirrus effective radius retrievals with small effective radii. However, current global operational algorithms for both retrieval methods assume that cloudy pixels are homogeneous (Plane Parallel Approximation (PPA)) and independent (Independent Pixel Approximation (IPA)). The impact of these approximations on ice cloud retrievals needs to be understood and, as far as possible, corrected. Horizontal heterogeneity effects can be more easily estimated and corrected in the TIR range because they are mainly dominated by the PPA bias, which primarily depends on the COT subpixel heterogeneity. For solar reflectance channels, in addition to the PPA bias, the IPA can lead to significant retrieval errors if there is large photon transport between cloudy columns and brightening/shadowing effects that are more difficult to quantify.

A study has been undertaken to improve MODIS TIR retrievals at 1 km by taking into account cirrus heterogeneity effects using higher resolution MODIS VNIR through (SWIR) measurements (two channels at 250 m, five channels at 500 m). Differences between heterogeneity effects in the VNIR/SWIR and TIR are also investigated in order to estimate their impact on cloud products retrieved using a combination of the VNIR/SWIR and TIR retrieval methods. These investigations are performed using a cirrus 3D cloud generator (3DCloud), a 3D radiative transfer code (3DMCPOL) as well as two retrieval algorithms: the official MODIS retrieval algorithm (MOD06) and an algorithm based on the infrared SWT.

Abstract ID: 35356

Final Number: AS44A-0034

Title: Assessment of OCO-2's Vulnerability Against Spatial Variability of Surface Reflectivity in "Glint" (over Land), "Nadir" and "Target" Modes

Presenter/First Author: Anthony B Davis, NASA Jet Propulsion Laboratory, Pasadena, CA

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Co-authors: Zheng Qu, Raytheon/JPL, Pasadena, CA

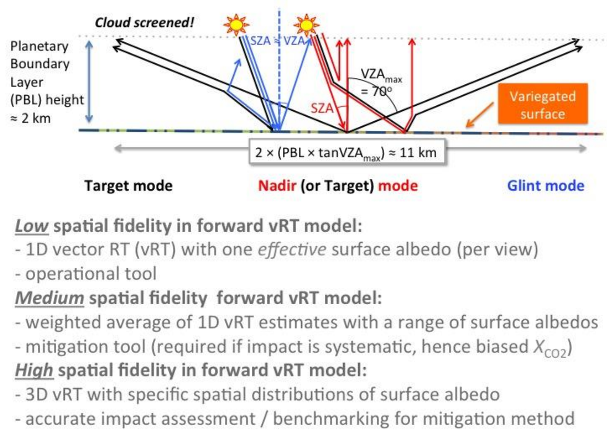
Published Material: AGU Fall Meeting 2014, but only for "Target Mode" findings.

Abstract Body: The goal of NASA's Orbiting Carbon Observatory (OCO-2) mission is to measure the X_{CO2} column from space at an unprecedented (~1 ppm) precision to enable globally mapping of CO_2 sources and sinks. To achieve that goal, the mission depends critically on X_{CO2}product validation that, in turn, hinges on successful exploitation of OCO-2 data acquired in "target mode." That is, when OCO-2 rotates in such a way that, for almost as long as it is above the horizon, it stares at a Total Carbon Column Observing Network (TCCON) ground station equipped with a powerful Fourier transform spectrometer.

TCCON measures X_{CO2} by looking straight at the Sun. This leads to a far simpler forward model for TCCON than for OCO-2. In the ideal world, OCO-2's spectroscopic signal results from the cumulative gaseous absorption for one direct transmission of sunlight to the ground (as for TCCON), followed by one diffuse or specular reflection, and one direct transmission back to the sensor, at a series of viewing angles in target mode. In the real world, all manner of multiple surface reflections and/or scatterings contribute signal. See figure. In the idealized world of OCO-2's operational forward model, horizontal variability of the scattering atmosphere and reflecting surface are ignored, leading to the adoption of a 1D radiative transfer (RT) model. We investigate part of this source of forward model error in target as well as nadir and glint-over-land modes.

In principle, atmospheric variability in the horizontal plane, largely due to clouds, can be avoided by careful screening. Also, it is straightforward to account for the angular variability of surface reflection in the 1D RT framework. But it is not clear how the unavoidable horizontal variations of surface reflectivity affects the OCO-2 signal, even if said reflection was Lambertian. To quantify this OCO-2 "adjacency" effect, we drive a 3D RT model with realistic aerosol and molecular profiles, but use (at present) a simplified surface variability model: a single spatial frequency in each horizontal direction, and a single albedo contrast. This specific kind of 3D RT error will be compared with other documented forward model errors and instrumental uncertainties. It can thus be translated into X_{CO2}error, for programmatic consideration and eventual mitigation.

Figure:



Abstract ID: 34737

Final Number: AS44A-0035

Title: Radiative effects of in-situ observed ice supersaturated regions and cirrus clouds in the extratropical upper troposphere and lower stratosphere

Presenter: Xiaoxiao Tan, McGill University, Montreal, QC

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First Author Student?: No

Co-authors: Yi Huang, McGill University, Montreal, QC, Canada

Abstract Body: Cirrus clouds are important modulators on the Earth's climate budget. The prerequisite condition for ice crystal formation is ice supersaturation (ISS, where relative humidity with respect to ice > 100%). A recent observational study shows that the spatial distribution of ISSRs is highly heterogeneous, with a median horizontal length of ~1 km (Diao et al. ACP 2014), which is much smaller than climate model grid scales. In addition, a previous study shows that the radiative effects of an idealistic clear-sky ISSR and an artificial cirrus cloud can be very different (Fusina et al. 2007). However, it is unclear how much radiative impact it would make if ISSRs in the real atmosphere were to be replaced by artificial cirrus clouds.

In this work, we compare the radiation impacts of three scenarios: 1) in-situ observed ISSRs, 2) excluding ISS by removing the excess water vapor over saturation, and 3) artificial cirrus clouds (i.e., replacing the observed ISS with ice crystals). The first scenario is based on high-resolution (~200 m) aircraft observations in the extratropical upper troposphere and lower stratosphere (Diao et al. ACP 2014). The radiative impact of each scenario is calculated by the rapid radiative transfer model (RRTM) of AER (Mlawer et al. JGR 1997), with atmospheric conditions (e.g., cloud distributions) adopted from the ERA-Interim data.

By calculating the radiation impacts of 184 cases of clear-sky ISSRs, we find that the clear-sky ISSRs lead to higher vertical heating rate by ~0.2–1.5 K d^{-1} than the ISS exclusion scenario. In contrast, replacing the observed ISSRs with artificial ice crystals can generate even larger perturbations on the vertical heating rate by up to ~8.6 K d^{-1}, as well as on the net radiation at 100 hPa and surface by up to ~20 W m^{-2} and ~ -25 W m^{-2}, respectively. More work is in progress to examine the radiative effects when ISS and ice crystals coexist. Overall, our results show that instantaneously replacing ISS with ice crystals after ice nucleation (e.g., a cirrus cloud scheme by Tompkins et al. (2007)) can potentially generate large perturbations on the net radiation at the Top of Atmosphere (TOA) and surface. Our work helps to quantify the radiation perturbations when ISS is misinterpreted as artificial ice crystals in cloud and climate models.

Abstract ID: 33838

Final Number: AS44B-0036

Title: Clouds, Precipitation and Marine Boundary Layer Structure during the MAGIC Field Campaign

Presenter/First Author: Xiaoli Zhou, McGill University, Montreal,

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Co-authors: Pavlos Kollias, McGill University, Montreal, QC, Canada; Ernie R Lewis, Brookhaven National Laboratory, Upton, NY

Published Material: These findings were reported in the ASR (Atmospheric System Research) meeting, and were accepted by Journal of Climate

Abstract Body: The recent ship-based MAGIC field campaign with the marine-capable Second ARM Mobile Facility (AMF2) deployed on the Horizon Lines cargo container M/V *Spirit* provided nearly 200 days of intra-seasonal high-resolution observations of clouds, precipitation and marine boundary layer (MBL) structure on multiple legs between Los Angeles, California, and Honolulu, Hawaii. During the deployment, MBL clouds exhibited a much higher frequency of occurrence than other cloud types and occurred more often in the warm season than in the cold season. MBL clouds demonstrated a propensity to produce precipitation, which often evaporated before reaching the ocean surface. The formation of stratocumuli is strongly correlated to a shallow MBL with a strong inversion and a weak transition, while cumuli formation is associated with a much weaker inversion and stronger transition. The estimated inversion strength (EIS) is shown to depend seasonally on the potential temperature at the 700 hPa. The location of the commencement of systematic MBL decoupling (DE) always occurred eastward of the locations of cloud breakup (CBs), and the systematic decoupling showed a strong moisture stratification. The entrainment of the dry warm air above the inversion appears to be the dominant factor triggering the systematic decoupling, while surface latent heat flux, precipitation and solar radiation did not play major roles. MBL clouds broke up over a short spatial region due to the changes in the synoptic conditions, implying that in real atmospheric conditions, the MBL clouds do not have enough time to evolve as is in the idealized models.

Abstract ID: 34224

Final Number: AS44B-0037

Title: A Comparison of Algorithms for Determination of Marine Boundary Layer Height

Presenter/First Author: Ernie R Lewis, Brookhaven National Laboratory, Upton, NY

Presenter/First Author Email: elewis@bnl.gov

Published Material: Some of this analysis was presented at the 2014 AGU fall meeting

Abstract Body:
The MAGIC field campaign, funded and operated by the ARM (Atmospheric Radiation Measurement) Climate Research Facility of the US Department of Energy, occurred between September 2012 and October, 2013 aboard the Horizon Lines cargo container ship Spirit making regular trips between Los Angeles, CA and Honolulu, HI. Along this route, which lies very near the GPCI (GCSS Pacific Cross-section Intercomparison) transect, the predominant cloud regime changes from stratocumulus near the California coast to trade-wind cumulus near Hawaii. During MAGIC, radiosondes were routinely launched four times daily, and during one round trip in July, 2013, radiosondes were launched eight times daily. In total, more than 550 soundings were made. Boundary layer heights were calculated from the radiosonde data using several different algorithms. Some of these algorithms gave values that correspond to the abrupt decrease in the relative humidity with height that occurs above a well-mixed boundary layer, but others routinely underestimated the boundary layer heights and appeared to occur at heights at which no obvious transitions are occurring. Heights determined by the various algorithms are compared and reasons for the differences are examined.

Abstract ID: 34394

Final Number: AS44B-0038

Title: Thermally-driven circulation and convection over a mountainous tropical island

Presenter/First Author: Chun-Chih Wang, McGill University, Montreal,

Presenter/First Author Email: wang.monsoon@gmail.com

Co-authors: Daniel J Kirshbaum, McGill University, Montreal, QC, Canada

Published Material: The findings from this study were presented during the 16th AMS Mountain Meteorology Conference in San Diego, CA (Aug. 18-22, 2014). A manuscript reporting the results was also submitted to Journal of the Atmospheric Sciences in November, 2014. The manuscript is currently undergoing minor revisions to address the reviewers' comments for future publication.

Abstract Body: Observational data from the 2011 Dominica Experiment (DOMEX) and cloud-resolving numerical simulations are exploited to gain a better understanding of controlling parameters of thermally-driven convection over a mountainous tropical island. A "golden" case from DOMEX with a clear diurnal cycle in cumulus convection and quasi-steady large-scale conditions is studied using observations and cloud-resolving numerical simulations. The simulations are quasi-idealized in that they use full model physics and the real Dominica terrain, along with a horizontally homogeneous initial flow based on a single observed sounding. Simulations at different grid resolutions reveal that large-eddy resolution (~100 m) provides the most accurate representation of the in-situ measurements from DOMEX and the radar-derived island precipitation. However, regardless of grid resolution, the simulations robustly under-predict the island diurnal cycle and over-predict the precipitation, which stem from biases in land-surface and subgrid microphysics parameterizations. Sensitivity tests reveal the importance of key factors including island terrain height, land-surface type, cloud-radiative feedbacks, moist stability, and background wind velocity in controlling the thermally-driven convection.

Abstract ID: 34232

Final Number: AS44B-0039

Title: Velocity and Length Scales for Moist Convection: Estimation of Scale-Aware Convective Adjustment Timescale

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Abstract Body: One of the most uncertain parameters in some of the cumulus convection parameterization (CCP) schemes is the convective adjustment time scale (τ). Yet there exists no generalized τ formulation that can be used in these CCP schemes for regional and global models as well as with measurements. To address this critical research need, for continental convection I have developed a generalized and scale-aware dynamic formulation to estimate convective adjustment time scale for CCP schemes as well as for observational studies. First, appropriate length and velocity scales for subcloud and cloud layers are identified. For subcloud layer, its depth is considered as the length scale and the velocity scale is based on turbulent kinetic energy. For cloud layers, the depth of a cumulus cloud is used as length scale while a simplified form of Arakawa and Schubert's cloud work function is used to derive the velocity scale. Then, a scale-aware convective adjustment time scale (τ) formulation for cumulus convection for shallow and deep clouds is developed as a turn-over timescale that depends on the ratio of length scale and velocity scale (simplified cloud work function). Key features of the τ formulation are: (1) it can be used in any mass flux or convective adjustment type of CCP schemes; (2) it has scale-awareness; and (3) it responds to the stabilization of subcloud layer as well as cloud layer. Various measurement data available from the TWP-ICE and MC3 experiments are used for the estimation of τ. It is found that τ can vary from about 30 minutes to about 3 hours depending on the depth of a shallow/deep convective cloud observed during the TWP-ICE and MC3 experiments' periods. Further, results obtained from a regional climate model simulations using the proposed τ formulation also indicated similar range of τ variability. Pertinent climate parameters as well as simulated surface precipitation are evaluated using corresponding observations and these results will be presented.

Abstract ID: 34463

Final Number: AS44B-0040

Title: Observational estimates of entrainment rate in convective clouds

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Co-authors: Tami Toto, Brookhaven National Laboratory, Upton, NY; Pavlos Kollias, McGill University, Montreal, QC, Canada; Chunsong Lu, NUIST Nanjing University of Information Science and Technology, Nanjing, China

Published Material: Some of the initial results were reported at 2014 ASR PI meeting

Abstract Body: The mixing of environmental air across the cloud interface plays a significant role in the lifecycle of the convective cloud system and subsequent influences on the hydrological and energy cycles. Despite its importance, the entrainment process remains poorly understood and its measurement and its quantification is extremely difficult. We present a remote sensing technique that builds upon previous aircraft in-situ based techniques (Lu et al. 2012) in order to estimate the vertical profile of entrainment rate. The profile of vertical velocity observed by the Ka-band ARM Zenith Radar (KAZR) is used with an adiabatic parcel model that incorporates conservation of total water and energy in the retrieval algorithm. This initial study concentrates on five years of non-precipitating cumulus observations over the ARM SGP site, where radar-based observations of mean Doppler velocity are a reasonable proxy for the in-cloud air motion. A preliminary application of the methodology has shown reasonable agreement with simple bulk entrainment estimates using an entraining plume model (Jensen et al. 2006).

Abstract ID: 34681

Final Number: AS44B-0041

Title: Climatology of Boundary Layer Depth over the US Southern Great Plains

Presenter/First Author: Virendra P Ghate, Argonne National Laboratory, Argonne, IL

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Co-authors: Pavlos Kollias, McGill University, Montreal, QC, Canada; Richard Coulter, , ,

Abstract Body: The boundary layer (BL) is an important link between the surface and free troposphere that heavily modulates the transport of energy and momentum between them. In a convective environment clouds often form on the top of the mixed layer providing a constraint on the radiative heating of the surface and the energy transport. The BL over land also exhibits considerable changes (in structure, depth etc.) on diurnal, seasonal and annual timescales. In this study we have used long-term (~20 years) data collected at the Atmospheric Radiation Measurement (ARM)'s Southern Great Plains (SGP) observational facility near Lamont, Oklahoma that has been operational since October, 1993. The Radar Wind Profiler (RWP) operating at 915 MHz frequency made observations of the raw Doppler spectrum and its moments continuously (>80% uptime) at a 60 m and 30 second resolution. These observations were used to deduce BL depth on hourly time-scales from which it's diurnal, seasonal and annual cycles were deduced. The data collected by collocated instruments like the ceilometer, microwave radiometer, flux suite and met system were also used to characterize environmental conditions.

We will present the diurnal, seasonal and annual cycle of the RWP derived BL depth in the context of the environmental conditions as observed over the US Southern Great Plains.

Abstract ID: 34976

Final Number: AS44B-0042

Title: Characterizing Long-Term Observations of Convective Clouds from Combined ARM Profiling Radar and Lidar Measurements

Presenter/First Author: Karen L Johnson, Brookhaven National Laboratory, Upton, NY

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Co-authors: Michael P Jensen, Brookhaven National Laboratory, Centerport, NY; Shannon Baxter, SUNY at Geneseo, Geneseo, NY; Tami Toto, Brookhaven National Laboratory, Upton, NY; Meng Wang, Brookhaven National Laboratory, Upton, NY; Pavlos Kollias, McGill University, Montreal, QC, Canada; Eugene Edmund Clothiaux, Penn State, University Park, PA

Abstract Body: The U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) program has continuously operated profiling cloud radars and micropulse lidars at five fixed sites, for periods ranging from eight to nineteen years. The sites include the U.S. southern Great Plains, the Alaska North Slope and three Tropical Western Pacific locations. The radar and lidar observations, along with ceilometer and precipitation measurements, have been synthesized using ARM's Active Remote Sensing of Clouds (ARSCL) value-added product, which provides cloud boundaries and best-estimate radar reflectivities, mean Doppler velocities and spectral widths. The product's time resolution ranges from 10 seconds down to 4 seconds, with height resolution of 45 meters or better. Through its use in retrievals of cloud microphysics and dynamics, this high-resolution, long-term data set has the potential to make major contributions toward improved cloud representations in climate models and the understanding of cloud processes. However, it is essential that data set quality and accuracy be assessed and made available to data users in order to maximize utility and reliability.

In this study, we apply a variety of approaches to characterize observation quality throughout the ARSCL data record at each site with a particular emphasis on the characterization of convective cloud types. We describe instrument availability and radar operating status and possible issues. Radar sensitivity is tracked as a function of time through cirrus detection statistics as well as changes in radar signal saturation level over time. We also examine noise and insect clutter reflectivity levels as possible surrogates for radar calibration changes. We assess the impacts of changes in radar sensitivity and proxy calibration changes on convective cloud property statistics and provide valuable guidance to potential data users, for both case-study research and long-term climatological applications.

Abstract ID: 36040

Final Number: AS44B-0043

Title: Organization of subcloud layer for different cloud regimes

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Co-authors: Pavlos Kollias, McGill University, Montreal, QC, Canada; Chidong Zhang, Univ Miami-RSMAS/MPO, Miami, FL

Abstract Body: Convective boundary layer acts as an interface for transporting fluxes of scalars (heat, moisture, pollutants, etc.) and momentum from the surface into the depth of the atmosphere. Most of the transport in the CBL takes place through the large eddies (coherent structures). The spatial structure and growth of eddy length scales in the sub cloud layer influence the cloud layer and vice-versa. Some of the cloud parameterizations utilize length scales in the sub cloud layer to parameterize various cloud variables. Most of these parameterizations are based on the LES model data and they have hard time capturing the realistic cloud regimes. Recent model studies have suggested that the organization of the sub cloud layer is different for various cloud-topped conditions. These studies aimed test these model results and to further understand the role of sub cloud layer organization under different cloud regimes. Long-term statistics of the sub cloud layer length scales and their variability are documented for various cloud regimes using the observations at the DOE ARM sites.

Abstract ID: 36017

Final Number: AS44B-0044

Title: Aging Species of Atmospheric Particles with Height: Implications to Cloud Microphysics

Presenter/First Author: Ajit SINGH Ahlawat, National Physical Laboratory, Jhajjar,

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Abstract Body: Aging Species of Atmospheric Particles with Height: Implications to Cloud Microphysics

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ABSTRACT:

Atmospheric particles have great impacts on different scales spanning from regional to global climate change (Watson et al., 2002). Aerosol plays an important role as the cloud condensation nuclei based on their composition and complex mixing states. Most of the observations pertaining to aerosol physico-chemical characteristics are limited to ground level observations. The altitude variation of the same (balloon based) is extremely limited (Zhang et al., 2012; Hara et al., 2013). The aged aerosols show enhanced ability of serving as nuclei for droplet formation and finally affect the radiative properties of clouds (Moteki et al., 2007).

To the best of our knowledge, there is no detailed study of aerosol aging information with varying altitude over India. To study the physico-chemical properties of aerosols with varying altitude, a tethered balloon based field campaign have been organized in National Physical Laboratory campus (28° 38′ 10′′N, 77° 10′ 17′′E) from 21-27 Feb, 2014 (Mishra et al., 2014). TOF-SIMS (Time of Flight-Secondary Ion Mass Spectrometry) was used to study the aging chemicals of aerosols collected at various altitudes. Samples were collected from ground level to 700m (total six altitudes). At 200m altitude, the particles were found to be heavily aged with aliphatic hydrocarbons which are fragments of tails of aliphatic amide group. Peterson and Tyler (2003) have already shown that the aging of aerosol with aliphatic amides may be of critical importance for cloud droplet formation. Together with hydrocarbons, particles were also found to be aged with $HSO4^-$, $SO3^-$ and Cl^- at 200 m altitude. The strong temperature inversion and air parcel movement from IGP (Indo Gangetic Plain) are the probable reason for enhanced aging of aerosols at this altitude. Implications of the observed aging with varying altitude to the cloud microphysics will be discussed during presentation.

ACKNOWLEDGEMENTS

Authors acknowledge CSIR Network Project AIM_IGPHim (PSC-0112) for the financial support and TIFR Balloon Facility for the tethered hoisting.

Abstract ID: 35266

Final Number: AS44B-0045

Title: Covariability in the monthly mean convective and radiative diurnal cycles in the Amazon

Presenter/First Author: Jason Brant Dodson, NASA Langley Research Center, Hampton, VA

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Abstract Body: The diurnal cycle of convective clouds greatly influences the radiative energy balance in convectively active regions of Earth, through both direct presence and the production of anvil and stratiform clouds. Previous studies show that the frequency and properties of convective clouds can vary on monthly timescales as a result of variability in the monthly mean atmospheric state. Furthermore, the top-of-atmospheric radiative budget in convectively active regions varies by up to 7 Wm^{-2}. These facts suggest that convective clouds connect atmospheric state and radiation variability beyond clear sky effects alone.

Previous research has identified monthly covariability between the diurnal cycle of CERES-observed top-of-atmospheric radiative fluxes and multiple atmospheric state variables (ASVs) from reanalysis over the Amazon region. ASVs that enhance (reduce) deep convection, such as convective available potential energy (lower tropospheric stability), tend to shift the daily outgoing longwave radiation and cloud albedo maxima earlier (later) in the day by 2-3 hr. We first test the analysis method using multiple reanalysis products for both the dry and wet seasons to investigate the robustness of the previous results. We find general qualitative agreement between multiple reanalysis products, though the amplitude of the effect can vary by 50%. The seasonal results show the importance of both the cloud and clear-sky effects in determining the shift in the radiative diurnal cycle.

We then use CloudSat as an independent cloud observing system to further evaluate the relationships of cloud properties to variability in radiation and ASVs. While CERES can decompose OLR variability into clear sky and cloud effects, it cannot determine what variability in cloud properties (e.g. cloud cover, height, and microphysics) lead to variability in the radiative cloud effects. CloudSat observes these cloud properties, as well as the presence and variability of deep convective cores responsible for anvil clouds. While CloudSat cannot sample the full diurnal cycle, it can observe changes between early morning and early afternoon, such as the higher convective intensity of daytime versus nighttime. We use these capabilities to determine the covariability of convective cloud properties, ASVs, and the radiative diurnal cycle.

Abstract ID: 35101

Final Number: AS44B-0046

Title: Insights Into Precipitation Processes As Revealed By Profiling Radar, Disdrometer and Aircraft Observations During The MC3E Campaign.

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Co-authors: Tami Toto, Brookhaven National Laboratory, Upton, NY; Aaron Bansemer, National Center for Atmospheric Research, Boulder, CO; Matthew Kumjian, Pennsylvania State University Main Campus, University Park, PA; Alexander Ryzhkov, Cooperative Institute for Mesoscale Meteorological Studies, Norman, OK

Published Material: 2014 AGU Fall Meeting Poster; However, was unable to attend;

Abstract Body: The Midlatitude Continental Convective Clouds Experiment (MC3E) was a collaborative campaign led by the National Aeronautic and Space Administration's (NASA's) Global Precipitation Measurement (GPM) mission and the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program. This campaign was held at the DOE ARM Southern Great Plains (SGP) Central Facility (CF) in north-central Oklahoma, with the programs joining forces to deploy an extensive array of airborne, radiosonde and ground-based instrumentation towards an unprecedented set of deep convective environment and cloud property observations. An overarching motivation was to capitalize on the wealth of aircraft observations and new multi-frequency dual-polarization radars to provide insights for improving the treatments of cloud processes in convective models.

This study considers a coupled aircraft, radar and surface disdrometer approach for identifying key cloud processes and linking those to possible radar-based microphysical fingerprints and/or cloud properties. Our emphasis is on the MC3E observations from April 27th, 2011 and collected during successive aircraft spirals over the column of the ARM CF. We investigate the usefulness of radar to inform on processes including aggregation and riming as viewed by vertically-pointing ARM wind profiler (915 MHz) and cloud radar Doppler spectral observations (35 GHz). Corresponding dual-polarization radar signatures from the nearby cm-wavelength radar are also consulted for complementary insights. For this event, the successive Citation II aircraft spirals through the melting layer and associated ground observations indicate a fortunate capture of the transition from a region of weak embedded updrafts and riming to one favoring aggregation processes more typical of the trailing stratiform shield of this event.

Abstract ID: 34310

Final Number: AS44B-0047

Title: A Summary of Convective Cloud Updrafts Observed during the MC3E by the ARM SGP Precipitation Radar Network

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Abstract Body: Our understanding of convective clouds and their associated updrafts is vital to the progress and improvement of numerical weather and climate models. To this date, cloud resolving models (CRMs), which have recently been used as a benchmark for global circulation models (GCMs), are known to have nontrivial issues with their treatment of convection, including the significant overestimation of updraft strength in the upper 7-15 km of the atmosphere. However, there is a noticeable measurement gap in convective cloud observations, in particular the vertical air motion of these systems. Historically, in situ aircraft and profiling radars have been regarded as the most robust observational data sets for convective clouds, but these data sets offer only a limited footprint of the convective system being sampled. The U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program's network of scanning Doppler precipitation radars at its Southern Great Plains (SGP) site can help bridge this measurement gap by providing coordinated, high resolution radial velocity observations of convective clouds over a large area (e.g., 10,000 km^2). A 3D variational (3D-VAR) algorithm is then used to estimate the 3D wind field through the minimization of a cost function defined by these radial velocity observations, mass continuity, and other a priori constraints. Using a data set covering roughly 15 hours worth of observations from the Midlatitude Continental Convective Clouds Experiment (MC3E), we map individual convective updraft cores in three dimensions and document important properties such as their depth, projected area, volume, aspect ratio, and mass flux. This type of analysis can be reproduced on numerical model output, the results of which can be compared with their observational targets as a means to provide further constraints on convective parameterization schemes.

BIOGEOSCIENCES

Abstract ID: 34026

Final Number: B11A-01

Title: Methane Emissions from rice paddies, natural wetlands, and lakes in China: Synthesis and New Estimate

Presenter/First Author: Huai Chen, Chinese Academy of Sciences, Chendu,

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Published Material: Major results were published in Global Change Biology.

Abstract Body: Methane Emissions from rice paddies, natural wetlands, and lakes in China: Synthesis and New Estimate

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Abstract: Sources of methane (CH_4) become highly variable for countries undergoing a heightened period of development due to both human activity and climate change. An urgent need therefore exists to budget key sources of CH_4, such as wetlands and lakes , which are sensitive to these changes. For this study, references in relation to CH_4 emissions from rice paddies, natural wetlands, and lakes in China were first reviewed and then re-estimated based upon the review itself. Total emissions from the three CH_4 sources were 11.25 Tg CH_4 yr^{-1}. Among the emissions, 8.11 Tg CH_4 yr^{-1} derived from rice paddies, 2.69 Tg CH_4 yr^{-1} from naturalwetlands, and 0.46 Tg CH_4 yr^{-1} from lakes Plentiful water and warm conditions, as well as it large rice paddy area make rice paddies in southeastern China the greatest overall source of CH_4, accounting for approximately 55% of total paddy emissions. Natural wetland estimates were slightly higher than the other estimates owing to the higher CH_4 emissions recorded within Qinghai-Tibetan Plateau peatlands. Total CH_4 emissions from lakes were estimated for the first time by this study, with three quarters from the littoral zone and one quarter from lake surfaces. Rice paddies, natural wetlands, and lakes are not constant sources of CH_4 but decreasing ones influenced by anthropogenic activity and climate change. A new progress-based model used in conjunction with more observations through model-data fusion approach could help obtain better estimates and insights with regard to CH_4emissions deriving from wetlands and lakes in China.

Abstract ID: 34360

Final Number: B11A-02

Title: CH_4 flux changes with permafrost thaw in a subarctic peatland

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Abstract Body: To assess peatland CH_4 flux changes with permafrost thaw, intensive field research was conducted across transect from intact palsas, through thawed internal lawns, to pond sedges and thawed ponds in a subarctic peatland in north Quebec in the growing seasons of 2013 and 2014. From dry to wet areas, shrub and herb abundance and biomass declined, but sedges increased. Pore water pH increased, and N supply rates decreased (PRS™-probe), but K increased and P was similar along the transect. Chamber measurements showed that the palsa was the only CH_4 sink, and CH_4 emissions significantly increased in thaw areas, correlated with dissolved CH_4 concentrations in 10 cm pore water. Seasonal CH_4 efflux of each site could be modeled by 10 cm temperature, water table and sedge biomass. Seasonal average CH_4 exchange rates ranged from -0.23 mmol m^{-2} d^{-1} at the dry palsa to 13.32 mmol m^{-2} d^{-1} at sedges sites, with the largest emissions in the later part of growing season. The contribution of CH_4-C to net ecosystem exchange significantly increased from dry to wet sites, which greatly enforced radiation effect to atmosphere in thaw areas, and even changed the sedges sites from "cooling to heating". The thaw area with more sedges had much stronger gross ecosystem production, more liable fatty acid in root exudates, more labile pore water DOC, and emitted more CH_4. The effects of DOC mass and biodegradability, labile exudates and gross ecosystem production rather than net ecosystem exchange were correlated with CH_4 effluxes across the transect. This link suggests that vegetation activity and composition change with permafrost thaw dominates changes in CH_4 emission in subarctic peatland.

Abstract ID: 34993

Final Number: B11A-03

Title: Ecosystem-scale Methane Fluxes at Mer Bleue Bog

Presenter/First Author: Elyn Humphreys, Carleton University, Ottawa, ON

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Co-authors: Peter Lafleur, Trent University, Peterborough, ON, Canada; Tim R Moore, McGill Univ, Montreal, QC, Canada; Nigel T Roulet, McGill University, Montreal, QC, Canada

Published Material: The first two years of this four-year dataset are published: Brown, M. G., E. R. Humphreys, T. R. Moore, N. T. Roulet, and P. M. Lafleur. 2014. Evidence for a nonmonotonic relationship between ecosystem-scale peatland methane emissions and water table depth, J. Geophys. Res. Biogeosci., 119, doi:10.1002/2013JG002576.

Abstract Body: The relationship between water table position and methane emissions in a wetland is a result of a complex interaction between methane production, storage and transport processes. After two years of growing season eddy-covariance methane flux measurements at Mer Bleue, a temperate ombrotrophic bog, we made a number of key observations. Methane fluxes were small at Mer Bleue with average daily fluxes of ~ 20 mg CH_4-C m^{-2} d^{-1} but with considerable day-to-day variability. Fluxes generally increased as the water table fell to 47 cm depth (just past the long-term average water table position for the bog at 43 cm), there was hysteresis in the relationship between methane fluxes and water table position, and after a long mid-summer dry period in 2012, methane fluxes dropped and did not recover that year. Since that original analysis, an additional two years of measurements have been collected. Methane fluxes in 2013 did recover after the 2012 drought and continued to follow the patterns observed from the previous two years . 2014 however was an exceptionally wet summer and the water table remained above 43 cm. Summer methane emissions were greater than in previous years presumably due to conditions that enhanced both methane production and transport.

Abstract ID: 34378

Final Number: B11A-04

Title: Mitigation Options for CH_4 and N_2O Emissions from Rice Field in China : A Meta Analysis

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Co-authors: Changhui Peng, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Yu'e Li, , ,

Abstract Body: The planted paddy in China is a critical source of CH_4 and N_2O emissions to the atmosphere. Implement practices to reduce CH_4 and N_2O emissions will benefits for not only grain productivity and yield stability but also climate change mitigation. Here we performed a meta-analysis of CH_4 and N_2O emissions to quantify the mitigation potential of each management practice (water management, organic fertilizer, N input ratio etc.). The results showed that the CH_4 emissions under water management of flooding-drainage-reflooding(F-D-F), flooding-drainage-reflooding-moist intermittent irrigation(F-D-F-M) and moister irrigation (M) was reduced by 45%, 59% and 83%, respectively, comparing with that under continuously flooded (CF). The water status of non-growing season also significantly enfluenced on CH_4 emission, e.g. the CH_4 emission was reduced by 42% for short drainage, by 51% for long drainage, and by 56% for tow drainage compared to containable flooded in non-growing season, respectively. The ability of organic fertilizer to produce CH_4 emission followed an order of crop straw > farm manure > green manure > biogas digestion. The CH_4 emission was decreasing gradually with increasing chemical nitrogen fertilizer ratio. The water management regimes in rice growing period and the non-growing season, and total nitrogen fertilizer input both influenced N_2O emission. Compared to CF, the N_2O emission was increased by 12% under F-D-F, by 140% under F-D-F-M and by 48% under M. The mean N_2O emission fluxes was increased by 40% ~110% under water status of short drainage, long drainage and tow drainage in the non-rice growing season A trade-off relationship between emission of CH_4 and N_2O in rice field appeared as water management regimes in rice growing period, water status of non-rice growing season, and the amount of synthetic nitrogen fertilizer. Mitigation measurements in rice fields should be taken into consideration for both of CH_4 and N_2O emissions comprehensively.

Abstract ID: 34034

Final Number: B11A-05

Title: Estimating global natural wetland methane emissions using process modeling: spatiotemporal patterns and contributions to atmospheric methane fluctuations

Presenter/First Author: Qiuan Zhu, Northwest A&F University, Yangling,

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Published Material: some results were under review

Abstract Body: The fluctuations of atmospheric methane (CH_4) in recent decades are not fully understood, particularly regarding contributions by wetlands. Application of spatially explicit parameters has been suggested to be an effective method for reducing uncertainties in bottom-up approaches for wetland CH_4 emissions, but not being included in recent studies. Our goal was to estimate spatiotemporal patterns of global wetland CH_4 emissions using the process model of TRIPLEX-GHG and then to identify the contribution of wetland emissions to atmospheric CH_4 fluctuations. A newly developed process-based model integrated with full descriptions of methanogenesis (TRIPLEX-GHG) was applied to simulate global wetland CH_4 emissions. The simulation results showed that: Global annual wetland CH_4 emissions ranged from 155 $TgCyr^{-1}$ to 185 $TgCyr^{-1}$ between 1901 and 2012, with peaks occurring in 1991 and 2012. There is a decreasing trend between 1990 and 2010 with a rate of approximately 0.36 $TgCyr^{-1}$, which was largely caused by tropical wetlands emissions that have a decreasing trend of 0.33 $TgCyr^{-1}$ since the 1970s. Emissions from tropical, temperate, and high latitude wetlands comprised 59%, 26% and 15% of global emissions, respectively. Tropical wetlands are the primary contributors to the inter-annual variability of global wetland CH_4 emissions and atmospheric CH_4. The stable-to-decreasing trend in wetland CH_4 emissions, which resulted from a balance of emissions from tropical and extratropical wetlands, was a factor particularly for the slow-down in the atmospheric CH_4 growth rate during the 1990s. The rapid decrease in tropical wetland CH_4 emissions that started in 2000 is supposed to offset the increase in anthropogenic emissions, and resulted in a relatively stable level of atmospheric CH_4 during the period 2000–2006. Increasing wetland CH_4 emissions, particularly after 2010, are an important contributor to the resumed growth of atmospheric CH_4 since 2007 and to the expected increases in the near future.

Abstract ID: 33370

Final Number: B11A-06

Title: Estimates of CH_4 Emissions from Natural Wetlands in China: From 1950 to 2008

Presenter/First Author: Tingting Li, Institute of Atmospheric Physics, Chinese Academy of Science, Beijing,

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Co-authors: Yao Huang, , ,

Published Material: This presentation has been preciously reported in AOGS conference in 2014. It will be submitted to Global Change Biology in recent days.

Abstract Body: Natural wetland loss has been one of the potential environmental concerns in China, while less attention was paid to concomitant changes in methane (CH_4) emissions. In this paper, we developed a model framework based on a biogeophysical model $CH4MOD_{wetland}$, which was firstly modified to apply to the coastal wetland. Then it was coupled with TOPMODEL and TEM model in order to extrapolate to the regional scale. We estimated national CH_4 emissions resulting from the natural wetlands in China in 1950, 1978, 1990, 2000 and 2008 based on the model framework. Model simulations indicated that annual CH_4 emissions decreased from 4.50 Tg (3.74—5.37 Tg) in 1950 to 2.15 Tg (1.83—2.56 Tg) in 2008. Tremendous decrease of 2.33 Tg in CH_4 emissions happened before 2000, with wetland loss of 16.28 M ha. Among the reduction, 0.26 Tg (0.24—0.28 Tg) derived from lakes and rivers, 0.17 Tg (0.13—0.20 Tg) from coastal wetlands, and 1.92 Tg (1.54—2.33 Tg) from the inland wetlands, including marshes, floodplains, peatlands and swamps. The wetlands in northeastern China contributed ~71% to the total CH_4 reduction. Slight wetland loss happened in the Qinghai Tibet Plateau, where contributed only ~6% of total CH_4 reduction. Climate warming increased CH_4 fluxes, especially in the inland wetlands of northeastern China between 1950 and 2008. Our study implies that the increase of CH_4 fluxes will be different between Regions in future.

Abstract ID: 33691

Final Number: B11A-07

Title: Predicting the impacts of repeated El Niño Southern Oscillation (ENSO) on the methane emissions of tropical wetlands

Presenter/First Author: Changhui Peng, University of Quebec at Montreal UQAM, Montreal, QC

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Abstract Body: Methane emission from tropical/subtropical wetlands contributed about 78% methane emissions of global nature wetlands. Decreased wetland CH_4 emissions could act as a negative feedback to future climate warming and vice versa. Recent study suggested that powerful warming events in the eastern equatorial region, known as El Niños, are likely to double as greenhouse-gas emissions rise this century. However, the impact of ENSO on wetland emission variability has been paid less attention and remained poorly quantified at both regional and global scales. Here, we used an improved global greenhouse gases dynamic model of TRIPLEX-GHG to investigate the impacts of interannual variations on CH_4 emissions in tropical wetlands during the period 1950 to 2010. Our modeled results suggest that CH_4 emissions from tropical wetlands respond strongly, with larger negative anomalies during El Niño years and larger positive anomalies in La Niña years, to repeated ENSO events throughout 1950s- 2000s, which has probably contributed to the recent decrease in the atmospheric growth rate of CH_4 concentration during 1980s-1990s and stabilized observed atmospheric CH4 concentrations during 1999-2006.

Abstract ID: 36755

Final Number: B12A-01

Title: Communicating Climate Risk to Natural Resource Managers

Presenter/First Author: Richard N Palmer, , Amherst, MA

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Abstract Body: The Northeast Climate Science Center (NECSC) is one of eight centers funded by the Department of Interior through the USGS to work with regional stakeholders to evaluate the impacts of climate change on natural resource management. The NECSC in housed at the University of Massachusetts Amherst and is composed of a consortium of institutions including the University of Wisconsin Madison, University of Minnesota, University of Missouri, Columbia University, the College of Menominee Nation, and the Marine Biology Laboratory. The geographic extent of the Center ranges from Maine to Virginia to Missouri to Minnesota. The goal of the center is to provide scientific information, tools, and techniques that managers and other parties interested in land, water, wildlife and cultural resources can use to anticipate, monitor, and adapt to climate change in the Northeast region.

Essential to this goal is the delivery climate projections that allow resource managers to make decisions at local and regional levels that are well-informed relative to future climate conditions. This challenge is complicated by a variety of uncertainties including those associated with future greenhouse gas levels, the current limitations and biases of general circulation and regional climate models, the relationship of climate change to species and ecosystems of interest, and limitation on our ability to model complex biological systems.

This paper discusses how the NECSC has approached these challenges in our efforts to support regional nature resource management. A combination of regional climate projections, stakeholder engagement, and improved science communication has been applied to ensure that the results generated provide users with management relevant variables, that recent historic trends as well as climate projects inform our understanding, and that the uncertainties associated with all stages of impact analysis are clearly understood by stakeholders.

Abstract ID: 35098

Final Number: B12A-02

Title: Evaluating Statistical Downscaling Performance Under Changing Climatic Conditions

Presenter/First Author: Keith W Dixon, NOAA, Princeton, NJ

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Co-authors: John R Lanzante, NOAA, Princeton, NJ; Carlos F Gaitan, University of Oklahoma Norman Campus, Norman, OK; Katharine Hayhoe, Texas Tech University, Lubbock, TX; Anne Marie K Stoner, Texas Tech University, Lubbock, TX

Published Material: The introduction & experimental design will be similar to work presented at an AMS meeting and an NCPP workshop, but that info has not appeared in a journal or in the media. Results are mostly new.

Abstract Body: A broad range of empirical statistical downscaling (ESD) methods of varying levels of complexity exist, all of which may be used to refine Global Climate Model (GCM) projections via processes that glean information from a combination of observations and GCM-simulated climate change responses. ESD output files are viewed as value-added products – deemed to be more suitable for downstream applications than the raw GCM results from which they are derived. Yet, different ESD methods have different performance characteristics, indicating that ESD processing introduces uncertainties of its own. Often, assumptions that may limit the suitability of statistically downscaled projections for specific decision-support applications are not well-conveyed to researchers interested in incorporating high resolution climate projections into regional climate change impacts studies. We are developing a framework to systematically evaluate performance characteristics of ESD methods. For example, there is an inherent stationarity assumption that presumes ESD techniques perform as well in the future as during the observed period – a difficult to evaluate assumption, given the lack of future observations. A "perfect model" experimental design quantifies aspects of ESD method performance both for a historical period and for late 21st century climate projections, thereby quantitatively assessing how well the stationarity assumption holds. Results illustrate how ESD performance varies geographically, by time of year, variable of interest, amount of climate change, and is dependent upon the specific ESD method used. By revealing sensitivities, strengths and weaknesses, these evaluations contribute to inform ESD method improvements and can provide guidance regarding aspects of the confidence one should attribute to different statistically downscaled climate projections used for regional climate change impacts studies.

Abstract ID: 34648

Final Number: B12A-03

Title: Quantifying Climate Change Impacts on Infrastructure: A Statistical Downscaling Application

Presenter/First Author: Anne Marie K Stoner, Texas Tech University, Urbana, IL

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Co-authors: Katharine Hayhoe, Texas Tech University, Lubbock, TX

Abstract Body: Over the coming century, climate change has the potential to impact infrastructure in many different ways, particularly in population-dense areas that depend on transportation and built environments. Many of these impacts may occur via changes in the frequency and magnitude of extremes: high and low temperature, precipitation, coastal flooding, and storm events.

In some cases, it is not yet possible to quantify how global change will affect local extremes, and/or how climate change might impact society. At the same time, resilience can be built into planning through preparing for conditions that already occur: tornadoes, derechoes, or even extreme thunderstorms. For other applications, simply the direction of change is sufficient to inform future planning: will hurricanes become stronger, or winter storms more or less frequent? For some impacts, though, particularly those that show significant historical trends as well as consistent future change and quantifiable impacts, it is possible to resolve both projected changes as well as impacts under a given scenario.

In this presentation, we describe a framework for developing and implementing future projections using the example of a set of infrastructure-relevant climate indices for the state of Delaware, USA. The indices are based on mean and extreme temperature, precipitation, humidity, and combinations thereof calculated from GCM simulations from nine models corresponding to a lower and a higher scenario, statistically downscaled to 14 individual station records using the ARRM model. We also describe the process of selecting an appropriate subset of GCMs and future scenarios, as well as how to extract useful information from a large selection of downscaled output with associated uncertainties. The results highlight the importance of including future climate projections into infrastructure planning, as opposed to using the past as a guide when planning for the future.

Abstract ID: 34686

Final Number: B12A-04

Title: From range retraction to population cycling: How spatially-explicit demographic models can inform climate change vulnerability

Presenter/First Author: Benjamin Zuckerberg, University of Wisconsin Madison, Madison, WI

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Co-authors: Ilona Naujokaitis-Lewis, , , ; Lars Pomara, , ,

Published Material: Midwest Fish and Wildlife ConferencePomara, L.Y., O.E. LeDee, K.J. Martin, and B. Zuckerberg. 2014. Demographic consequences of climate change and land cover help explain a history of extirpations and range contraction in a declining snake species. Global Change Biology 20: 2087-2099

Abstract Body: Adaptation to climate change requires understanding species vulnerabilities in terms of demographic sensitivity and exposure to climatic and other environmental factors across full life cycles and in diverse landscapes. As part of an ongoing project, we present findings from two case studies using spatially-explicit demographic modeling to assess the vulnerability of Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) and Ruffed Grouse (*Bonasa umbellus*) to climate change in the upper Midwest and Great Lakes region of the United States. Results from multiple survival and reproductive success studies were used to identify demographic sensitivities to several climatic and land use factors. We then used these relationships to parameterize demographic simulations with dynamic climate and land use from 1960 to 2012, and evaluated the resulting population models by comparison to long-term and spatially extensive monitoring datasets. Our modeling framework is implemented in a region showing marked variation in habitat connectivity and climatic conditions; allowing for a quantitative assessment of the relative influence of these factors on long-term population dynamics and geographic distributions. We highlight several important findings demonstrating the role of climate and land use on long-term range contraction in massasauga rattlesnakes and altered dynamics of population cycling in ruffed grouse. Both analyses are critical examples of the role of variation in temperature and precipitation extremes, synergistic effect of climate and land use change, and the importance of considering the full life cycle of vulnerable species. Climate change vulnerability assessment provides a framework for linking demographic and distributional dynamics to environmental change, and can provide unique information for conservation planning.

Abstract ID: 35814

Final Number: B12A-05

Title: Reconciling scales for modeling the effects of climate change on wildfire

Presenter/First Author: Uma Shankar, University of North Carolina, Chapel Hill, NC

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Co-authors: Donald McKenzie, US Forest Service, Pacific Wildland Fire Sciences, Seattle, WA; Jared Heath Bowden, University of North Carolina at Chapel Hill, Chapel Hill, NC; Kevin Talgo, , , ; Limei Ran, University of North Carolina at Chapel Hill, Chapel Hill, NC; Bok Haeng Baek, , , ; Zachariah Adelman, Institute for the Environment, Chapel Hill, NC; Aijun Xiu, , , ; Mohammad Omary, , , ; Elizabeth A Adams, , Cary, NC; Dongmei Yang, , ,

Published Material: A review article co-authored by the first and second authors was published under the title "Smoke consequences of wildfire regimes driven by climate change" in the AGU online journal Earth's Future (McKenzie et al., Earth's Future, 2, 35-59, 2014). It describes the issues of scale associated with earth system models that are used to study the effects of climate change on wildfires. However it did not present the results of the modeling study described in this submission; the study began after that publication.

Abstract Body: Smoke from wildfires has adverse biological and social consequences, and various lines of evidence suggest that smoke from wildfires in the future may be more intense and widespread, demanding that methods be developed to address its effects on people, ecosystems, and the atmosphere. Projecting smoke consequences of future wildfires requires a multidisciplinary approach that involves reconciling complex physical and biological processes at widely different scales in space and time. We review the most difficult scaling issues, which include: (1) reconciling regional-scale atmospheric processes with fine-scale fire-spread dynamics and variation in fuel loadings, (2) translating contagious disturbance (fire) across landscapes in varying topography into estimates of regional smoke transport, and (3) identifying the feasibility of coupled modeling that incorporates important feedbacks vs. a simpler approach that may be less error-prone for integrating modules at different scales. We illustrate model linkages and tradeoffs with results from an ongoing study of climate change, wildfire, and air quality in the Southeastern US. This study dynamically downscales general circulation model (GCM) output to model the regional climate, and includes vegetation from coupling land cover to the GCMs; empirical fuel loadings at fine scales, projected into the 2040s with a delta method; a stochastic coarse-scale fire generator, and regional air quality assessments of the fire emission impacts with the Community Multiscale Air Quality (CMAQ) model. There are considerable challenges in representing future climatic variability important for fire while keeping computations feasible, but also in two efforts associated explicitly with reconciling processes across scales. First, how can coarse-scale carbon pools generated by the global model be translated into the fine-scale fuel characteristics that are critical for modeling fire? Second, how can fine-scale variation in fire activity associated with the spatial patterns of topography and vegetation (fuels) be aggregated meaningfully to produce regional projections?

Abstract ID: 34938

Final Number: B12A-06

Title: *Cross Site Analysis of Projections of the Biogeochemical Responses of Forested Watersheds in the Northeastern U.S. to Future Climate Change and Increasing CO_2 over the 21st Century Using a Dynamic Model (PnET-BGC)*

Presenter/First Author: Charles T Driscoll, Syracuse Univ, Syracuse, NY

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Co-authors: Afshin Pourmokhtarian, Boston University, Boston, MA; John L Campbell, USDA Forest Service, Vallejo, CA; Anne Marie K Stoner, Texas Tech University, Urbana, IL; Katharine Hayhoe, Texas Tech University, Lubbock, TX

Abstract Body: A cross-site analysis of seven diverse, intensive study watersheds was conducted to evaluate how northeastern U.S. forests might respond to future changing climate. We used outputs of four AOGCMs; CCSM4, HadGEM2, MIROC5, and MRI-CGCM3 coupled with RCP8.5 and RCP4.5 emissions scenarios to represent possible higher- and lower-emission futures, respectively. These outputs were statistically downscaled using ARRM trained on meteorological observations from watershed stations. Meteorological projections were applied as inputs to the hydrochemical model PnET-BGC to evaluate the response of watershed attributes of management-relevant ecosystem services (NPP, soil C, stream water quantity and quality). Evapotranspiration (ET) is projected to increase across all sites under potential future conditions of warmer temperature and longer growing season. Spruce-fir forests are more susceptible to temperature stress due to their lower optimum temperature for photosynthesis and may be replaced in the future with more tolerant hardwoods. Some hardwood forests are projected to experience water stress due to early loss of snowpack, longer growing season and associated water deficit. This response is counter-intuitive to the anticipated increase in precipitation. The streamflow projections are highly variable with some sites showing significant increases in annual water yield, while others decrease. This variability in hydrologic response could challenge the future management of the Northern Forest. Following increases in temperature, ET and water stress associated with future climate change scenarios, a shifting pattern in carbon allocation in plants was evident causing significant changes in NPP. The soil humus C pool is projected to decrease with increases in temperature. This analysis suggests that dominant vegetation type and historical land disturbances coupled with climate variability will influence responses of forest ecosystem services to future changes in climate.

Abstract ID: 35815

Final Number: B12A-08

Title: Simulating Pacific Northwest Forest Response to Climate Change: How We Made Model Results Useful for Vulnerability Assessment

Presenter/First Author: John B Kim, US Forest Service Corvallis, Corvallis, OR

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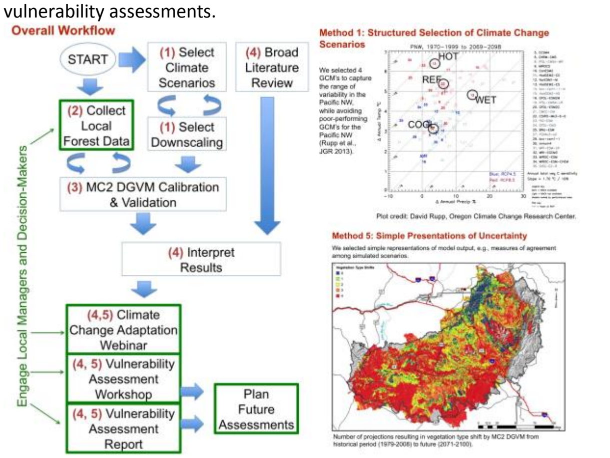
Co-authors: Becky K Kerns, US Forest Service Corvallis, Corvallis, OR; Jessica Halofsky, University of Washington Seattle Campus, Seattle, WA

Published Material: This was presented as a poster at AGU 2014 annual meeting.

Abstract Body: GCM-based climate projections and downscaled climate data proliferate, and there are many climate-aware vegetation models in use by researchers. Yet application of fine-scale DGVM based simulation output in national forest vulnerability assessments is not common, because there are technical, administrative and social barriers for their use by managers and policy makers. As part of a science-management climate change adaptation partnership, we performed simulations of vegetation response to climate change for four national forests in the Blue Mountains of Oregon using the MC2 dynamic global vegetation model (DGVM) for use in vulnerability assessments. Our simulation results under business-as-usual scenarios suggest a starkly different future forest conditions for three out of the four national forests in the study area, making their adoption by forest managers a potential challenge. However, using DGVM output to structure discussion of potential vegetation changes provides a suitable framework to discuss the dynamic nature of vegetation change compared to using more commonly available model output (e.g. species distribution models). From the onset, we planned and coordinated our work with national forest managers to maximize the utility and the consideration of the simulation results in planning. Key lessons from this collaboration were: (1) structured and strategic selection of a small number climate change scenarios that capture the range of variability in future conditions simplified results; (2) collecting and integrating data from managers for use in simulations increased support and interest in applying output; (3) a structured, regionally focused, and hierarchical calibration of the DGVM produced well-validated results; (4) simple approaches to quantifying uncertainty in simulation results facilitated communication; and (5) interpretation of model results in a holistic context in relation to multiple lines of evidence produced balanced guidance. This latest point demonstrates the importance of using model out as a forum for discussion along with other information, rather than using model output in an inappropriately predictive sense. These lessons are being applied currently to other national forests in the Pacific Northwest to contribute in

vulnerability assessments.



Abstract ID: 33956

Final Number: B12B-01

Title: Status of our understanding about legacy mercury, its role in the global biogeochemical cycle, and implications for forecasting environmental change

Presenter/First Author: Helen Marie Amos, Harvard University, Somerville, MA

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Co-authors: Elsie M Sunderland, Harvard University, Cambridge, MA

Published Material: I will be presenting a critical review on legacy Hg, including results from Amos et al. (2013) in Global Biogeochemical Cycles, Amos et al. (2014) in Environmental Science & Technology, and Amos et al. (2015) in reivew in Environmental Science & Technology.

Abstract Body: Humans have been releasing mercury (Hg) to the environment since antiquity, resulting in a significant accumulation in the ocean, atmosphere, and terrestrial ecosystems. A large fraction of anthropogenic Hg accumulated in surface ecosystems can be re-emitted to the atmosphere, re-entering an active global cycling. This recycled portion is referred to as legacy Hg. It plays a central role in the present-day global cycle influences future trajectories of environmental Hg concentrations. We present a critical synthesis of the current state of the science regarding legacy Hg and discuss implications for our ability to anticipate future responses to regulatory action. The synthesis includes perspectives from the atmosphere, ocean, and terrestrial systems as well as primary sources of Hg (natural + anthropogenic) to the environment. There has been considerable debate in recent literature in particular about the importance of historical anthropogenic Hg emissions from early large-scale precious metal mining. We present a combined analysis using models, natural archives (sediment, peat, ice), and direct observations (atmosphere, soil, seawater) to examine anthropogenic impacts on the global Hg cycle. The weight of evidence from this analysis suggests early anthropogenic Hg emissions contribute significantly to present-day enrichment. Lastly, we use measurements and models to identify key processes driving the uncertainty in legacy Hg and anthropogenic enrichment. We also identify key uncertainties affecting future projections, providing results in a global context as well as a case study from the North Pacific Ocean. The need for aggressive future reductions of global anthropogenic Hg emissions in order to stabilize Hg concentrations in the top 1000 m of the ocean is robust to uncertainties in Hg cycling and emissions, and is due to the intrinsic timescales involved. In the atmosphere, there will be a rapid (<1 year) benefit if future anthropogenic emissions are curbed.

Abstract ID: 33580

Final Number: B12B-02

Title: Distribution of Hg and Pb in peatlands of Ontario

Presenter/First Author: Julie Talbot, University of Montreal, Montreal, QC

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Co-authors: Tim R Moore, McGill Univ, Montreal, QC, Canada; Meng Wang, , Montreal, QC, Canada; John L Riley, , ,

Abstract Body: While considerable attention has been given to the measurement of Hg and Pb concentrations and accumulation in a few detailed peat cores in central Canada, the geographic distribution and density of sampling is weak. Here we use the Ontario Peatland Inventory to examine broad patterns of Hg and Pb concentration with depth, based on over 400 peat cores (containing ~1500 analyzed samples) in southeastern, northeastern and northwestern sections of Ontario. Overall, Hg concentrations averaged 0.052 $\mu g\ g^{-1}$ and that of Pb averaged 11.1 $\mu g\ g^{-1}$. When samples were binned by 10-cm increments in the profile, Hg concentrations fell from 0.06-0.08 $\mu g\ g^{-1}$ in the top 30 cm to 0.03-0.05 $\mu g\ g^{-1}$ below 50 cm. The pattern was more pronounced for Pb, with concentrations falling from 20-25 $\mu g\ g^{-1}$ in the top 30 cm and 5-10 $\mu g\ g^{-1}$ below 50 cm. With average organic C:Hg and C:Pb ratios of $14.9*10^6$ and $0.18*10^6$, respectively, below 50 cm and assuming an average long-term C accumulation rate of 30 g $m^{-2}\ yr^{-1}$, these results suggest average long-term accumulation rates of 1-2 μg Hg $m^{-2}\ yr^{-1}$ and 125-150 μg Pb $m^{-2}\ yr^{-1}$.

The spatial pattern of Hg concentration in the surface layers (0-30 cm) shows small values < 0.05 $\mu g\ g^{-1}$ in remote locations, increasing to 0.10 to 0.50 $\mu g\ g^{-1}$ in SE Ontario and around population and industrial centres. Pb concentration shows a similar pattern, with values < 25 $\mu g\ g^{-1}$ in remote locations rising to 30 – 120 $\mu g\ g^{-1}$ particularly in SE Ontario and around population and industrial centres.

Abstract ID: 33468

Final Number: B12B-03

Title: Spatial and Temporal Trends in Mercury Accumulation in Laurentian Great Lakes Fish: Are Global Mercury Inputs Affecting the Great Lakes Ecosystem?

Presenter/First Author: Thomas Holsen, Clarkson University, Potsdam, NY

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Co-authors: David P Krabbenhoft, USGS Wisconsin Water Science Center, Middleton, WI; Hao Zhou, , , ; Timothy Johnson, , , ; Bernard Crimmins, , ,

Abstract Body: Lake Trout (*Salvelinus namaycush*) and walleye (*Sander vitreus*) are collected from two sites within each lake, every other year, and total mercury (HgT) is measured as part of the Great Lakes Fish Monitoring and Surveillance Program (GLFMSP). Previous analyses of Hg concentration trends at these locations were inconsistent, with concentrations at some locations increasing, some decreasing and some not changing. This updated trends analysis indicates that at nearly all sampling locations, HgT concentrations are decreasing with the exceptions of the shallow (nearshore) site in Lake Michigan and the deep (offshore) site in Lake Huron, which showed increasing Hg concentrations. Apparent increasing trends at these two locations are likely the result of older fish present in the size class collected as well as possible localized deposition emanating from nearby industrial centers. These results in conjunction with significant reductions in water column Hg; decreases in Hg(0) concentrations in air over the lakes over the past 7-10 years, and declining trends in Hg wet deposition at most locations near the Great Lakes over the past 10 years

suggest that environmental regulations enacted by U.S. and Canada are having positive effects in the Great Lakes ecosystem and that increasing global anthropogenic emissions are not overwhelming regional controls and significantly impacting mercury concentrations in the Great Lakes. Analysis of stable Hg isotope results, which is a new tool in Hg research

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Abstract ID: 36705

Final Number: B12B-04

Title: A cross-ecosystem comparison of mercury accumulation in Canadian lakes and aquatic food webs along a 30º latitudinal gradient

Presenter/First Author: Murray Richardson, Carleton University, Ottawa, ON

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Co-authors: John Chetelat, Environment Canada Ottawa, Ottawa, ON, Canada; Gwyneth Anne MacMillan, Universite de Montreal, Montreal, QC, Canada; Marc Amyot, Universite de Montreal, Montreal, QC, Canada

Abstract Body: A cross-ecosystem study was initiated in 2012 to test a conceptual model of aquatic ecosystem sensitivity to atmospheric mercury (Hg) pollution along a climatic gradient spanning 30° of latitude, from southern Quebec to the Canadian high Arctic. The overarching goal of the study was to quantify local (physiographic, hydrogeomorphic) and regional (climatic) factors that limit or enhance mercury bioaccumulation in aquatic food webs, including both biotic and abiotic pathways. This presentation will report on inter- and intra-regional differences in water-column concentrations of total mercury (THg), methyl-mercury (MeHg) and dissolved organic carbon (DOC), and MeHg concentrations in zooplankton among 26 lakes in four different regions: Gatineau Park, QC (45.63°, 75.81° W), Kuujjuarapik-Whapmagoostui, QC (55.27° N, 77.76° W) Iqaluit, NU (63.75° N, 68.52° W) and Resolute Bay, NU (74.70° N, 94.83° W).

Surface water concentrations of MeHg were strongly and positively correlated to THg concentrations (R^2=0.72, p<0.001) in lakes across the latitudinal gradient, implying strong control of inorganic mercury supply on MeHg concentrations. THg was strongly correlated to DOC in surface waters after pooling arctic and subarctic lakes ($R^2 = 0.67$, $p < 0.001$). Surface water concentrations of both THg and MeHg decreased logarithmically ($r^2 = 0.48$ and 0.60, for THg and MeHg, respectively, $p < 0.001$) as a function of lake residence times (derived through watershed morphometry and available climate normals), suggesting that in-lake processing of THg and MeHg may reduce their concentrations within the water column. This effect was observed at both inter- and intra-regional scales. Moreover, we found water column concentrations of MeHg to explain some of the inter-lake variations in zooplankton MeHg concentrations across the latitudinal gradient (R^2= 0.47, p<0.001). These results point to an interaction between watershed and lake morphometry (i.e. watershed area to lake-volume ratio) and regional climate (mean annual runoff) that can explain large variations in Hg concentrations in northern freshwater ecosystems. Changing temperature and precipitation regimes will alter hydrologic residence times of lakes across Canada, with important implications for biogeochemical cycling and food web bioaccumulation of Hg.

Abstract ID: 35373

Final Number: B12B-05

Title: Climate Change Impacts on Mercury Mobility in Peatland Ecosystems

Presenter/First Author: Kristine Haynes, University of Toronto, Toronto,

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Co-authors: Carl P J Mitchell, University of Toronto, Toronto, ON, Canada; Evan S Kane, Michigan Technological University, Houghton, MI; Lynette Potvin, USDA Forest Service, Northern Research Station, Houghton, MI; Erik Lilleskov, USDA Forest Service, Northern Research Station, Houghton, MI; Randy K Kolka, USDA Forest Service, Grand Rapids, MN

Abstract Body: Mercury (Hg) cycling, speciation and mobility in peatlands will likely be affected by alterations in carbon cycling and redox conditions resulting from climate-induced changes in hydrological processes and shifting vegetation communities. The overall objective of this research is to assess the impacts of climate change, specifically fluctuating water tables and altered vegetation communities, on Hg cycling and mobility in northern peatlands through mesocosm-scale experimental research. This study is being conducted at the PEATcosm Mesocosm Facility at the USDA Forest Service Northern Research Station in Houghton, Michigan. Throughout the 2013 and 2014 growing seasons, pore water samples were collected at 20, 40 and 70 cm below the surface of 1 m^3 peat mesocosms, with manipulated (average control or low) water table positions and different vegetation communities (sedge only, ericaceae only or unmanipulated control) in a factorial design. Total Hg (THg) and methylmercury (MeHg) analyses revealed significant influences of both water table position and dominant plant functional group on pore water THg and MeHg concentrations and MeHg production and/or accumulation (as determined by the percentage of THg present as MeHg, %MeHg). The %MeHg was highest in mesocosms with lowered water tables and sedge vegetation with mean pore water MeHg concentrations of 1.0 ng L^{-1} accounting for approximately 7% of pore water THg. Pore water MeHg concentrations exhibit a positive correlation with dissolved organic carbon concentrations. These preliminary results suggest that climate change, inducing greater amplitude fluctuating water tables and shifting vegetation communities towards sedge-dominated systems, may have notable impacts on MeHg production and/or accumulation in peatland pore waters and these change may be influenced by organic matter dynamics.

Abstract ID: 35535

Final Number: B12B-06

Title: Effects of Timber Harvest on Mercury Cycling in the Pacific Northwest, USA

Presenter/First Author: Chris Eckley, Environmental Protection Agency Seattle, Seattle, WA

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Co-authors: Collin Eagles-Smith, Forest and Rangeland Ecosystem Science Center, Corvallis, OR; Michael Tate, , , ; David P Krabbenhoft, USGS Wisconsin Water Science Center, Middleton, WI; Brandon Kowalski, USGS Forest and Rangeland Ecosystem Science Center, Corvallis; Leigh Woodruff, Environmental Protection Agency Idaho Operation Office, Boise

Published Material: Poster at AGU meeting in SF 2014

Abstract Body: Forested landscapes have been shown to act as a net sink for atmospheric mercury inputs which has resulted in a legacy of mercury accumulated in the soil. Timber production and harvesting (frequently via clearcutting) is a common land-use feature throughout forested regions and can influence mercury cycling through hydrological and biogeochemical alterations. The objective of our study was to understand how forest harvesting impacts key components of the mercury cycle including: mobilization in runoff, methylation, volatilization, and downstream bioaccumulation. The study was performed within an experimental forest located within the Trask River watershed in Oregon, USA. The study utilized three paired harvested and un-harvested sub-catchments plus a pair of reference catchments. Flumes were located at the outflow of each of the catchments and were continuously monitored for flow volume and other water quality parameters. Water samples for filtered and particulate total and methylmercury (as well as several

ancillary parameters) were measured approximately monthly for 1.5 years following harvest and represented the full range of hydrologic conditions. The results showed that there was no significant difference between particulate total mercury or total suspended solids between clearcut and forested catchments. However, there was a significant increase (36%) in filtered total-mercury concentrations in paired clearcut watersheds. Salamander tail mercury samples were also significantly higher in the clearcut catchments compared to the paired forest catchments. Soil-air mercury fluxes showed higher levels of net emission from the clearcut catchments compared to the forested sites, which appears to be related to increased levels of solar radiation reaching the soil. Overall, these results highlight the effects of forestry operations on several important aspects of mercury cycling in forested landscapes.

Abstract ID: 36338

Final Number: B13A-01

Title: Comparisons of Terrestrial Mercury (Hg) Accumulation and Dynamics across Temperate Forests and an Arctic Tundra site

Presenter/First Author: Daniel Obrist, Desert Research Institute, Reno, NV

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Co-authors: Detlev Helmig, University of Colorado at Boulder, Boulder, CO; Yannick Agnan, Desert Research Institute Reno, Reno, NV; Christine Hedge, Desert Research Institute Reno, Reno, NV; Christopher W Moore, Desert Research Institute, Reno, NV; Jacques Hueber, , ,

Abstract Body: The patterns show that the arctic tundra site contains high levels of Hg in spite of its remote location. While atmospheric Hg is strongly retained in, and associated with, organic horizons at temperate sites, in the tundra Hg is not correlated with organic carbon and is subject to strong vertical translocation through organic layers and efficient sorption in mineral soils, possibly due to increased snow-melt induced vertical transport, freeze-thaw cycles, or frequent water-saturated conditions. Using semi-permeable Teflon wells to measure gas-phase Hg concentration and exchanges, we observe that both organic and mineral soil horizons at temperate and polar sites serve as sinks for gaseous elemental Hg, indicating a dominance of oxidation over reduction processes independent of climatic or moisture regimes. This study suggests a particularly strong role of mineral soil layers for Hg sorption and storage in tundra soils, with possible consequences of climate-induced warming which is expected to increase the active layer depth of tundra mineral soils.

Abstract ID: 35400

Final Number: B13A-02

Title: Mercury chemical transformation and speciation in atmospheric and aquatic media

Presenter/First Author: Parisa A Ariya, McGill University, Montreal, QC

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Abstract Body: Due to the toxicity and propensity for bio-magnification and bioaccumulations, mercury species are identified as among most toxic compounds in the planet. Despite the significant evolution of our knowledge in understanding mercury cycling, particularly in the polar regions during the last decade, there are major key science questions in our understanding of mercury transformation, including (a) mercury chemical speciation and (b) mercury chemical reactions, particularly heterogeneous reactions, topics which will be discussed in this paper. We present our recent data surface-selective femto second spectroscopy on mercury surface, as well as heterogeneous reactions on series of environmental aerosols and on particles in aquatic media. We will also present the observation of mercury speciation that was performed during the summer 2014 in the city of Montreal using our newly developed mercury spectrometry. We will discuss the implications in the context of mercury cycling in environment.

Abstract ID: 35508

Final Number: B13A-03

Title: Determining microbial methylmercury production through the use of molecular probes: Insights into *hgcAB* expression and distribution in the environment

Presenter/First Author: Dwayne A Elias, Oak Ridge National Laboratory, Oak Ridge, TN

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Co-authors: Richard A Hurt, , , ; Eugenio F U Santillan, Smithsonian Environmental Research Center Edgewater, Edgewater, MD; Ann M Wymore, , , ; Andrew J King, , , ; Allyson Bullock, , , ; Cynthia C Gilmour, Smithsonian Institution, Edgewater, MD

Abstract Body: Biotic Hg methylation to methylmercury (MeHg) is performed through the actions of anaerobic micoorganisms, and this function is encoded by the newly discovered gene pair *hgcAB*. These genes have been identified in three clades of microorganisms: the *Deltaproteobacteria*, *Firmicutes*, and *Archaea*. Because this discovery is still recent, the functions, abundance, and distribution of these genes in relation to Hg methylation have yet to be elucidated. To address this, we have designed a set of universal PCR and clade-specific qPCR primers as molecular probes. Previous primers from other studies have been created, but are very selective in the organisms they target and do not capture the breadth of *hgcAB* diversity. Our PCR primer, designed to span the entire *hgcAB* gene pair, is universal, and can be used to compare diversity among all methylating organisms. We also developed qPCR primers, which are specific for *Deltaproteobacteria*, *Firmicutes*, and *Methanomicrobia*, the three main clades of *hgcAB*+ microbes. The qPCR primers are based on the *hgcA* gene only, and were designed for evaluation of gene copy number. Primers were designed by identifying and comparing conserved regions within the HgcA and HgcB protein between 48 methylating organisms and between specific clades. After design, primer effectiveness was determined by testing the probes on monocultures of methylating organisms from a comprehensive collection curated by the Smithsonian Environmental Research Center and Oak Ridge National Laboratories. Further validation was performed by testing the probes on mixed cultures and by combinations of DNA with sand to simulate environmental samples. Lastly, primers were validated by testing their efficiency on environmental samples ranging from Arctic soils to marshes. Of the methylating organisms tested in the laboratory, the universal *hgcAB* PCR primer amplified the gene from 90% of the all cultures. The clade-specific qPCR primers amplified 70-90% of the cultures within each targeted clade. These primers give us the tools to perform meaningful quantification and taxonomy of *hgcAB* in the environment, a significant step understanding and mitigation MeHg risk.

Abstract ID: 34945

Final Number: B13A-04

Title: Mercury Methylation by *hgcAB*$^{+}$ Methanogens

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Abstract Body: Organisms from the Class *Methanomicrobia*, a group of methylotrophic and hydrogenotrophic methanogens, have recently been identified as the first known group of Hg-methylating *Archaea*. They are one of several newly identified clades of *hgcAB*⁺ organisms, which include *Firmicutes* and syntrophic *Deltaproteobacteria*. However, despite the expanded diversity of Hg-methylating organisms and environments, orthologues of *hgcAB* are rare among available microbial genomes.

Here we begin to evaluate how important methanogens may be in Hg methylation in the environment. As a first approach, we measured Hg-methylation rates by *hgcAB*⁺ methanogens in pure culture, using organisms from culture collections with available genomes. Based on available genomes, we identified 12 *hgcAB*⁺ methanogens, all Class *Methanomicrobia*. All of the *hgcAB*⁺ *Archaea* identified from microbial genomes fall in this specific group of methanogens. Twelve of ~25 sequenced *Methanomicrobia* genomes have *hgcAB* orthologues.

Using a standardized approach to measuring methylation, we compared methylation rates among cultures, and across different culture conditions. We found major differences in methylation rates among organisms, even when normalize to growth and culture chemistry. Sulfur complexes like cysteine and sulfide appear to be critical controls on Hg methylation by methanogens, as they are in sulfate- and iron-reducing bacteria. *Methanosphaerula palustris* E1-9c and *Methanospirillum hungatei* JF-1 are particularly able methylators, rivalling SRB and FeRB, and converting over 70% of provided Hg into MeHg under optimal conditions. These results support the idea that methanogens may be important contributors to MeHg production in certain environments.

Abstract ID: 34024

Final Number: B13A-05

Title: Hotspots of Methylmercury in Thaw Ponds from the Eastern Canadian Arctic: Link between Methylmercury and Nutrient Loading in the Rapidly Changing North

Presenter/First Author: Gwyneth Anne MacMillan, Universite de Montreal, Montreal, QC

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Published Material: These findings were reported at a workshop on Permafrost Thawing, THAW 2014: Thermokarst Aquatic Ecosystems Workshop, organized by the Centre d'Études Nordiques, in Québec City (QC) in an oral presentation by Marc Amyot. These findings are also ready for submission to the scientific journal Environmental Science and Technology (ES&T) (submission in the next few weeks).

Abstract Body: Permafrost thaw ponds are ubiquitous in the eastern Canadian Arctic, yet little information exists on their potential as sources of methylmercury (MeHg) to freshwaters. MeHg is a potent neurotoxin that can biomagnify to elevated concentrations in aquatic food webs. Thaw ponds are microbially-active and conducive to methylation of inorganic mercury, and are affected by changes in nutrient inputs related to Arctic warming. This multi-year study investigates thaw ponds in a discontinuous permafrost region in the subarctic taiga (Kuujjuarapik-Whapmagoostui, QC) and a continuous permafrost region in the Arctic tundra (Bylot Island, NU). MeHg concentrations in thaw ponds were well above levels measured in most freshwater ecosystems in the Canadian Arctic (> 0.1 ng L-1). On Bylot, ice wedge trough ponds showed significantly higher MeHg (0.3 - 2.2 ng L-1) than polygonal ponds (0.1 - 0.3 ng L-1) or lakes (< 0.1 ng L-1). High MeHg were also measured in the bottom waters of subarctic thaw ponds near Kuujjuarapik (0.1 - 3.1 ngL-1). High water MeHg in thaw ponds were strongly correlated with variables associated with high inputs of organic matter (DOC, a320, Fe), nutrients (TP, TN), and microbial activity (dissolved CO_2 and CH_4). Our results suggest a relationship between organic matter erosion from thawing permafrost, reducing conditions in the sediments and the production of methylmercury in these sites. Thawing permafrost due to Arctic warming will continue to release nutrients and organic carbon into these systems and increase ponding in some regions, likely stimulating higher water concentrations of MeHg. Greater hydrological connectivity from permafrost thawing may potentially increase transport of MeHg from thaw ponds to neighbouring aquatic ecosystems.

Abstract ID: 35678

Final Number: B13A-06

Title: Methylmercury Cycling in the Arctic: What do we need to know in the face of a changing climate

Presenter/First Author: Igor Lehnherr, University of Toronto, Mississauga,

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Published Material: I will be presenting a synthesis of some of my recent work, published in Lehnherr 2014 (Environ. Rev.), Lehnherr et al. 2012 (ES&T) and other related papers.

Abstract Body: There has been increasing concern regarding mercury (Hg) – and more specifically methylmercury (MeHg) – levels in marine and freshwater organisms in the Arctic, due to the importance of traditional country foods such as fish and marine mammals to the diet of Arctic Aboriginal people. This presentation will provide a synthesis of some recent advances in our understanding of MeHg cycling and sources in Arctic aquatic ecosystems. Included in this synthesis will be a discussion of the environmental factors that impart controls on MeHg production, how climate and environmental change may impact MeHg cycling, and what key knowledge gaps need to be addressed to better predict MeHg exposure in Arctic biota. In Arctic marine ecosystems, Hg(II) methylation in the water column, rather than bottom sediments, is the primary source of MeHg, although a more quantitative understanding of the role of DMHg as a MeHg source is needed. Because MeHg production in marine waters is limited by the availability of Hg(II), predicted increases in Hg(II) concentrations in oceans are likely to result in higher MeHg concentrations and increased exposure to Hg in humans and wildlife. In Arctic freshwaters, MeHg concentrations are a function of two antagonistic processes, net Hg(II) methylation in bottom sediments of ponds and lakes, and MeHg photodemethylation in the water column. Hg(II) methylation is controlled by microbial activity and Hg(II) bioavailability, which in turn depend on interacting environmental factors (temperature, redox conditions, organic carbon and sulfate) that induce non-linear responses in MeHg production and which are sensitive to changes in climate.

Abstract ID: 33925

Final Number: B14A-0053

Title: Rendering Future Vegetation Change across Large Regions of the US

Presenter: Marc Stieglitz, Georgia Institute of Technology Main Campus, Atlanta, GA

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Abstract Body: We use two Machine Learning techniques, Decision Trees (DT) and Neural Networks (NN), to provide classified images and photorealistic renderings of future vegetation cover at three large regions in the US. The training data used to generate current vegetation cover include Landsat surface reflectance images, USGS Land Cover maps, 50 years of mean annual temperature and precipitation (1950 - 2000), elevation, aspect, and slope data. Future vegetation cover for the period 2061- 2080 was predicted using bias corrected data from the NASA GISS Global Climate Model E simulation.

The three test regions encompass a wide range of climatic gradients, topographic variation, and vegetation cover. The central Oregon site covers 19,182 sq. km. Vegetation is 50% evergreen forest and 50% shrubs-scrubs. The New Mexico site covers 5,500 sq. km. Vegetation is predominantly evergreen forest, shrubs, and grasses. The northwest Washington site covers 14,182 sq. km. Vegetation is predominantly evergreen forest. The remainder of the area includes deciduous forest, perennial snow cover, and wetlands.

Using the above mentioned data we first trained our DT and NN models to reproduce current vegetation. Land cover classified images were compared directly to the USGS land cover data. Photorealistic generated vegetation images were compared to the remotely sensed surface reflectance maps.

The three trained models were then used to explore what the equilibrium vegetation would look like for the period 2061 - 2080. The predicted mean annual air temperature change for the three sites ranged from +1.8°C to +2.3°C. For the three sites precipitation changed little. In Oregon, this resulted in a 37% shift of forested areas to shrub vegetation. In New Mexico, shrubs and evergreen vegetation increased by 18% and 5%, respectively. Deciduous and grassland vegetation decreased by 90% and 52%, respectively. In Washington, deciduous vegetation, shrubs, and grasslands increased by 25%, 15%, and 7%, respectively. Evergreen vegetation and perennial snow cover on mountain tops decreased by 4.5% and 46%, respectively.

Abstract ID: 36054

Final Number: B14A-0055

Title: Responses of ET and GPP to Climate Variability and Management over the North China Plain

Presenter: Suxia Liu, Chinese Academy of Sciences, ,

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Abstract Body: anthropogenic activities like coal combustion and metal smelting. using high-resolution transmission electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy, NanoScan and Brunauer-Emmett-Teller. removal efficiency and electrochemical regeneration efficiency of mercury vapor. specific results will be presented in the conference and the impact will be discussed.

Abstract ID: 33399

Final Number: B21A-01

Title: CO_2, CH_4 and N_2O Emissions from Boreal Reservoirs, 20 years of data!

Presenter/First Author: Alain Tremblay, Hydro-Québec, Montreal, QC

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Co-authors: Maryse Lambert, , ,

Published Material: This is a synthesis of 20 years of data, data have been partly presented in different scientific meeting over the years throught different aspect and angles. A part of this has also been presented at ASLO in Spain in February 2015.

Abstract Body: Eastmain 1 reservoir (Quebec, Canada) was flooded in November 2005. To increase the volume of water stored in Eastmain 1, the Rupert River was diverted. Partial flooding of the Rupert diversion bays (RD) took place in 2009 and the flooding was completed in 2011. The impoundment of organic matter is known to lead to GHG emissions at the water surface of newly created reservoirs. Remarkably, the different approaches/methods used to monitor CO_2 and CH_4 partial pressures and emissions over 7 years showed comparable results. The impact of the creation of a new reservoir upstream the Eastmain 1 Reservoir was shown to be week in term of emissions. Summer and winter system productivity was estimated from CO_2 continuous measurements; for example respiration rates from 19 to 148 $mgC.m^{-3}.d^{-1}$ were found in summer at the central station of the reservoir, which is comparable to published data using different method. Finally datasets from other boreal reservoirs were used to explore the relationship between winter and summer production rate and put in perspective the lability of the organic matter in these systems.

Abstract ID: 33476

Final Number: B21A-03

Title: Modelling Seasonal and Annual Variability of Carbon Fluxes in a Large Boreal Hydroelectric Reservoir

Presenter/First Author: Weifeng Wang, McGill University, Montreal, QC

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Co-authors: Youngil Kim, Oregon State University, Corvallis, OR; Nigel T Roulet, McGill University, Montreal, QC, Canada; Ian B Strachan, McGill University, Montreal, QC, Canada; Alain Tremblay, Hydro-Québec, Montreal, QC, Canada

Published Material: The content was presented in the AGU fall meeting, but we have more solid simulation results and new findings.

Abstract Body: Greenhouse gas emissions from hydroelectric reservoirs have attracted much attention over the past decades. To quantify CO2 emissions from reservoir surfaces we intergrate a lake carbon model, modified from the Hanson Lake Carbon Model, a newly developed 1-dimension thermal stratification model, and a terrestrial biogeochemistry model (DNDC: DeNitrification-DeComposition) that simulates vegetation litter and soil organic carbon dynamics under flooded conditions. We evaluated CO2 emissions simulated by the newly developed FAQ (Flooded AQuatic)-DNDC model using observed fluxes from an eddy covariance tower in an ~600 km2 boreal hydroelectric reservoir, Eastmain-1, in northern Quebec, Canada, for the period of 2007-2012. Simulated annual CO2 emissions generally matched the observed fluxes. The model captures well the seasonal pattern of CO2 flux from the reservoir surface, although the simulated peak emission in spring are overestimated compared to the observations. Sensitivity analysis shows that the amounts of dissolved organic carbon (DOC) input rarely affect CO2 emissions but greatly influences the DOC concentration in water column. Our analysis also suggests that warming changes the temporal pattern and magnitude of CO2 emissions. Future research on mechanisms of CO2 evasions through ice is necessary for reliable simulation for seasonal ice covered aquatic ecosystems.

Abstract ID: 34205

Final Number: B21A-04

Title: Predicted Releases of Greenhouse Gases from Land-use Change of a Proposed Hydroelectric Reservoir in Canada Using a Carbon Mass-balance Model

Presenter/First Author: Jean-Michel A. DeVink, Stantec Consulting Ltd, Saskatoon,

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Published Material: These results were presented in an Environmental Assessment and CEAA report, but have not been specifically presented elsewhere in the scientific community.

Abstract Body: Understanding the potential contributions of large projects to greenhouse gases (GHGs) in the atmosphere is increasingly important in the current social context of heightened awareness about climate change. Regulatory agencies are requiring greater attention to activities and projects that have long-term changes to land-use that could result in substantial releases of GHGs to the atmosphere. Here we present a site-specific carbon cycle in the form of a landscape carbon mass-balance model. This model is used to predict the net GHG emissions as part of an environmental assessment for a proposed hydroelectric reservoir located in northeast British Columbia. We based the model inputs on local biophysical and geophysical properties of the site, and modeled several hypothetical Project scenarios. The model was based on the exchange (flows) of carbon between the primary carbon stores (stocks). These stocks included atmosphere (CO_2 and CH_4), surface water, soil, sediment, terrestrial plants, wetlands, and large ruminants. A baseline model was first constructed to model existing conditions and calibrated to a long-term net-zero carbon mass-balance. The baseline model was then adjusted for post-flooding landscape parameters and results were compared to the baseline model to determine the Project's net GHG emission. Overall, the model predicted a net GHG emission of the Project in the order of 43,400 to 58,200 t CO_2e/yr for the assumed 100 yr Project lifespan as a result of the land use change. Based on the Project's anticipated 5,100 GWh energy output, this translated to between 8.5 and 11.4 CO_2e/kWh from land-use change (9.7 and 13.3 g CO_2e/kWh, including construction-related emissions), which is at the lower end of the reported range of life-cycle assessments (8 to 60 g CO_2e/kWh) for boreal hydroelectric reservoirs. These results were not surprising given the Project is a tertiary reservoir drawing hydraulic capacity from a large upstream reservoir and due to its northern latitude location where the river is narrow and the resulting hydroelectric reservoir is relatively deep.

Abstract ID: 36671

Final Number: B21A-06

Title: Climate and Land-Use Gradients Drive Spatially Coherent CO2 Driver-Response Relationships Across US Lakes

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Co-authors: Kendra S. Cheruvelil, , , ; Sarah M. Collins, , , ; Carol Emiko Fergus, Michigan State University, East Lansing, MI; Christopher Filstrup, Iowa State University, Ames, IA; David A Seekell, University of Virginia, Charlottesville, VA; Patricia Ann Soranno, , ,

Abstract Body: Understanding how diverse environmental factors influence partial pressure of CO2 (pCO2) in lakes is challenging because local or regional relationships can rarely be generalized at continental scales. The ability to predict lake pCO2 typically decreases at larger spatial extents and with increasing environmental gradients, suggesting non-linearities in the pCO2 driver-response relationships across large and diverse landscapes. We explored spatial patterns in the response of pCO2 to several biological (chlorophyll a) and chemical (nutrients, dissolved organic carbon and alkalinity) drivers in lakes across the contiguous United States using geographically weighted regressions. Allowing the regression parameters to change spatially more than tripled our ability to predict pCO2 compared to traditional multi-linear regression models. The regression parameters formed spatially contiguous clusters, indicating that there were large-scale differences in pCO2 driver-response relationships and that these clusters were substantially different from widely used, pre-determined regionalisation frameworks. The clusters were mainly differentiated on the basis of climate and land-use. In dry and low development areas, pCO2 was primarily related to alkalinity, whereas high precipitation and intensive land use (e.g., agriculture and urban) areas were negatively related to Chl a and positively related to dissolved organic carbon. These results highlight the need to consider non-linearities in the relationships between lake pCO2 and its drivers across large environmental and spatial gradients, which may improve extrapolations based on smaller-scale studies and will improve our understanding of how the aquatic carbon cycle responds to global change.

Abstract ID: 36534

Final Number: B21A-07

Title: Methane Oversaturation in Boreal Lakes: Towards Process-based Understanding

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Published Material: Will be presented in part at ASLO meeting in Granada, Spain in February.

Abstract Body: Methane (CH4) oversaturation in lakes, particularly in the surface waters, is a common finding of limnological research on gas dynamics. A few possible explanations have been put forth to explain this ubiquitous condition of the landscape, but the interaction of these possible processes and their ability to truly explain the oversaturation remain

unresolved. In this context, 11 lakes in the Laurentian region of southern Quebec, Canada were surveyed in detail for CH4 dynamics during summer 2014. Surface sampling throughout the lakes and a cross-section of depth profiles across the deepest point of the lake revealed a persistent CH4 oversaturation in each lake at the surface, as well as at several other depths with depleting concentrations in between. No significant ebullition was found in the profundal zone of any lake, while substantially high CH4 emissions were observed from floating chamber measurements in the littoral zones. Higher dissolved CH4 concentrations in the littoral along with the floating chamber measurements, as well as submerged bubble trap surveys in the littoral zones of three of the lakes, suggest that littoral methane production is mostly responsible for the CH4 oversaturation in Laurentian lakes. Mass balance models will help in determining the CH4 contribution from the littoral zone and other possible sources as well as provide the basis for testing a lake-level process-based model at the landscape and regional level of Quebec.

Abstract ID: 35466

Final Number: B21A-08

Title: Methane under ice in boreal lakes

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Co-authors: Paul del Giorgio, Groupe de Recherche Interuniversitaire en Limnologie, Montréal, QC, Canada

Published Material: The preliminary analysis were presented as a poster in GLEON16 meeting in Octobre 2014.

Abstract Body: Lakes are important sources of greenhouse gases (GHG) to the atmosphere, emitting both carbon dioxide (CO_2) and methane (CH_4). The extent of ice cover and changes related to mixing of water column strongly influence the seasonal variation in GHG dynamics, and without considering them, the annual estimates of GHG emissions from boreal lakes may be strongly biased. While seasonal variation of CO_2 is relatively well known, the seasonality of CH_4 has not been well described, particularly in northern lakes during the ice cover period. We conducted seasonal measurements of CH_4 and CO_2 concentrations of 13 boreal lakes in Québec over the course of an annual cycle. We observed significant under ice accumulation of CH_4 in seven out of the 13 lakes, whereas CH_4 concentrations and fluxes consistently increased during summer in almost all lakes. Winter CH_4 accumulation has been previously related to the anoxic conditions but most of our lakes remained oxic also in winter and thus the role of oxygen limitation seemed to be minor in these lakes. Lakes accumulating CH_4 under ice were in general larger than non-accumulator lakes (2985±1787 km^2 and 23±14 km^2) and had higher total phosphorous concentration (20.1 $\mu g\ L^{-1}$ and 12.9 $\mu g\ L^{-1}$) but there was no difference in the mean depth between the two groups of lakes. Higher nutrient concentrations can increase primary production increasing the amount of organic matter that sediments to the bottom and acts as a source for methanogenesis. In larger lakes the residence time can be longer than in smaller lakes, which can allow more efficient accumulation. Contrary to CH_4, the seasonal CO_2 patterns were similar across the lakes, with all the lakes accumulating CO_2 under ice and having lowest concentrations in the middle of summer. Whereas winter accumulation of CO_2 and subsequent emissions following ice melt represent a major contribution to the annual CO_2 flux, this is not always the case for CH_4, since a significant fraction of lakes did not accumulate CH_4 under the ice and peak CH_4 fluxes occurred in late summer, representing the bulk of annual emissions. Our results collectively suggest that seasonal GHG patterns vary greatly across boreal lakes, and it is therefore important to account for such seasonal heterogeneity to generate reliable annual emissions budgets for boreal lakes.

Abstract ID: 33868

Final Number: B22A-01

Title: Lurking Just Beneath the Surface: Antibiotic Resistance Among Fe(III)-Reducing Bacteria and Other Members of Freshwater Surface Microlayer Bacterial Communities

Presenter/First Author: Christopher Drudge, McMaster University, Hamilton, ON

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Abstract Body: Bacterial communities that included Fe(III)-reducing bacteria (IRB) were enriched from the surface microlayer (SML; a trace metal, nutrient, and microbially enriched interfacial microenvironment) and at 0.5 m depth in two freshwater littoral environments (wastewater-impacted Sunnyside Beach; pristine Coldspring Lake). The presence of IRBs was permitted at these well-oxygenated depths by the availability of O_2-depleted floc-based microhabitats. Enriched communities were expected to be highly resistant to metals and antibiotics due to the ability of IRB to dissolve metal-rich Fe minerals and thus be highly exposed to metals. However, inhibition of soluble Fe(III) reduction (i.e. IRB activity) occurred at significantly lower ($P < 0.05$) concentrations of environmentally relevant trace metal or antibiotic cocktails compared to the inhibition of bulk Fe(III)-reducing enrichment community metabolic activity. Further, Cu exposure selectively inhibited Fe(II) production by solid Fe(III)-reducing enrichment community members, which were specifically expected to be highly resistant to trace metals, and was associated with a decrease in the relative abundance of known IRB genera (*Aeromonas* and *Clostridium*) in 16S rRNA gene clone libraries derived from enrichments. Interestingly, unlike trace metal resistance, antibiotic resistance was significantly higher ($P < 0.05$) among IRB in soluble Fe(III)-reducing enrichment communities from the SML relative to those from 0.5 m depth, pointing to the selective promotion of antibiotic resistance in SML communities independent of metal and antibiotic resistance co-selection mechanisms. SML soluble Fe(III)-reducing enrichment communities also possessed a greater variety of antibiotic resistance gene-carrying mobile genetic elements and opportunistic pathogens compared to enrichments from 0.5 m depth in both lakes, identifying the SML as a potential reservoir and disseminator of antibiotic resistant pathogens within aquatic systems.

Abstract ID: 36818

Final Number: B22A-02

Title: Cyanobacteria Dominance in the Lake Simcoe Georgian Bay Area: an Oxygen, Sulfate and Iron Approach.

Presenter/First Author: Eric McQuay, University of Waterloo, Waterloo,

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Co-authors: Jason J Venkiteswaran, Wilfrid Laurier University, Waterloo, ON, Canada; Sherry L Schiff, University of Waterloo, Waterloo, ON, Canada

Abstract Body: Cyanobacteria blooms are an increasing concern for cottage owners and tourists in the Lake Simcoe and Georgian Bay area. These blooms ruin the aesthetics of lakes and can result in the production of toxins that have led to the illness of children and, in some cases, the death of animals. The near annual appearance of these blooms on some lakes has reduced property values to the point where land is unsellable. Current knowledge suggests that an excess of nutrients, such as phosphorous (P) and nitrate (NO_3), are the leading cause for algal blooms. However, it is proposed that the availability of ferrous iron (Fe^{2+}) in the water column is the key to cyanobacteria dominance due to the inability of cyanobacteria to transfer Fe^{3+} across the cell membrane. This research is focused on predicting the potential of a lake to support cyanobacteria by

observing the biogeochemical interactions of P, O_2, Fe^{2+} and sulfate (SO_4) in several lakes in the Georgian Bay and Lake Simcoe area. Excess P promotes anoxia of the hypolimnion which allows for the dissolution of Fe^{2+} making it available to cyanobacteria which can migrate into the hypolimnion. Once O_2 becomes scarce, SO_4^{2-} reducers which produce sulfide (HS^-) can dominate. HS^- binds with Fe^{2+} forming insoluble iron sulfides FeS. Three sites: Sturgeon Bay, Deep Bay and North Bay were sampled throughout the summer season for SO_4^{2-}, TP, TN, O_2, Fe, NH_4^+ and NO_3^- in 2012 when blooms where present and in 2014 when blooms where absent. It is hypothesized that in 2014 these sites had less P loading, higher SO_4^2 concentrations and lower Fe^{2+} concentrations than were present in 2012. If this is the case then it may be possible to predict which lakes are likely to become dominated by cyanobacteria based solely on their chemistry and implement preventive measures accordingly.

Abstract ID: 33893

Final Number: B22A-03

Title: Quantification of Gas Fluxes through Frozen Sand and Snow Cover using a Multi-Tracer Approach

Presenter/First Author: Sophie Guillon, GEOTOP-UQAM, Montréal,

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Abstract Body: Seasonal freezing of the vadose zone affects approximately 50% of the exposed land in the Northern Hemisphere, while 30 % has a seasonal snow cover. The occurrence and thickness of frozen soil and snow cover are directly responsible for water, energy and gas fluxes from the surface to aquifers and vice-versa. Fluxes of CO_2 and other trace gases such as CH_4 and N_2O have been shown to occur during winter and to contribute to the annual budget, but they are often not measured or considered. Microbial processes, temperature and soil permeability are involved in controlling these gas fluxes, which need to be better understood and quantified. A multi-tracer approach is used to identify gas transport mechanisms and quantify gas fluxes. The experimental site is located on a sand deposit (esker), southwest of Montreal (Canada). Radon and CO_2 dynamics are currently monitored in the first meters of soil and in the snowpack throughout the 2015 winter and spring seasons. Soil water content, frost depth, snow cover and air pressure in soil and snow are also measured. Air permeability in these porous media is determined. Radon, a non-reactive gas that is produced homogeneously in the soil, is used to identify transport processes. Biological processes controlling CO_2 production can then be discriminated. In addition to these naturally produced gases, SF_6 is injected at the soil/snow interface as a tracer to evaluate the possibility for gases to seep to the atmosphere or to the unsaturated zone during winter. Transport mechanisms of gases through frozen and thawing soil as well as through heterogeneous snow cover will be discussed, in particular the role of barometric pumping as opposed to diffusion.

Abstract ID: 34498

Final Number: B22A-04

Title: Disturbance legacies and paludification mediate the ecological impact of an intensifying wildfire regime in the Clay Belt boreal forest of eastern North America.

Presenter/First Author: Aurélie Terrier, University of Quebec at Montreal UQAM, Verdun,

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Co-authors: Martin P Girardin, Canadian Forest Service, Québec, Canada; Alan Cantin, , , ; William de Groot, , , ; Kenneth Agbesi Anyomi, , , ; Sylvie Gauthier, , , ; Yves Bergeron, Industrial Chair CRSNG-UQAT-UQAM in sustainable forest management, Rouyn-Noranda, QC, Canada

Published Material: The paper is going to be published in the Journal of Vegetation Science (early view)The results were presented as a poster at: - the Wildland Fire Canada Conference 2014, Halifax, Canada- the 6th Ouranos Symposium 2014, Québec, Canada

Abstract Body: High moisture levels and low occurrences of wildfires have contributed during recent millennia to the accumulation of thick layers of organic soil and to a succession into open black spruce (Picea mariana)-Sphagnum dominated forests in the Clay Belt boreal landscapes of eastern North America. In these forests, the anticipated increase in drought frequency with climate change could lead to a shift in forest structure and composition, and to a subsequent transfer of the stored carbon back into the atmosphere via increased fire disturbance and decomposition. Herein we conducted modeling experiments using the Canadian Fire Effects Model (CanFIRE) to investigate potential changes in forest structure and composition in response to a changing fire regime. Vegetation dynamic was governed by the fire danger and behaviour that affect tree mortality and postfire recruitment of species, and by long-term successional pathways that are driven by postfire recruitment and forest age. Results from multiple scenarios suggested that fire danger will rise significantly during the 21st century in the Clay Belt forest. The burn rate was projected to change from 4.2%/decade during 1971-2000 to 18.6%/decade during 2071-2100. Stand mortality, fire intensity and areas affected by crown fires were also projected to increase significantly. A shift in forest composition did not occur over the simulation period across most of our fire regime scenarios. Moist and cool conditions in these forests prevent high depth of burn and contribute to the ecological resistance of these forests to increasing fire danger.

Abstract ID: 34363

Final Number: B22A-06

Title: Vegetation Continuous Fields: The Evolution of Sub-Pixel Land Cover Mapping from AVHRR, MODIS and Landsat

Presenter/First Author: Robert Allen Sohlberg, University of Maryland, College Park, MD

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Abstract Body: Land cover is an essential parameter describing the Earth's surface. In traditional satellite-based land cover maps, each pixel is assigned a single land cover class, but this method does not capture the subpixel and within-class heterogeneity present in the landscape. Traditional land cover maps also have a limited number of *a priori* vegetation classes, which may not be well tailored for all applications.

Mapping vegetation as subpixel fractions of biophysical types addresses short-comings of traditional land cover maps. Maps of Vegetation Continuous Fields (VCFs) capture gradations of landscape variability, such as those due to disturbance or subpixel patterns of nutrient and water availability. VCFs are inherently better suited to representation of gradual spatial and temporal changes in land cover, and offer improved estimation of biophysical parameters over large areas. They allow modelers greater flexibility in constructing parameterizations that directly depict driving factors in the landscape at a range of spatial resolutions, for example surface roughness.

The VCF depictions are unique and not furnished by normalized difference vegetation index (NDVI) and leaf area index (LAI) products. VCFs describe the heterogeneity of each pixel, differentiating, for example, between a pixel covered with sparse forest and a pixel covered with a mixture of forest, crops and bare ground. VCFs also quantify the subpixel proportions of tree cover, non-tree vegetation, bare ground and water found in each pixel.

Current VCF products are generated with four fractional layers: tree cover, non-tree vegetation, bare ground and water. Vegetation is further partitioned by leaf type (broadleaf / needleleaf) and leaf longevity (evergreen / deciduous). This presentation describes the evolution, lessons learned and application of VCFs over the past two decades from AVHRR (1°, 8 km, 1 km) to MODIS (500 m, 250 m) to Landsat (30 m) as well as current advances toward an inter-calibrated, multi-sensor, 30+ year data set at 1/20º. Through the VCF development history, methods have evolved from end-member mixture modeling to multiple regression trees with dynamic hands-off automated training. This evolution is described and current applications of the products are described. Funded by NASA via NNX14AJ33G and NNX13AJ35A.

Abstract ID: 35507

Final Number: B22A-07

Title: Efficient Updating of Land-Cover Classifications in a Data-Rich Environment

Presenter/First Author: Jeffrey A Cardille, Universite de Montreal, Montreal, QC

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Co-authors: Julie Anne Fortin, McGill University, Montreal, QC, Canada

Abstract Body: *What was the land cover of Las Vegas, Nevada on July 10, 2014? In the view of Landsat 5, 7, and 8, how much wetland area has been lost or gained annually on the Gulf Coast since Hurricane Katrina? Given observations from both MODIS and Landsat, where has forest in Bolivia been converted to non-treed land cover since 1984?*

For many scientists interested in using interpretations of remote-sensing data such as land-cover classifications, questions like these are enticing but remarkably difficult to answer given the current state of the art for interpreting remote sensing image sequences. We developed a new algorithm designed for the continuous updating of land-cover classifications through time in large data sets. The algorithm ingests classified land-cover data from any of the wide variety of earth-resources sensors; it maintains a running estimate of land-cover probabilities and the most probable class at all time points along a sequence of events. We tested this algorithm in central Quebec with Landsat 8 data for summer 2013, when a series of large fires erupted and burned through forests. Across 10 images of widely varying quality, our algorithm detected the fires, ignored contaminated image information, and mapped fire borders consistently throughout the summer. The sequence of land-cover maps through time had producer's and user's accuracies that were better than many of the component days, which were often contaminated by fire haze and clouds but nevertheless contained useable information. As we leave remote sensing's data-poor era and enter a period with multiple looks at Earth's surface from multiple sensors over a short period of time, this algorithm may help to sift through images of varying quality to extract the most useful information for mapping.

Abstract ID: 35742

Final Number: B22A-08

Title: Bayesian Updating of Land Cover Classification in th Brazilian Provinces of Amazonas and Mato Grosso

Presenter/First Author: Julie Anne Fortin, McGill University, Montreal, QC

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Co-authors: Jeffrey A Cardille, Universite de Montreal, Montreal, QC, Canada

Abstract Body: Land cover classifications are extremely useful tools that can be applied to help solve issues in policy, social sciences, conservation and more. However, they only capture information on a region for a snapshot in time. Given the dynamic state of the Earth and the impact of anthropogenic changes to land use and land cover on various timescales, there is need for continuous tracking of landscape change. This is of particular relevance for areas such as the Brazilian Amazon, where the rate of landscape change, especially from deforestation, has fluctuated over the past few decades. We have developed an algorithm in R (Bayesian Updating of Land Cover Classifications, a.k.a. BULC) which is capable of performing updates on land cover classifications by applying Bayesian statistics to classified images on a pixel-by-pixel basis. We have tested it on a study area around the Roosevelt River at the border between the Amazonas and Mato Grosso states in Brazil. As inputs into the algorithm, we used satellite imagery from Orbiew, Aster, CBERS, Landsat 1, 2, 7 and 8; classified imagery from the Finer Resolution Observation and Monitoring - Global Land Cover program and MODIS; as well as aerial imagery, at spatial resolutions ranging from 5 m to 500 m. We found that our algorithm is capable of providing up-to-date classifications despite relatively poor quality input classifications, in addition to being robust to using varied input data sources. Future developments of the BULC algorithm include testing the fidelity of its updates with that of pre-existing classification updates from the National Land Cover Database (NLCD) collection in the Las Vegas area between 1992, 2001 and 2006.

Abstract ID: 35816

Final Number: B22B-01

Title: Organic carbon cycling in lakes: exploring the source and sink balance through process modeling

Presenter/First Author: Paul C Hanson, University of Wisconsin Madison, Verona, WI

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Co-authors: Hilary A Dugan, , , ; Jordan Stuart Read, USGS Wisconsin Water Science Center, Middleton, WI

Abstract Body: Understanding of the roles lakes play in the global carbon cycle will be improved through advances in ecosystem models that include major components of the lake carbon cycle. Integrating lake models with catchment models and climate re-analysis products provides opportunities to study how lakes respond to both changes in landscape characteristics and climate variability and to better understand the circumstances controlling the fate of carbon in lakes. In this study, we model organic carbon dynamics in lakes and their catchments, capturing seasonal dynamics of both allochthonous and autochthonous sources of carbon. Model results are compared with major scales of variability in observed organic carbon concentrations to identify shortcomings in model structure reflective of our knowledge gaps in carbon cycling. Uncertainty in predictions, derived from uncertainties in observations and model parameters help identify ecosystem variables that warrant better observations and processes that warrant closer study.

Abstract ID: 34312

Final Number: B22B-02

Title: The Role of Fe and pH in the Photolytic Decomposition of Dissolved Organic Carbon in Boreal Lakes

Presenter/First Author: Jennifer L Mead, University of Waterloo, Waterloo,

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Co-authors: Sherry L Schiff, University of Waterloo, Waterloo, ON, Canada; Jason J Venkiteswaran, Wilfrid Laurier University, Waterloo, ON, Canada; Richard J Elgood, University of Waterloo, Waterloo, ON, Canada; Ryan H.S. Hutchins, Université du Québec à Montréal, Montreal, QC, Canada; Pieter Aukes, University of Waterloo, Waterloo, ON, Canada; John Spoelstra, Environment Canada, Burlington, ON, Canada

Published Material: Preliminary results from experiments that will be presented at AGU were first presented at the CCFFR/SCL Conference in Ottawa, January, 2015.

Abstract Body: Dissolved organic carbon (DOC) is the largest input of carbon to northern shield lakes but retention of DOC within lakes is large. Photodegradation of DOC is an important abiotic process for DOC loss. Products of DOC photodegradation including particulate organic carbon (POC), dissolved inorganic carbon (DIC), and photolytically altered DOC affect the size of carbon pools in lakes. Concomitantly, lake parameters such as pH and Fe concentrations can influence the rates of carbon transformation, yet these influences are poorly understood. Stable isotope analysis has been used to provide insight into the fate of allochthonous DOC and the accumulation of POC in lake sediments. In laboratory experiments, pH and Fe concentrations of three boreal streams (2 sites from The Experimental Lakes Area, Kenora, ON and one site from Dorset, ON) were manipulated to observe the impact on DOC photodegradation and POC formation. Measurement of carbon pools before, during and after photolysis allows the determination of DOC loss (production of DIC and POC formation) and carbon mass and isotopic mass balances. A novel size exclusion method, LC-OCD, was used in conjunction with other measures of quality to identify changes in DOC composition resulting from photodegradation. Changes in $^{13}C/^{12}C$ from photolysis were measured in the DOC before and after the experiment while the evolved CO_2 was measured throughout the experiment. The data will provide insight into the mechanisms controlling the partitioning of terrestrial carbon between the atmosphere and lake sediments.

Abstract ID: 33562

Final Number: B22B-04

Title: Modelling the impact of increasing dissolved organic carbon load on seasonal anoxia in a boreal humic lake.

Presenter/First Author: Raoul-Marie Couture, Norwegian Institute for Water Research, Oslo,

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Co-authors: Heleen De Wit, , , ; Koji Tominaga, , , ; Petri Kiuru, , , ; Igor Markelov, University of Waterloo, Waterloo, ON, Canada

Published Material: Under review in Journal of Geophysical Research: Biogeosciences

Abstract Body: Boreal lakes are impacted by climate change, reduced acid deposition and changing loads of dissolved organic carbon (DOC) from the catchment. We set to explore how these changes, in particular the increasing DOC load, modulate ice phenology and dissolved oxygen (DO) of a boreal humic lake located in southeastern Norway. Observed trends in daily air temperature (+0.045 $^oC\ yr^{-1}$) and weekly DOC concentration (0.1 mg C yr^{-1}, +1% annually) measured over the past 40 years at the study site were used as forcings for the lake model MyLake. The model was parametrized against year-round time-series of water temperature and DO from a high-frequency lake buoy. A backcast of ice freezing and break-up dates to 1974 reveals that ice break-up occurs on average 8 days earlier in 2014 than in 1974. An earlier ice break-up enhances water column ventilation, resulting in higher DO in the spring. Later in the season, warmer water in late summer lead to longer anoxic periods, as microbial DOC turnover increases. Long-term increase in DOC concentrations causes decline in lake DO, leading to 15% more hypoxic days (< 3 mg L^{-1}) and 10% more anoxic days (< 15 ug L^{-1}) in 2014 than in 1974. We conclude that climate warming and increasing DOC loads are antagonistic with respect to their effect on DO availability. The model suggests that DOC is a stronger driver of DO consumption than temperature. DOC increase thus has the potential to reduce the oxythermal habitat of fish and aquatic biota in boreal lakes.

Abstract ID: 35751

Final Number: B22B-05

Title: Ecohydrological Controls on Carbon Drainage via Groundwater in a Coastal BC Douglas-Fir Headwater Catchment During Pre- and Post-Harvest Periods

Presenter/First Author: Mark S. Johnson, University of British Columbia, Vancouver, BC

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Co-authors: T. Andrew Black, University of British Columbia, Vancouver, BC, Canada; Rachhpal Jassal, , , ; Nicholas J. Grant, , , ; Iain Hawthorne, UBC, Vancouver, BC, Canada

Abstract Body: Delivery of dissolved carbon from landscapes to streams is highly pronounced in headwater catchments where terrestrial-aquatic connectivity is high. Dissolved CO_2 is of particular interest in headwater systems since it can rapid evade from inland waters to the atmosphere, which can complicate resolution of the terrestrial carbon balance. Here we focus on groundwater as the primary flowpath for delivery of terrestrially-fixed carbon from the biosphere to the hydrosphere in a ~90 Ha managed forest catchment near Campbell River, British Columbia. We present 5 years of near-continuous in situ measurements of dissolved CO_2 in riparian groundwater at the catchment outlet. These data are compared against ecosystem respiration, as well as gross and net ecosystem productivity determined using eddy covariance within the catchment prior to and following forest harvest mid-way through this study. Ecohydrological controls on carbon drainage are considered in relation to forest harvest impacts on carbon uptake dynamics and hydrological flowpaths.

Abstract ID: 35424

Final Number: B22B-06

Title: Hydrological and Biogeochemical Controls on Transport, Modification and Export of Dissolved Organic Matter in Large Drainage Networks.

Presenter/First Author: Jenn B Hoyle, Yale University, New Haven, CT

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Co-authors: James E Saiers, Yale University, New Haven, CT; Peter A Raymond, Yale University, New Haven, CT; William V Sobczak, Holy Cross College, Worcester, MA

Abstract Body: Dissolved organic matter (DOM) is essential to the ecology and chemistry of inland waters as an energy and nutrient source, a regulator of light attenuation and a transporter of heavy metals and other pollutants. The key questions explored in this research project include the controls on DOM movement from the terrestrial landscape and modification of DOM during its transit through streams and rivers and toward the ocean in a large drainage network. We explore the riverine fate of terrestrial DOM subsidies by developing a simple model that routes water and DOM through the 1300 km^2 Passumpsic River watershed located in northern New England. The Passumpsic watershed is drained by a dendritic channel network comprised of 1,500 first- through fifth-order streams that feed the 75-km long, sixth-order Passumpsic River, a tributary to the Connecticut River. Published scaling laws are used to specify the numbers, lengths, and connectivities of the stream segments, while the routing algorithm describes the precipitation-induced delivery of terrestrial DOM to headwater reaches and the down-network changes in DOM concentrations resulting from mixing with other waters and rate-limited decomposition. Results of model simulations conducted to date underscore the dominant contribution of low-frequency precipitation events to the annual subsidy of terrestrial DOM to the drainage network and reveal that most of this DOM subsidy is utilized in large rivers, far from its source within the drainage network.

Abstract ID: 36713

Final Number: B22B-07

Title: Revisiting Global Riverine Carbon Export to the Oceans

Presenter/First Author: Mingfeng Li, University of Quebec at Montreal UQAM, Montreal, QC

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Abstract Body:
Riverine carbon (C) export to the oceans is recognized as a key component in the global C cycling, yet is still poorly understood, in part because most p revious studies have assessed either inorganic or organic C species separat ely, and have thus yielded a fragmented perspective of riverine C exported to oceans. In addition, differences in approach have resulted in widely vary ing estimates, for example, of global annual
DOC or TOC export, ranging from 0.03 to 1 Pg. Here we revisit the global riv erine C export, explicitly taking into account DOC, POC, DIC and PIC transpo rt to the oceans, based on the most extensive meta-
analysis of published data carried out to date covering 568 rivers draining 7 3.7% of the global exorheic area. This analysis yields a global annual riverin e C export of 1.05 Pg (somewhat higher than the widely-
accepted 0.9 Pg), of which DOC, POC, DIC and PIC account for 0.32, 0.17, 0. 48 and 0.08 Pg yr^{-1}, respectively. Our estimate of global DOC export is 45% higher than the c urrently accepted value of 0.22Pg. Our results show that, at a global scale, organic C export has a significant negative relationship with catchment are a, and that DOC and DIC exports are both significantly related to catchmen t elevation, albeit in opposite directions. There is a negative latitudinal tren d in the DIC/DOC and in the POC/DOC export ratios. Our analysis also highli ghts the impact of human activities on riverine C export: Irrigation, the deg ree of impoundment, and the level of economic activity in the watershed h ave strong negative relationships with DOC export, though none on DIC ex port. Our study
more tightly brackets global riverine C export to the oceans, and further hi ghlights the differential regulation of global inorganic and organic riverine C export, with strong implications in terms of future climate and human-induced environmental change.

Abstract ID: 35738

Final Number: B22B-08

Title: Quantifying carbon burial in northern forested lakes since the Anthropocene

Presenter/First Author: Adam Heathcote, Groupe de Recherche Interuniversitaire en Limnologie, Montréal, QC

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Abstract Body: The northern forested zone is one of the most important areas for the processing of carbon (C) on an annual basis. Lakes play an important role in this carbon cycle burying large amounts of organic-C in their sediments. Estimates of organic-C burial in boreal lakes are poorly constrained and do not account for possible increases in burial rates driven by global ecosystem change during the last century. To address this issue, we used a large set of ^{210}Pb-dated sediment cores to determine spatial and temporal trends in organic-C burial over the last 180 years across the northern forests of continental North America. We found that baseline organic-C burial was negatively correlated with latitude and positively correlated with mean annual temperature. Additionally, mean post-1950 rates represent nearly a 2-fold increase over background rates and a 4- to 13-fold increase over average Holocene estimates. Up-scaling the mean lake C-burial rate observed in this study to the whole boreal forest biome could account for as much as 10% of the total organic C stored in lake sediments since the Holocene. With future disturbance regimes in the boreal forest biome, lake sediment may become an even more important site of C burial.

Abstract ID: 34516

Final Number: B23A-01

Title: Simulating Regional Impacts of Climate Change Mitigation Policies on the Global Timber Market: Implications for Regional Forest Management

Presenter/First Author: John B Kim, US Forest Service Corvallis, Corvallis, OR

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Published Material: The global vegetation simulation, which drives the global timber market analysis, was presented at the International Union of Forest Research Organizations (IUFRO) World Congress 2014 in Salt Lake City, UT. The proposed talk will cover the global vegetation simulation, its link to the global timber market analysis model, and the final results of the global timber market analysis.

Abstract Body: Climate change will bring different types of climate change to regions of the world, and will drive different types of responses by the various forest ecosystems of the world. In turn, the global timber market will dynamically respond to and adjust to the changing productivities of forested regions around the world. Local and regional mitigation strategies and forest management policies must take into account the not only forest responses to climate change, but the additional dynamics exerted by the global timber market.

As a part of the Climate Change Impacts and Risk Analysis (CIRA) project by the U.S. EPA Climate Change Division, we integrated climate, vegetation and timber market models to estimate regional implications of global mitigation policies. The Emissions Predictions and Policy Analysis (EPPA) model and the Integrated Global System Model (IGSM) created three socioeconomic & emissions scenarios: Business-as -usual and two mitigation policy scenarios that stabilize radiative forcing levels in 2100. NCAR Community Atmospheric Model (CAM) linked to the IGSM generated 10 future climate projections. MC2 DGVM was run using the 10 climate projections, and the biophysical results from these models were used as boundary conditions for a global forestry and land use model (GTM). The resulting integrated climate-vegetation-economic modeling system is used to assess the implications of the three socioeconomic & emissions scenarios on various forest stocks, prices, and land use. Using the model, we estimate the regional impact of global mitigation policies on regions within the United States; explore the implications on regional forest mitigation policy; and assess the economic efficiency of alternative adaptation policies for the United States.

Abstract ID: 33899

Final Number: B23A-03

Title: Greenhouse Gas Mitigation Potential and Timing of Forest Bioenergy in Canada

Presenter/First Author: Jerome Laganiere, Natural Resources Canada - Canadian Forest Service, Québec City, QC

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Abstract Body: The delay before the substitution of fossil fuel by forest bioenergy starts having a net beneficial impact on atmospheric CO_2 (referred as the carbon debt) is object of debate notably among scientists, ENGO's and policymakers. Several studies have documented a long carbon debt for some forest bioenergy uses (e.g. over a century before benefits occur). As the cost of delaying GHG emission reductions is increasingly being recognised, policies are being discussed, in Europe and elsewhere, to favour bioenergy uses with precise and specific carbon debt repayment time or parity time.

We have documented the carbon parity time of forest bioenergy sourced from different feedstocks (harvest residues, salvage wood, green trees) typical of the forest biomass production in Canada to substitute three fossil fuel types (coal, oil, gas) in heating or power generation. Each scenario includes the widest possible range of factors found in the literature for forest lands remaining forest lands that could impact the timing of atmospheric CO_2 benefits including transportation distances, wood processing and environmental characteristics.

As expected, the results indicate short-to-long ranking of parity times for residues<salvage<green trees, and for substituting the less efficient fossil fuels (coal<oil<natural gas). A sensitivity analysis indicates that silviculture and enhanced biomass conversion efficiency helps reducing time to achieve atmospheric benefits. The results show that the uncertainty around the estimate of carbon parity time is generally small and inconsequential for harvest residues options, but generally large for the other feedstocks, indicating that some options present reasonable parity times with respect to current policy timeframes, while others do not.

These results illustrate that meeting specific parity time for bioenergy options using salvage or green trees is possible but under restricted conditions that would require a good tracking system. They also point out that the carbon parity time may be prone to a large uncertainty that should be taken into account when evaluating the GHG mitigation performance of particular bioenergy uses.

Abstract ID: 33922

Final Number: B23A-04

Title: Integrating Carbon Price Trajectories Into Canadian and California Forest Sector Mitigation Scenarios

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Co-authors: Chi-chung Tsao, , , ; Carolyn Smyth, Natural Resources Canada - Canadian Forest Service, Edmonton, AB, Canada; Mark Hafer, , , ; Werner Kurz, Canadian Forest Service, Victoria, Canada

Abstract Body: Forest policies in Canada and California are increasingly interlinked through the wood products trade as well as evolving integration between state and provincial carbon markets. While California only has 2% as much forest area as Canada, it has more end-users of wood products. Our goal is to use a rigorous systems perspective for both wood exporting regions and wood importing regions. We add price driven scenarios to recent forest management and product utilization scenarios developed with the Carbon Budget Model of the Canadian Forest Sector

(CBM-CFS3) and a harvested wood products (HWP) model. In addition, we develop plot based yield curves for California's forests to simulate the same scenarios for Canada and California.The first scenario is an increase in the global-level adoption of the current methane capture practices common to the upper quartile of the European Union's economies. The second is the substitution of bioenergy for the most polluting, rather than the average polluting, units of energy in regional energy grids. The third is the reallocation of a greater percentage of the chip-based harvest from paper products to engineered wood products. For California, we add an additional forest management option based on silvicultural thinning to reduce mortality in water limited Mediterranean climate forests. We then test whether increasing carbon price trends change the relative rank order of scenarios in terms of cumulative mitigation impacts as carbon pollution in later years will be more expensive per ton than carbon pollution in the earlier years. We use the social cost of carbon from William Nordhaus's DICE2013 model that starts at $17.7 per tCO2e in 2015 and increases 3% annually. We then explore situations where increasing carbon prices drive a more rapid diffusion of best current technologies that could significantly improve overall mitigation benefits.

Abstract ID: 33343

Final Number: B23A-05

Title: Long-Term Impacts from Mountain Pine Beetle Outbreaks on Merchantable Biomass, Ecosystem Carbon, Surface Albedo, and Net Radiative Forcing: The Major Role of Vegetation Response

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Abstract Body: Although field-based studies have highlighted the role of non-target vegetation following mountain pine beetle (MPB) outbreaks, the range of possible growth release responses has not been systematically assessed in model-based studies. The potential for the spatial distribution of mortality to modulate by itself the effects from MPB outbreaks has also been overlooked heretofore, while only one study has combined the albedo-induced cooling with the CO_2-based temperature change in order to estimate the net impact of MPB on the global climate. And even if MPB outbreaks have been recurring for millennia in western North American forests, previous studies have often spanned a few decades or less, and have never gone beyond two centuries. The main objective of our study was to contribute to the understanding of MPB consequences on forestry, ecosystem carbon cycling, and climate by modifying an existing model that computes land–atmosphere exchanges of carbon, energy, and water, and simulates dynamic changes in vegetation state and distribution. We performed various long-term simulations over different locations in British Columbia, Canada, in order to address the issues identified above and a few additional ones. We found that the growth release from the non-target vegetation can indeed play a dominant role in the strength, and even the direction, of MPB-induced changes. We also observed strong non-linearities in MPB mean effects for different outbreak severities or return intervals, along with major changes in these effects through time. Our results also support the idea that the spatial distribution of mortality may explain part of the high variability in MPB effects revealed by satellite-based studies. All these complicating factors imply that extrapolating the knowledge gained from short-term or localized studies to larger spatiotemporal scales might be misleading, so that the actual impact of the ongoing MPB outbreak cannot be estimated with confidence yet over its entire domain. For example, our results suggest that the feedback to climate change from the current MPB outbreak over British Columbia could be positive or negative. Despite this uncertainty, a simple analysis nevertheless shows that the magnitude of this impact is probably much smaller than one month of current anthropogenic CO_2 emissions.

Abstract ID: 35358

Final Number: B23A-07

Title: Economic feasibility of conifer afforestation in North America using a process-based growth model

Presenter/First Author: Jung meng Lee, NCHU National Chung Hsing University, Taichung,

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Abstract Body: Anthropogenic emission of carbon dioxide is one of the most significant contributions to the global climate change. One potential option to reduce atmospheric CO_2 is to make use of forest growth. Afforestation and reforestation could be a cost-effective option to sequester atmospheric carbon. The Canadian Forest Service developed an investment analysis model, the Canadian Forest Service-Forest Bioeconomic Model (CFS-FBM) to examine the carbon sequestration potential of fast growing poplars as a substitute for fossil fuels. Unfortunately despite their fast growth, poplars are costly to establish and manage which affects their economic attractiveness. There is a need to examine other species and develop forest growth curves that better account for climate variability. Our objective is to develop spatial productivity estimates that better incorporate climate variability by examining and integrating long-term eddy covariance measurements and a process-based C and N coupled model, CLASS-CTEM+N, simulated fluxes in a spatially explicit productivity and economic model (e.g. CFS-FBM). The aim is to better depict the economic potential of conifer afforestation across North America. Preliminary results indicate that there is a strong correlation between net primary productivity and minimum temperature. Biological productivity is projected to increase in all future climate scenarios. It is also projected that net ecosystem productivity is expected to grow which constitutes for the increase in atmospheric carbon sequestration. Ultimately the study will examine the economic attractiveness of conifer afforestation with and without carbon sequestration as an economic value. By incorporating a growth process model directly tied to possible future climate pathways, it better depicts yield potential and helps determine what carbon would have to be valued at to make this type of afforestation attractive.

Abstract ID: 35439

Final Number: B23B-01

Title: The Impact of Open-Water Pools on the Net Ecosystem CO_2 Exchange of a Boreal Peatland

Presenter/First Author: Luc Pelletier, McGill University, Montreal, QC

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Published Material: Part of the findings presented have been published in Pelletier et al., (2014-*JGR Biogeosciences*) while others have been submitted for publication in *Biogeochemistry* and *Environmental Research Letters*

Abstract Body: Peatland open-water pools are a common feature on temperate, boreal and subarctic peatlands but their impact on the net ecosystem carbon dioxide exchange (NEE-CO_2) is poorly understood. A limited number of studies using measurements made solely during the growing season have shown pools to represent net sources of CO_2 to the atmosphere. To date, the evaluation of the CO_2 budget of peatlands with pools has only been explored through spatial extrapolation and temporal interpolation of point measurements made using static chambers; the errors introduced can be larger than the fluxes. In this study, we evaluated the annual CO_2 exchange from peatland open-water pools using a combination of methods (headspace technique and non-dispersive infrared CO_2 sensor) to obtain a complete annual surface to atmosphere CO_2 exchange from pools, including ice melt emissions. Simultaneously, we assessed if the presence of pools has a measurable impact on the peatland NEE-CO_2 using a combination of eddy covariance (EC) measurements and source area analysis. Our results confirm that the peatland open-water pools are a significant source of C to the atmosphere, with an annual release of 99 g CO_2-C m^{-2}, of which 15% was released during the ice-met period. The source area analysis performed on the EC tower data shows that an increase in pool contribution to the ecosystem CO_2 fluxes results in a reduction in both ecosystem level maximum gross photosynthesis and respiration. Despite significant CO_2 loss from the pools, we found the overall peatland to be a net sink for CO_2 for the measurement period.

Abstract ID: 36438

Final Number: B23B-03

Title: Understanding uncertainties in net ecosystem CO_2 exchange measurements by open-path gas analysers

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Published Material: Parts of this study are intended to be presented at the EGU Annual Assembly in Vienna in April 2015.

Abstract Body: Open-path (OP) infrared gas analysers (IRGAs) are often used to estimate net ecosystem CO_2 exchange (NEE) using the eddy covariance technique. A main focus of this research is to better understand the variability of NEE dynamics across contrasting ecosystems. A sophisticated understanding and documentation of potential uncertainties inherent to the use of OP IRGA is necessary to ensure inter-site comparability.

In contrast to closed-path (CP) IRGAs, OP IRGAs are exposed to high-frequency temperature and humidity variations affecting CO_2 density fluctuations not related to biological sources or sinks of CO_2. The Webb-Pearman-Leuning (WPL) term accounts for these gas density fluctuations. However, the application of the WPL term introduces different sources of uncertainty compared to NEE estimates based on CP IRGAs. Potential sources of such errors in NEE are uncertainties in the measurements of sensible and latent heat fluxes, biases in absolute gas density measurements, sensor surface heating, and non-sufficient corrections for high-frequency band-broadening effects.

With this contribution, we present results from a sensor inter-comparison study conducted at the Mer Bleue peatland near Ottawa, Ontario. Eddy covariance systems with a CP IRGA (LI7000) and with an OP IRGA (EC150) were compared between September 2012 and January 2013, whereas the same CP IRGA system was compared to a second OP IRGA (LI7500) between January and April 2006. The results indicate significant biases in NEE estimates obtained with the OP IRGAs compared to CP IRGA NEE estimates. For both OP IRGAs, the differences in NEE scaled with the magnitude of the sensible heat flux. Since the absolute magnitude of the bias seems to be directly related to the magnitude of the sensible heat flux rather than to the magnitude of NEE, the relative error is likely larger at sites with small NEE. Preliminary results indicate multiple error sources for the OP IRGAs and highlight the importance of site-specific uncertainty analyses.

Abstract ID: 35969

Final Number: B23B-05

Title: Using Ground Penetrating Radar (GPR) to Investigate Greenhouse Gas Releases from Peatland Ecosystems: from boreal to subtropical systems

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Published Material: Some of the materials that will be introduced as overview on applications of the method have been already published in several scientific journals

Abstract Body: As concerns grow over the effect that greenhouse gas releases to the atmosphere from natural sources have on Earth's climate, studies investigating the contribution from freshwater peatlands have increased largely over the last few decades. Freshwater peat soils are considered important carbon (C) reservoirs and sources of greenhouse gases such as methane (CH_4) and carbon dioxide (CO_2); it is therefore important to better understand how changes in environmental variables (such as temperature) may affect biogenic gas releases from these soils. Most studies investigating such dynamics have mainly focused on discrete point measures (such as gas chambers) or invasive techniques (such as probe insertion and/or sampling) that may provide little information on spatial and temporal patterns in gas flux variability whilst directly disturbing the gas regime. Although the use of eddy covariance methods has helped to better understand temporal patterns of gas release, the method may not resolve spatially isolated, rapid ebullition events due to the large footprint. Hydrogeophysical methods such as ground penetrating radar (GPR) can be used to non-invasively investigate the spatial and temporal variability in gas releases from freshwater peat at a spatial scale that is intermediate between the footprints provided by chamber and eddy covariance methods. The method has now been used for over a decade to target small contrasts in volumetric gas content (both in time and space) within peat soils (i.e. approximately >1%). In this study we use case studies at multiple scales of measurement (i.e. from field to laboratory scales) to show the potential of GPR to (1) better understand the spatial distribution of biogenic gases in a variety of freshwater peatlands over a wide latitudinal gradient, and (2) monitor in situ gas dynamics driven by environmental forcing. Previously unreported datasets will also be presented to further demonstrate the value of GPR for investigating biogenic gas dynamics in peat soils and highlight the potential of the method to overcome some of the limitations imposed by traditional methods.

Abstract ID: 35041

Final Number: B23B-06

Title: Controls on below ground free phase gas dynamics in a Northern peatland inferred from field-scale electrical resistivity tomography (ERT)

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Abstract Body: Northern peatlands act as sources of methane and both sources and sinks of carbon dioxide, but the mechanisms that control subsurface free phase gas (FPG) cycling within peatlands, and therefore estimates of past, present, and future gas flux remain unclear. In particular, the spatiotemporal variability of FPG production and release within peatlands is uncertain. While chamber-based measurements provide a direct estimate of FPG flux, these methods measure only at the surface over a small footprint (< 1 m^2). We collected one hundred and twenty-seven 3D electrical resistivity tomography (ERT) datasets during July and August of 2013 in Caribou Bog, Maine to investigate changes in FPG at a unique spatiotemporal scale. Our setup consisted of 72 electrodes placed in the surface of the peat in a 28 by 10 m array configured to sample from the entire peat volume (7 m deep). Water levels, soil temperature, atmospheric pressure, and other environmental parameters were simultaneously acquired at a minimum of 1 hour sampling interval. Methane fluxes were also measured using a flow-through gas chamber and fast methane analyzer located within the ERT array over a limited time period. Although gas flux cannot be directly quantified through ERT measurements, we assume that resistivity and FPG content are directly related due to the well-known dependence of resistivity on water content and use information from our other sensors to support this assumption. Our results indicate that water table variation exhibits the strongest control on FPG changes, but that soil temperature and atmospheric pressure are also somewhat correlated with FPG changes throughout the peat. In the shallow and middle peat (0.2 to 4.4 m depth), we witness evidence for mobility-driven ebullition in responses to changes in atmospheric and/or hydrostatic pressure. In the deep peat (> 4.4 m) we infer that buoyancy-driven migration of FPG to upper layers or the atmosphere is the dominant mechanism resulting from changes in atmospheric and hydrostatic pressure.

Abstract ID: 35986

Final Number: B23B-07

Title: Time-lapse geophysical measurements targeting spatial and temporal variability in biogenic gas distribution and releases from peat soils in a hydrologically controlled wetland in the Everglades

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Abstract Body: Peat soils are known to release globally significant amounts of methane (CH_4) and carbon dioxide (CO_2) to the atmosphere. However, uncertainties still remain regarding the spatio-temporal distribution of gas accumulations and triggering mechanisms of gas releasing events. Furthermore, most peatland gas dynamics research has historically been focused on high latitude peatlands, while recent works have suggested that gas production rates from low-latitude peat soils may be higher than those from colder climates. Therefore, understanding gas dynamics in low-latitude peatlands (*e.g.* the Florida Everglades) is key to global climate research. Recent studies in the Everglades have demonstrated that biogenic gas flux values may vary when considering different temporal scales of measurements (*i.e*. hourly vs. daily averages). The work presented here mainly targets spatial variability in gas production and release at the plot scale in an approximately 85 m^2 area. The study was conducted during two separate field campaigns in the Loxahatchee Impoundment Landscape Assessment (LILA), a hydrologically controlled, landscape scale (30 Ha) model of the Florida Everglades. Ground penetrating radar (GPR) has been used in the past decade to non-invasively investigate the release of biogenic gases from peat soils. A grid of GPR profiles was collected to image biogenic gas distribution over the study area and estimate biogenic gas production and flux from its temporal variability. Also, gas flux chambers outfitted with time-lapse cameras captured high resolution gas flux measurements in order to constrain GPR data.

Abstract ID: 36648

Final Number: B23B-08

Title: Methane dynamics in a montane fen: Factors controlling production, accumulation and emissions

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Abstract Body: Characterization of methane dynamics in peatlands is essential to improve understanding of peatlands contribution to carbon balance and interaction with climate. Of the two peatland types, natural fens are known to be a larger contributor of methane emissions to the atmosphere than natural bogs. This study uses geophysical methods integrated with in-situ direct measurements and chamber fluxes to improve understanding of temporal and spatial variation in methane production, accumulation and emissions from natural montane fen in Alberta Canada. Meteorological data and peat cores (~150 cm) were collected to study factors affecting methane production, accumulation and emissions from the Sibbald Research Wetland, a montane fen in the Rocky Mountains in southern Alberta.

Our results show a direct correlation between methane accumulation and degree of peat humification, substrate quality and porosity. Changes in temperature, pressure and water table position were shown to relate to ebullition events, with the highest number of ebullition events occurring from late August to early November. The geophysical results indicate a small spatial variation in free phase biogenic gas accumulation within the studied area. Diffusive methane fluxes were correlated to plant productivity on both daily and seasonal time scales with patterns varying between plots dominated by Juncus sp. and Carex spp. These results highlight the interacting ecological and physical controls on peatland methane dynamics.

Abstract ID: 33456

Final Number: B24A-0072

Title: SUGARCANE CARBON SEQUESTRATION POTENTIAL UNDER THE CLEAN DEVELOPMENT MECHANISM THE CASE OF KAKIRA SUGAR ESTATES-UGANDA

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Published Material: It was presented as a poster on the 28th of March 2014 in Brussels- Belgium and was reviewed and accepted for presentation in the African Green Revolution Conference 2014: BRIDGING THE GAP BETWEEN SCIENCE, SOCIETY AND INDUSTRY: Building a new generation of African Soil Scientists and Agronomists Kenyatta University, Nairobi, Kenya, 1st – 5th December, 2014 but was not presented due to lack of sponsorship

Abstract Body: Abstract

Soils, and managed agricultural soils in particular, represent a potentially significant low cost sink for greenhouse gases (GHGs) with multiple potential co-benefits to farm productivity and profitability (Jonathan, Ryan and Jeffrey, 2010). Since agricultural soils can store more carbon, a modest increase in carbon stocks across the large land areas used for agriculture would represent a significant GHG mitigation. Sugarcane accompanied with good farming practices has the potential to sequester considerable amounts of carbon and so contribute to climate change mitigation. However, little has been done to provide relevant information concerning carbon sequestration in crop lands and sugarcane in particular. This research analyzed the performance of four different sugarcane varieties to sequester carbon in the soil at Kakira sugar works in Uganda. Results show that sugarcane grown in Kakira estates has the potential to sequester carbon of about 239.4Tc/ha for plant crop and 2 ratoons. Therefore, with proper agronomic practices, carbon sequestration in sugarcane can contribute to clean development mechanism in sugar milling and processing.

Key Words: Carbon sequestration, sugarcane varieties, soil organic carbon, phytoliths, Bulk density.

Abstract ID: 33479

Final Number: B24A-0073

Title: Investigating the Landscape Scale Carbon Implications of 100 Years of Land Management in the Sooke Lake Water Supply Watershed, Victoria, British Columbia

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Published Material: Approximately 50% of this research was presented at the AGU 2014 Fall Meeting December 15-19 in San Francisco. Specifically, the baseline carbon budget and dissolved organic carbon parameterization was presented in poster form. This research has not yet been submitted to a scientific journal.

Abstract Body: To address how natural disturbance, forest harvest, and deforestation from reservoir creation affect landscape-level carbon (C) budgets, a retrospective C budget for the 8595 ha Sooke watershed from 1911-2012 was developed using historic spatial inventory and disturbance data. A baseline C budget was prepared using a spatially-explicit version of the C Budget Model-Canadian Forest Sector (CBM-CFS3), an inventory-based model used to simulate forest C dynamics at multiple scales. To examine management effects, two alternate management scenario C budgets were developed in CBM-CFS3: (S1) no reservoir raising (flooding) or sustained yield forestry and (S2) reservoir raising but no sustained forestry. In 1911 the watershed was dominated by mature/old Douglas-fir forests with aboveground biomass C (ABC) of 262 Mg C/ha and net biome production (NBP) of 0.38 Mg C/ha/yr. Successive dams were built, land cleared, and reservoir area expanded from 370 to 450 ha in 1915, 610 ha in 1970, 670 ha in 1980 and 810 ha in 2002. Early fires and logging from 1911-1953 were followed by sustained forestry from 1954 -1998, with a minimum ABC of 148 Mg C/ha in 1991. By 2012 ABC (177 Mg C/ha) had increased though still less than in 1910. Cumulative NBP (ΣNBP) for the baseline recovered from a low of -167 Mg C/ha in 1994 to -142 Mg C/ha in 2012. In contrast, the minimum ΣNBP for S1 was -85 Mg C/ha in 1956 and recovered to -35 Mg C/ha by 2012. Minimum ΣNBP for S2 was also in 1956 (-88 Mg C/ha) and increased to -49 Mg C/ha by 2012. Even with elimination of sustained forestry, deforestation alone did temper the ability of the landscape to recoup C losses earlier in the century. Over 100 years in the baseline run, 2430 ha of forest was cut and replanted, 640 ha deforested and 882,746 Mg C exported as harvested wood products (HWP). Total HWP export was decreased by 46% and 60% in S2 and S1, respectively, from the baseline. The effects of accounting for storage of C in HWP will be discussed.

Abstract ID: 35360

Final Number: B24A-0074

Title: Environmental Controls on Tree-Ring Growth in an Age-Sequence of Planted Pine Forests

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Abstract Body: The objective of this study was to assess the effect of regional climate patterns and forest management on growth rates of an age-sequence of three white pine (*Pinus strobus* L.) plantation forests established in 1939 (TP39), 1974 (TP74) and in 1989 (TP89) in southern Ontario, Canada. These sites are a part of the Turkey Point Flux Station and global Fluxnet. To evaluate the effects of climate and land management on annual biomass accumulation, surface area of growth rings was measured on 15 white pine discus (tree slices at DBH) cut in 2004 and compared to historical climate records from 1939 to 2004 (temperature and precipitation) for each of the three sites. The combination of annual climate variability and decadal scale climate oscillations such as the Arctic Oscillation and El Niño Southern Oscillation show relatively strong correlation in growth. Forest response to annual temperature changes show strongest correlation ($r^2 = 0.37$) with a 2-year lag in growth, as compared to growth year ($r^2 = 0.29$) and 1-year lag ($r^2 = 0.33$). Decreased growth was observed across the chronosequence in 1975, 1989 and 1999, corresponding to decrease annual temperatures and shortened growing seasons accompanying strong La Niña years. Precipitation does not show a strong correlation with growth except during extreme drought years. As expected, plantations on former agricultural land (TP89) approach maximum growth rate much faster (at 11 yrs of age) due to nutrient residue, as compared to stands planted on former oak savannah (TP39 and 74) (at 13 yrs of age). Impacts of canopy closure begin 25 years after afforestation as shown by decreased growth rates. Thinning at the oldest site (TP39) in 1983 enhanced annual biomass accumulation for 20 years following the treatment.

Abstract ID: 35457

Final Number: B24A-0075

Title: Carbon Dynamics of a Young White Pine Plantation Forest

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Abstract Body: This study assesses the effects of seasonal and annual climate variability on the growth and carbon dynamics of a temperate white pine (*Pinus strobus* L.) plantation established in 2002 in southern Ontario, using CO_2 fluxes measured by the eddy covariance technique. It is rare to have continuous long-term flux measurements in a young forest since its planting. The plantation became a carbon sink after 4 years of its establishment. Drought events resulted in reduction in net ecosystem productivity (NEP). In 2005, an early growing season drought and heatwave caused the stand to become a net carbon source. Water use efficiency consistently increased over the study period with a mean value of 3.0 g C uptake per kg of water loss in 2013. Quantum yield, α (0.01 to 0.07) and maximum photosynthetic capacity, A_{max} (4.0 to 25.1 µmol $m^{-2}s^{-1}$) increased steadily as the size and density of the canopy increased over the stand age. A linear stepwise regression analysis found that growing season mean soil water content, photosynthetically active radiation and soil temperature explained 67% of the variability in NEP. This study will be a significant contribution to our understanding of the carbon dynamics of young plantation forests and their environmental controls. It will also help to determine how young plantation forests may be affected by climate variability and extreme weather events.

Abstract ID: 35390

Final Number: B24A-0076

Title: An Analysis of Soil CO_2 Emissions in a Temperate Deciduous Forest Ecosystem

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Abstract Body: The production and emission of carbon dioxide (CO_2) from soils, referred to as soil respiration (Rs), has a significant influence on the global carbon balance. Carbon is acquired by vegetation from the atmosphere through photosynthesis and stored on the surface and in soils as organic matter. This stored organic matter is returned to the atmosphere as CO_2 through belowground decomposition of organic matter by microbial communities (heterotrophic respiration) and metabolic activity of roots and mycorrhizae (autotrophic respiration). In this study, we explore temporal and spatial dynamics of Rs in a temperate deciduous forest located in Southern Ontario and how it is influenced by climatic controls. The site is a 90-year-old managed hardwood forest (Carolinian species). It is part of the Turkey Point Flux Station and global Fluxnet network. An automated soil CO_2 flux system (LI-8100A) was utilized for continuous monitoring of Rs since July 2014 at our site. To better capture the spatial variability of Rs, a portable soil CO_2 flux system (LI-6400) was also used along two 50-m transects. Comparing the two chamber systems, they both measured within one standard deviation of each other indicating that the long-term automatic chamber site is representative of the surrounding area. Monthly mean Rs varied from a maximum of 12.78µmol/m^2/s in July to a low of 1.0µmol/m^2/s in December. The seasonal trend of Rs followed closely that of soil temperature. Spatially variability in the soil water content had little effect on Rs values. This study will allow us to have a better understanding of the dynamics of Rs and how it responds to its main controlling variables, soil moisture and temperature. It will also help us to determine the impact of climate change and extreme weather events on Rs in temperate deciduous forests and help in developing vegetation ecosystem models.

Abstract ID: 35998

Final Number: B24A-0077

Title: Response of Soil Respiration to Thinning of a Temperate Pine Forest in Southern Ontario

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Abstract Body: Soil respiration (Rs) is the largest component of ecosystem respiration, and the second largest amount in ecosystem carbon budgets after gross primary production. Soil temperature and soil moisture can explain most of the temporal and spatial variations seen in soil respiration. Forest thinning can change soil temperature and water content, organic matter, root biomass and microbial activity, thus changing soil respiration. This study will investigate the impact forest thinning will have on the forest soil respiration, with the use of an automated soil CO2 chamber system, in a 75-year old temperate pine (*Pinus strobes L.*) forest, near Lake Erie in southern Ontario, Canada. The chamber system was installed and started collecting data in the summer of 2008 with four chambers operating. In the spring of 2009, another four chambers were installed.

During the winter of 2012, the forest was selectively thinned and approximately 30% of the trees were removed to improved light and water availability and stimulate growth of the remaining trees. The chamber system was removed during this winter for precautionary measures and as heavy machinery needed to access the site to remove selected trees. This disturbance of soil layer and decomposition of debris left behind is expected to increase soil respiration. Gaps, resulting from chamber malfunctions, calibrations, winter snow and ice problems, were filled using empirical models that used a Q_{10} relationship for soil temperature and soil CO_2 efflux, and a logistic relationship for soil water content of the root zone and soil CO_2 efflux.

Total annual Rs (average of 930 g C m^2 y^{-1} over seven years) accounted for the majority (approximately 76%) of the total ecosystem respiration measured from the Turkey Point Flux Station. Distinct highs and lows were observed in Rs that closely tracked soil temperature. During the winter months, variability in Rs decreases with a decrease in soil temperature and a decrease in the variability of soil moisture. In the years following the thinning, Rs shows little difference to the pre-thinning years, and is most likely influenced by both interannual climate variability and thinning effects.

Abstract ID: 36723

Final Number: B24A-0078

Title: Quantitative, Non-destructive Estimates of Coarse Root Biomass using 3-D Ground-Penetrating Radar (GPR)

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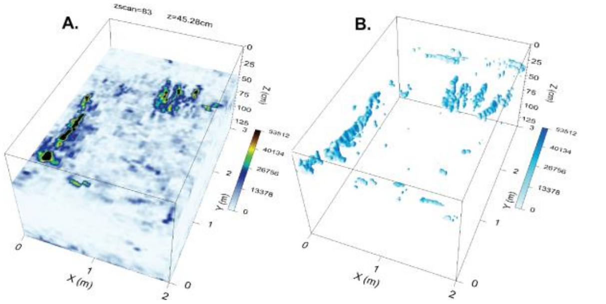
Abstract Body: Tree root biomass is an important component of carbon storage in forest ecosystems. In this study, we evaluated 3-D imaging of root structure in a temperate pine forest in southern Ontario, Canada using high-resolution (1-GHz) GPR with post-survey corrections for surface micro-topography. A MEMS (micro-electro-mechanical systems) accelerometer was used to record antenna motions and to calculate the transmit beam vector. Surveys were performed across a 2 x 3 m calibration pit (5 cm line spacing) containing reburied root segments and a 400-m^2 forested plot (12.5-25 cm line interval). Radargrams were corrected for beam angle, migrated and interpolated to a quasi-3-D volume using an inverse distance algorithm. Root volume and biomass were estimated from isosurfaces calculated on Hilbert-transformed GPR amplitudes using a marching cubes algorithm.

The forest floor micro-topography induced significant antenna tilt (pitch > 45°, roll > 28°) and yaw (up to 10°), leading to errors in the positioning of root diffraction events in 3-D radar volumes. The corrected vector migrated GPR amplitudes showed a 15.5% amplitude increase and improved imaging of root structures due to focusing of diffraction energy. Radial scanning produced superior root imaging and continuity due to the larger number of root crossings when compared to rectilinear survey grids. Isosurfaces calculated on Hilbert-transformed amplitudes provide a rapid means of quantifying the root diameter and total biomass volume. Estimation of root biomass requires high inline sampling and line density (< 5 cm). Estimates of belowground carbon using a multi-channel GPR with small inter-line spacing could provide a viable approach for surveying large test plots and could be employed to further refine and validate ecosystem models.



Abstract ID: 34178

Final Number: B24B-0081

Title: Noble gas, carbon and nitrogen in a St. Lawrence Lowlands bedrock aquifer (eastern Canada)

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Published Material: Mejean P., Pinti D. L., Takahata N., Wen H.Y., Sano Y., Larocque M. (2014). Helium, carbon and nitrogen in a bedrock aquifer of the St-Lawrence Lowlands, eastern Canada. 61th Annual Meeting of the Geochemical Society of Japan, Toyama (Japon), 16-18 september 2014.

Abstract Body: Flow patterns and residence times are fundamental parameters for quantifying groundwater resources, yet they are difficult to estimate and are better defined with an integrated isotopic approach. Noble gases are excellent groundwater tracers because they are inert. In order to decipher groundwater circulation and sources in one of the several watersheds providing groundwater in the vicinity of the Montreal metropolitan area, He, Ar, Ne, N_2, CO_2 and CH_4 elemental and isotopic composition were analyzed. The Vaudreuil-Soulanges watershed (895 km^2) has Cambrian sandstone and dolostone fractured aquifers confined by Quaternary clays. Fractured Cretaceous alkaline intrusions and Precambrian bedrock (Mont Rigaud) outcrop in the northwestern part of the basin, creating an important recharge area. Preliminary results from 16 wells show variable helium contents from $6.15.10^{-8}$ to $1.32x10^{-5}$ ccSTP/g. The He isotopic ratios (R), normalized to that of air (Ra = 1.386×10^{-6}), range from 0.18 to 2.33, indicating the occurrence of both radiogenic ^{4}He and tritiogenic ^{3}He excesses compared to the atmospheric composition. Tritium contents indicate pre-bomb recharge waters (^{3}H<0.8TU) and modern water infiltrated during the last decades (^{3}H = 10.8TU). The pre-bomb waters are Na-Cl type and are located in the most confined and chemically evolved water in the region. Helium components can be explained by the mixing of a freshwater tritium-rich component (from 12 to 65 TU) mixed with groundwater containing mainly crustal He, slightly contaminated by 2% of mantle helium. Interestingly, three groundwater samples suggest that they contain up to 16.7% of mantle He. N_2/Ar ratios range between 47 and 101, higher than the ASW (air saturated water) value of 37, indicating some N in excess of the atmospheric content. A relation between the CO_2/^{3}He molar ratio and the ^{3}He/^{4}He ratio indicates that both CO_2 and He derive from a mixing between a mantle source (max 25%) and crustal sources with variable CO_2/^{3}He ratios. Fossil mantle gases could be sourced by groundwater-rock interactions with the numerous intrusions buried under the Quaternary cover and related to the Cretaceous episode of the Monteregian Hills. Particularly, the carbonatite intrusion of Oka is 20 km away from the studied basin, where ^{3}He/^{4}He ratios up to 2.54 Ra have been measured.

Abstract ID: 34246

Final Number: B24B-0082

Title: Assessing the Predictive Accuracy and Uncertainty of the CAN-DNDC Model to Simulate Water Use Efficiency in Alfalfa Crops.

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Abstract Body: Improving the sustainability of water use in agricultural crop production requires an understanding of the existing water use efficiency (WUE) of individual crops. WUE in agricultural ecosystems may be expressed as net ecosystem exchange (NEE) / evapotranspiration (ET). When accurately calibrated and validated, the Canadian agricultural ecosystem model, Denitrification-Decomposition (CAN-DNDC) provides an ideal tool for predicting WUE by providing simulations of water and carbon cycle processes, as well as the nitrogen processes, of specific crops at the site or regional level. In support of a project addressing water use in the dairy production sector, Agriculture Canada is developing crop-specific growth curves and improved algorithms of nitrogen/water uptake for Canadian alfalfa. Our objective is to assess the predictive accuracy and uncertainty of the alfalfa model through a comparison of simulated NEE and ET data with in situ eddy covariance (EC) flux measurements. Eddy covariance measurements were obtained during the 2014 growing season from two Eastern Ontario alfalfa fields using a closed-path CO_2/H_2O gas analyzer (CPEC200, Campbell Scientific, Logan UT) and an integrated CO_2/H_2O open-path gas analyzer and 3-D sonic anemometer (IRGASON, Campbell Scientific, Logan UT). To assess the predictive accuracy of the model, a Matlab statistical program is used to estimate the structural uncertainty and a Monte Carlo analysis is performed to assess uncertainties arising from input variables.

Abstract ID: 34990

Final Number: B24B-0083

Title: Boreal forest: effects of canopy opening on the relationship between trees and the cryptogam layer

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Published Material: This study was presented in french for a meeting in Amos (Abitibi-Temiscamingue, Québec, Colloque 2014 de la Chaire en Aménagement Forestier Durable CRSNG-UQAT-UQAM, November 27th 2014). These findings are not under review and they were not recently accepted by a scientific journal.

Abstract Body: In the boreal forest, forest productivity can vary strongly in time and space. In some conditions, a forest can move from a productive state (dense) to a stable alternative state that is not commercially productive (lichen woodland or peatland). This long-term canopy opening occurs especially on sites with extreme conditions of drainage: poorly drained sites subject to paludification and strongly drained sites on coarse-grain deposits. In each case, during the transition there is an expansion and a shift in the composition of the moss/lichen layer. Feather mosses are replaced by Sphagnum mosses on poorly drained sites, and by lichens on excessively drained sites. The present work is part of a project which aims to explore the role of the moss/lichen layer in long-term forest opening, especially through its effects on forest soil. The objectives of this study are: (i) to determine the relationship between the degree of forest canopy openness and the composition of the moss/lichen layer; (ii) to determine the relationship between the composition of the moss/lichen layer and tree root development. Sampling was carried out in the summer of 2014 in lichen-pine and mosses-spruce woodlands of the boreal forest of Nord-du-Québec. First, we observed that Sphagnum and lichen communities, unlike feather mosses, are associated with open canopy forests. Furthermore, we observed that the presence of lichen or Sphagnum corresponded to a change in tree fine root development. These results demonstrate a non negligible relationship between the composition of the moss/lichen layer and tree fine roots production in the soil surface and suggested that while causal relationships have not been verified, canopy opening, cryptogam communities and tree root production do not vary independently. These preliminary results emphasize the potential negative effects of canopy opening on forest regeneration and the potential implications for forestry practices (partial cut and planting).

Abstract ID: 35007

Final Number: B24B-0084

Title: Vision-driven Land Use Scenario and Its Implications to Biogeochemical Interaction in The Columbia Basin, Pacific Northwest

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Abstract Body: Land management decision is the fundamental driving factor determining biogeochemical interactions between ecosystem and climate. In Earth system models, scenarios of emissions shape how land use change occurs, which is implicitly driven by socio-economic forces. Realistically speaking, natural resources are not commensurable to economic terms, and management of natural resources is ultimately a societal choice. The interaction between environment and land use management is dynamic, complex and interdependent, superimposed on top of this is the complicated decision making process that involves independent variables of socio-economic condition, public perception, and management priorities at local, national and international level. As such, comparing to a land use scenario driven by empirical economic models, visions about future projected by public may provide a more region-specific perspective that integrates both top-down socio-economic policy pressure and regional management effectiveness in fulfilling the socio-economic demand. In this study, I generated a simple but region-specific land use scenario for the year 2050 based on land manager and stakeholder perceptions in the Columbia basin, Pacific Northwest. This land use scenario is then extrapolated temporally to serve as input to a terrestrial ecosystem model (TEM-Hydro) to understand the ecosystem response to changes in climatic conditions. Preliminary land use simulation results showed that, lands under crop, urban and water coverage would likely to increase at the expenses of reductions in pasture, forest, and grassland coverages. Consequently, carbon sequestration potential reduced and the implications to ecosystem carbon exchange may be substantial. Further work will involve the comparison of ecosystem response to dynamic land use scenarios generated based on an economic model (MIT-EPPA) to highlight the uncertainties in land use simulations and the implications to regional biogeochemical interactions.

Abstract ID: 35506

Final Number: B24B-0085

Title: Relationship Between Valley Fever Occurrence and Satellite Assessment of Climate Response

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Abstract Body: North America and particularly the southwestern region of the United States have been experiencing record warming and drought for the past 25 years (Cook et al., 2007; Herweijer et al., 2007; Mensing et al., 2007). In addition, Coccidioidomycosis or Valley Fever onset cases in the southwest have also increased since 1998 (Centers for Disease Control and Preventions, 2013). The California Department of Public Health annual reports show a significant increase of Valley Fever cases in southern California. Here we attempt to better understand the relationship between climate and the increased incidence of Valley Fever in the Antelope Valley region of southern California. Thirteen years of public health annual reports show a particular spike of Valley Fever cases in 2005, 2010, 2011 and 2012. To classify this relationship we have characterized the Antelope Valley land surface using multi-temporal Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI 16-day composite data, Advanced Spacebourne Thermal Emission and Reflection Radiometer (ASTER) NDVI and Landsat NDVI composite imagery data. These satellite data were compared with climate variability data (surface temperature and precipitation) and Valley Fever onset statistics to correlate climate change to the increased Valley Fever cases. Results show a strong correlation between precipitation events and Valley Fever estimated onset, as well as a strong correlation between warmer years and increased registered cases. A correlation between hotter years and increased reported cases were prominent in results. Temperature increases in 2005, 2006, 2007, 2010 and 2012 show correlations between Valley Fever estimated onset and reported cases.NDVI values show a slight correlation between estimated onset and total cases. Substantial spikes in reported cases in 2005 and 2010 point to increased risk of onset for the months of August-December, indicating that August through December are particularly 'at-risk' months for contraction of Valley Fever. The methods used here can be used for other climate and human health hazard correlational studies for bacterial or fungal pathogens in arid soils.

Abstract ID: 35353

Final Number: B24B-0086

Title: From the Ground Up: Global Nitrous Oxide Sources are Constrained by Stable Isotope Values

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Published Material: This work is under review at a scientific journal.

Abstract Body: Rising concentrations of nitrous oxide (N_2O) in the atmosphere are causing widespread concern because this trace gas plays a key role in the destruction of stratospheric ozone and it is a strong greenhouse gas. The successful mitigation of N_2O emissions requires a solid understanding of the relative importance of all N_2O sources and sinks. Stable isotope ratio measurements ($\delta^{15}N$-N_2O and $\delta^{18}O$-N_2O), including the intramolecular distribution of ^{15}N (site preference), are one way to track different sources if they are isotopically distinct. 'Top-down' isotope mass-balance studies have had limited success balancing the global N_2O budget thus far because the isotopic signatures of soil, freshwater, and marine sources are poorly constrained and a comprehensive analysis of global N_2O stable isotope measurements has not been done. Here we used a robust analysis of all available in situ measurements to define key global N_2O sources. We showed that the marine source is isotopically distinct from soil and freshwater N_2O (the continental source). Further, the global average source (sum of all natural and anthropogenic sources) is largely controlled by soils and freshwaters. These findings substantiate past modelling studies that relied on several assumptions about the global N_2O cycle. Finally, two independent modelling methods were used to show that the relative contributions of marine and continental N_2O sources to the total annual emissions are 24%–26% and 74%–76%, respectively.

Abstract ID: 35755

Final Number: B24B-0087

Title: Maize Growth as Influenced by 12 Different Biochars in a Cerrado Region (Brazil) Arenosol

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Abstract Body: The climate in much of the state of Mato Grosso, Brazil, permits a year-round growing season. Maize grown during the dry season, known as *segunda safra*, currently accounts for 97% of all the maize grown in the state. However, since it is cultivated during the dry season, the segunda safra is vulnerable to changes in precipitation patterns. Therefore, improving soil water retention in the region's Arenosols is of particular interest to local farmers. The potential of biochar (charcoal derived from waste biomass by pyrolysis) to increase soil water retention and crop growth has been observed under some conditions, and so its amendment to sandy soils could potentially be beneficial in this system. The biochars used in this study were derived from four feedstocks: cotton husks, eucalyptus sawmill residue, filtercake resulting from sugarcane distillation, and swine manure. The four feedstocks were converted to biochar under three different pyrolysis temperatures: 400°, 500°, and 600°C resulting in a total of 12 biochars (4 feedstocks x 3 temperatures of pyrolysis). Biochar was mixed at 5% dry weight to 8 kg of an Arenosol and placed in pots in a greenhouse at 30°C for 6 weeks. Pots were set up in a split-plot random block design with 4 benches split into 2 rows receiving dry season rainfall and wet season rainfall, respectively. Maize seeds were planted in all pots. Preliminary results show that maize planted in soil mixed with cotton biochars produced at 500°C and 600°C had the lowest germination rates (38 and 44 %, respectively, in dry season rainfall, and 69 and 50 %, respectively, in wet season rainfall). Factors that may have contributed to the low germination rates, such as high nutrient levels in the feedstock and high soil water retention, will be discussed. Data on plant biomass and DOC and NO_3 in leachate from pots receiving wet season rainfall will also be presented.

Abstract ID: 35895

Final Number: B24B-0088

Title: Release of Phosphorus from Crop Residue and Cover Crops Over Winter in Southwestern Ontario

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Abstract Body: Maintaining sufficient crop residue on fields over the non-growing season as a means to improve soil health and reduce soil erosion remains a well-implemented agricultural beneficial management practice (BMP). As the concern for sustainable agriculture increases, there has been an emphasis on the use of cover crops to improve soil health through the retention of soluble nutrients, mainly nitrogen. However, in northern climates, crop residue and cover crops exposed to freeze-thaw cycles (FTC) have been recognized as a potential source of dissolved phosphorus to runoff; yet, there are limited field studies to support these findings. The objective of this study was to quantify the changes in water extractable phosphorus (WEP) from winter wheat (*Triticum aestivum*), red clover (*Trifolium pretense*) and oats (*Avena sativa)* over the non-growing season as the result of changes in hydroclimatic conditions such as FTC. WEP was determined from crop residue and cover crops placed in litterbags (20cm x 20cm) at different topographic locations (upland, midslope, low slope) on two fields. WEP in vegetation material was determined on fresh material, dead material, and material following FTC. Concentrations of WEP in cover crops were larger than those in the wheat residue, and, differences in WEP were also found with topographic position in the field. Concentrations of WEP varied with time, and were highest in freshly harvested wheat residue in comparison to residue that had been left on the field or exposed to FTC. In contrast, WEP in cover crops increased following FTC. This study provides insight into the timing of soluble phosphorus losses from crop residue and cover crops as well as discusses their potential contribution to winter phosphorus mobilization in Ontario.

Abstract ID: 35905

Final Number: B24B-0089

Title: The Impact of the Oasis Effect on Wind Tunnel Measurements of Ammonia Volatilization from Urea-Fertilized Agricultural Land

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Abstract Body: The average losses of nitrogen (N) in the form of ammonia (NH_3) from agricultural land treated with synthetic fertilizers are 10-19% of applied N, and urea is the most widely used synthetic fertilizer globally.[1] The lack of efficiency of urea as a fertilizer is an economic issue for producers, and the ammonia being emitted to the atmosphere can negatively impact human and ecosystem health.[1] The oasis effect can be defined as the decrease in NH_3 volatilization rate downwind from the leading edge of the fertilized plot, and is caused by the reduction of the concentration gradient of NH_3 near the emitting surface. It is a potential bias that could result in erroneously high emission factors calculated from wind tunnel NH3-flux measurements.[2] Two 24 m long wind tunnels were constructed indoors over soil plots fertilized with surface-applied urea, and measurements of NH_3 concentration taken every 2 m along the tunnel were used to test for the oasis effect. Out of the 85 periods of data collected, 58 resulted in the distance from the entrance of the tunnel having a significant linear effect on NH_3 concentration above the plot (α=0.05), indicating the absence of the oasis effect for those periods. In addition, 37 out of the 38 periods with linear regression coefficients greater than 10^{-5} show that distance from the entrance of the tunnel is a significant regression parameter for NH_3 concentration along the tunnel. Therefore during the periods when the largest losses of NH_3 occurred, the concentration profiles along the tunnel were not significantly affected by the oasis effect.

[1]Bouwman, A.F., et al. 2002. Estimation of global NH_3volatilization loss from synthetic fertilizers and animal manure applied to arable lands and grasslands. Global biogeochem. Cycles. 16: 1024.

[2]Sintermann, J., et al. 2012. Are ammonia emissions from field-applied slurry substantially over-estimated in European emission inventories? Biogeosciences. 9(5): 1611-1632.

Abstract ID: 36624

Final Number: B24B-0090

Title: Assimilation of Earth Observation leaf area index into the STICS crop model using a formal Markov Chain Monte Carlo algorithm

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Abstract Body: Assimilation of Earth observation (EO) derived crop biophysical descriptors into crop models is proven efficient to predict yield in complex agricultural ecosystems. However, the performance of crop models is affected by the accuracy of key input parameters related to soil properties and management practices, which often are not readily available at the regional scale. In this case, data assimilation could improve model performance to predict crop yield by re-initializing key model parameters. The objective of this study is to evaluate the performance of two optimization algorithms to re-initialize seeding date and density, and soil moisture at field capacity, all of which affect the yield predictions of the STICS crop model. Simulations were performed over a small region near Ottawa (ON, Canada) where soybean, corn, and spring wheat were grown. Images from multispectral satellite data (Landsat TM, SPOT and Formosat-2) and compact airborne spectrographic imager (CASI) were acquired over several growing seasons. The LAI was calculated with the modified transformed vegetation index (MTVI2). The two optimization techniques evaluated in this study were 1) the Nelder-Mead Simplex method and 2) an adaptive formal Markov Chain Monte Carlo named Differential Evolution Adaptive Metropolis (DREAM). The DREAM algorithm is expected to offer great advantages compared to the Simplex method for regional-scale predictions because: 1) its outcome is expected to be less dependent on the initial values of the optimized parameters, 2) it provides correlation coefficients between optimized model parameters, and 3) it provides uncertainties associated with model parameters and predictions. This was shown for hydrological simulations but not for yield predictions. Our preliminary results indicated that the DREAM method lead to a root mean square error of 0.7 t ha^{-1} regardless of how the initial values for the parameters were assigned, while the Simplex method showed a high level of sensitivity (root mean square error ranging from 0.5 to 2.3 t ha^{-1}) to initial values when they were taken from properly assigned pre-defined ranges.

Abstract ID: 34284

Final Number: B24C-0092

Title: Capturing and Processing Soil GHG Fluxes in a Multi-Analyzer Gas Flux System

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Abstract Body: The LI-COR LI-8100A Automated Soil CO_2 Flux System is designed to measure soil CO_2 efflux using automated chambers and a non-steady state measurement protocol. While CO_2 is an important gas in many contexts, it is not the only gas of interest for many research applications. With some simple modifications, many third party analyzers capable of measuring other trace gases, e.g. N_2O, CH_4, or $^{13}CO_2$ etc., can be interfaced with the LI-8100A System, and LI-COR's data processing software (SoilFluxPro™) can be used to compute fluxes for these additional gases. In this paper we describe considerations for selecting an appropriate third party analyzer to interface with the system, how to integrate data into the system, and the procedure used to compute fluxes of additional gases in SoilFluxPro™. A case study is presented to demonstrate methane flux measurements using an Ultra-Portable Greenhouse Gas Analyzer (Ultra-Portable GGA, model 915-0011), manufactured by Los Gatos Research and integrated into the LI-8100A System. Laboratory and field test (from a managed urban site and an artificial peat bog) results show that the soil CO_2 efflux based on the time series of CO_2 data measured either with the LI-8100A analyzer or with the Ultra-Portable GGA are essentially the same. This suggests that soil GHG fluxes measured with both systems are reliable.

Abstract ID: 35949

Final Number: B24C-0093

Title: Spatial Variability in Biogenic Gas Releases from Subtropical Wetland Ecosystems is Revealed from Ground Penetrating Radar (GPR) at the Lab and Field Scale

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Abstract Body: Peatlands are key contributors of greenhouse gases into the atmosphere that are capable of producing and releasing significant amounts of free-phase biogenic gases (CO_2 ,CH_4). Over the past two decades many studies have investigated gas flux dynamics in peat soils, however the spatial distribution of these fluxes are still highly uncertain, particularly for tropical and subtropical peatlands. This study implements an array of hydrogeophysical methods to investigate the spatial variability in biogenic gas accumulation and release in three 0.027 m^3 peat monoliths from three different wetland ecosystems in central Florida (sawgrass peatland, a wet prairie, and a depressional wetland within a pine flatwood). Over a period of five months gas content variability (i.e. build-up and release) within the peat matrix was estimated using a series of ground penetrating radar (GPR) transects along each sample about three times a week using high frequency (1.2 GHz) antennas. GPR measurements were constrained with an array of gas traps (eight per sample) fitted with time-lapse cameras in order to capture gas releases at 15 minute intervals. A gas chromatograph was used to determine CH_4 and CO_2 content of the gas collected in the gas traps. A grid of surface deformation points was also collected concurrently to monitor changes in the peat surface associated with gas build up and release. The approach was further upscaled to the field within the Blue Cypress Preserve (BC) where high temporal resolution datasets were implemented. The aim of this study is to investigate the spatial and temporal variability in gas accumulation and release of biogenic gases in subtropical peat soils at the lab and field scales and how they are potentially related to structural changes within the peat matrix. This work has implications for better understanding carbon dynamics in subtropical freshwater peatlands and how climate change may alter such dynamics.

Abstract ID: 34251

Final Number: B24D-0094

Title: Spatiotemporal distribution of DOC and DON in water after damming of the Three Gorges Reservoir

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Published Material: Most findings published on Fresenius Environmental Bulletin.

Abstract Body: Large reservoirs always influence water environment, the change of which in turn has direct impacts on biogeochemical cycles. In this study, we measured dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in the water of the Three Gorges Reservoir Region (TGRR) from February to September of 2008 at seven sites, in order to understand the spatiotemporal features of DOC and DON in this region after the dam impoundment. The concentration of DOC in water collected at all sites ranged from 0.02 to 54.48 $mg \cdot L^{-1}$ (average 3.85 $mg \cdot L^{-1}$), and for DON the range was 0.01 to 2.60 $mg \cdot L^{-1}$ (average 0.88 $mg \cdot L^{-1}$). The concentration of DOC was the highest at Sandouping, immediately before the dam, ranging from 1.65 to 54.48 $mg \cdot L^{-1}$ (average of 11.41 $mg \cdot L^{-1}$), much higher than the average value for several other reservoirs. It is probably because a large amount of organic matter from upstream erosion was accumulated at the reservoir. Through measurement of the DOC, DON and total carbon (TC) along the TGRR, we did not find vertical variation except for DON. However, we noticed a fluctuation of DOC and DON with time. Moreover, we found DOC concentration for the drawdown area was markedly lower than that of the permanently flooded sites. This was partly because the drawdown area provided a relatively long retention time for the microbial community to decompose the soluble carbon substrate. These results were consistent with our previous study reporting a high CH_4 emission in the drawdown area of the TGRR.

Abstract ID: 35933

Final Number: B24D-0095

Title: Modelling CO_2 and CH_4 Dynamics in a Small, Eutrophic, Monomictic Lake

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Abstract Body: Lakes play an important role in processing carbon derived from the terrestrial ecosystem. This carbon can accumulate as greenhouse gases, namely CO_2 and CH_4, as a result of biological processes. The accumulated gases are potentially emitted during seasonal mixing. Nonetheless, carbon fluxes and balances are still unclear, which limits our ability to forecast future impacts such as due to climate or land use change. To better understand greenhouse gas fluxes, we investigated the dynamics of CO_2 and CH_4 in a relatively small, eutrophic lake (Lake Okaro, New Zealand). Water column concentrations of these gases were observed monthly over one-year period. In addition, peeper incubations were made in the sediment over a period of one month to estimate sediment-water fluxes of CO_2 and CH_4. Releases of CO_2 and CH_4 from the sediment into water column were 27.03 and 28.2 mmol m^{-2} d^{-1}, respectively, and corresponded to rapid enrichment of both gases in the hypolimnion in a period of stable stratification. Calculations indicated that approximately 6.6 mmol m^{-2} d^{-1} of CO_2 was taken up by the lake from the atmosphere during the stable stratification. On the other hand, in the same period CH_4 was released to the atmosphere at a rate of around 0.1 mmol m^{-2} d^{-1}. We estimated pulsed emissions were released to the atmosphere with peaks at the onset of winter mixing when 23.5 and 6.4 mmol m^{-2} d^{-1} of CO_2 and CH_4, respectively. To complicate this analysis, however, large releases of CH_4 to the atmosphere are suspected to occur via ebullition, when large bubbles suddenly occur and cannot easily be sampled. We used a one dimensional lake ecosystem model (GLM-FABM) to better understand the temporal variability of processes affecting releases and uptake of CO_2 and CH_4 between the lake and the atmosphere.

Abstract ID: 34661

Final Number: B24D-0096

Title: Using GIS and SWAT to Model Stream Modification, Sediment and Carbon Transfer within the Grand River Drainage Network, Ontario

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Abstract Body: The Grand River watershed (~7000 km^2) is an important agricultural area in Southern Ontario, with several large and growing municipalities. As in many watersheds, there have been historical modifications to the drainage network related to various human endeavors. ArcMap has been used to model how a natural drainage network would appear, based on digital elevation maps (DEM) to predict flow paths. Channel lengths and locations of the predicted network were compared with a ground-truthed channel inventory (Grand River

Conservation Authority and Ontario Ministry of Natural Resources) to determine efficacy of the model. Channels not anticipated by topography were mostly first-order, with low sinuosity, and were most common in areas with high agricultural land use, and are likely excavated extensions to headwater streams to facilitate drainage. Land use, in particular agricultural activity, has significantly increased the total drainage density, sediment erosion and nutrient export in the Grand. The Soil and Water Assessment Tool (SWAT) was used to evaluate sub-basin hydrology, and the transfer of sediments, organic carbon, and other nutrients (N&P) from terrestrial to aquatic systems based on land use, management practices, historical flow and meteorological data for a 10-year period (January 2000 – December 2010) from the Grand River Basin. The SWAT model predicted well the stream discharge and sediment load, along with nutrient export when compared to observed data. A modified drainage network, based on introducing natural sinuosity to excavated headwater channels, was simulated using GIS, and SWAT was applied to estimate the retention of carbon, sediment and nutrients under this new "restoration" scenario. Model results suggest that remediation efforts could target these excavated channels in the head-water catchment areas in order to improve carbon and nutrient retention.

Abstract ID: 36548

Final Number: B24D-0097

Title: Contribution of Riverine CO2 and CH4 Atmospheric Fluxes from Five Distinct Regions within the Quebec Boreal Biome

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Published Material: Data from one region of study out of five was published:Campeau, A. and del Giorgio, P. A. (2014), Patterns in CH_4 and CO_2 concentrations across boreal rivers: Major drivers and implications for fluvial greenhouse emissions under climate change scenarios. Global Change Biology, 20: 1075–1088. doi: 10.1111/gcb.12479Campeau, A., J.-F. Lapierre, D. Vachon, and P. A. del Giorgio (2014), Regional contribution of $CO_2$and CH_4 fluxes from the fluvial network in a lowland boreal landscape of Québec, Global Biogeochem. Cycles, 28, 57–69, doi:10.1002/2013GB004685.

Abstract Body: Boreal rivers are a major component of the land-water interface in a region with a significant portion of the world's soil organic matter and freshwater. Rivers are often supersaturated with greenhouse gases (GHGs), CO2 and CH4, and emit these GHGs to the atmosphere. Although rivers represent a small fraction of the surface area of the boreal region, they are responsible for a disproportionately large amount of processing and export, thus their contribution to the global carbon budget is significant. This study measures CO2 and CH4 river fluxes in five distinct regions within the boreal biome in Quebec covering 315 000 km2. Regional CH4 fluxes were significantly higher in lower sloped regions. The river networks in these regions together release carbon to the atmosphere in teragrams per year in CO2 equivalents. However, lack of current methodology for calculating the area of zero-order streams in the network may underestimate these fluxes. Zero-order streams are most connected to terrestrial landscape and have the highest CO2 and CH4 concentrations in the network but do not show up on topographic maps.

Abstract ID: 34116

Final Number: B24D-0098

Title: High-Frequency Dynamics of Carbon Dioxide and Methane Fluxes in a Surface Flow Constructed Wetland as Affected by Discharge and Vegetation

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Published Material: Partly same data will be presented in ASLO Aquatic Sciences Meeting in Granada, Feb 2015.

Abstract Body: Constructed wetlands (CW) are built to manage runoff and matter fluxes to aquatic ecosystems from agricultural and urban environments. Free-water surface CWs with aquatic vegetation and stilling ponds resemble eutrophic aquatic ecosystems. We have studied fluxes of carbon, nutrients, and suspended solids in a CW at the mouth of an agricultural/residential watershed in Southern Finland. We will present dissolved [CO_2], [CH_4], and [O_2] in in- and out-flow measured at 10 min frequency since December 2012 and fluxes of CO_2 and CH_4 at the air-water interface measured weekly by chambers and bubble collectors in summer 2013. We will test a hypothesis that the photosynthesis of the submerged vegetation cause diurnal variations in dissolved [CO_2], [O_2], and [CH_4], consequently affecting gas fluxes at the air-water surface. We will also analyze the impact of discharge, weather, and vegetation on the seasonal gas flux dynamics in the CW. Continuous data with high temporal resolution of dissolved [CO_2] and [CH_4] can improve our understanding of aquatic metabolism and of the impacts of weather and vegetation on the aquatic C cycling.

Abstract ID: 34325

Final Number: B24D-0099

Title: Effects of flooding and drainage on CO_2 flux in Dongting Lake wetlands, China

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Abstract Body: Wetlands have been recognized as a main carbon sink on the earth. However, the role of carbon sink of flooding wetlands might be weakened due to the flooding duration time changes induced by anthropic disturbances. In this study, we quantified the effects of the flooding and drainage on CO_2 flux from a *Miscanthus sacchariflorus* marsh in Dongting Lake wetlands by eddy covariance technique from 20th June to 31st October, 2014. The results showed that the mean of CO_2 flux was -2.72μmol s^{-1} m^{-2} during 20th June to 8th July (before flooding), and it was reduced significantly to -4.29μmol s^{-1} m^{-2} during 9th July to 30th September (under flooding). However, the mean of CO_2 flux was 0.69μmol s^{-1} m^{-2} during 1st to 31th October (drained after flooding). The principal component analysis (PCA) among the environmental factors (water level (WL), sensible heat flux (H), latent heat flux (LE), air heat capacity (HC), air temperature (T), air pressure (P), air molar volume (molV), evapotranspiration (ET), water vapour density (WVD), relative humidity (RH), wind speed (S), friction velocity (U^*)) indicated that the CO_2 flux was

mainly effected by WL and air properties (i.e., T, P, HC, molV, and WVD), which explained 44.78% of total variance, while the RH and energy characters (i.e., H, LE, ET) explained 24.91% of total variance and 14.58% of total variance was explained by S and U^*. Our results indicated that the flooding in wetlands can enhance the ability of carbon fixing while the drainage might accelerate the carbon loss. The artificial controlling of water level might be an effective way to fix the atmosphere carbon in flooding wetlands.

Abstract ID: 36162

Final Number: B24E-0101

Title: Priming of terrestrially-derived dissolved organic matter: Implications for coastal carbon cycling

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Abstract Body: <span'',serif;">Although inland waters comprise a small fraction of Earth's surface, they play a critical role in the global C cycle. Global estimates of riverine flux of dissolved organic carbon (DOC) to the oceans range from about 250 to 360 Tg y^{-1}. Interestingly, only a small fraction of the roughly 2900 Tg C yr^{-1} transported through inland waters globally ever reaches the ocean. Recent observations of immense CO_2 evasion from streams and rivers thus suggest that terrestrially-derived DOC (TDOC) is not as recalcitrant as previously thought. In a lab-based experiment pine-litter leachate was converted to CO_2 at roughly the same rate in the trehalose and diatom leachate treatments, less than 1% of the diatom leachate was converted to CO_2, as opposed to ~50% of the trehalose over a few days. It is likely that a large fraction of the diatom leachate was assimilated by bacteria, whereas the trehalose was mostly respired to CO_2. Pilot field experiments in the Amazon River, with the incubation system performed during two cruises show that $\delta^{13}CO_2$ rapidly increased after adding labeled lignin; roughly 50% of the added lignin was converted to CO_2 in 10 hours. This is equivalent to a remineralization rate of ~0.021 mg C $L^{-1}d^{-1}$, or 2x the rate of FACE-only remineralization measured in the lab experiments.

Abstract ID: 34280

Final Number: B24E-0102

Title: Tracing Fire-Derived Organic Carbon on a Global Scale

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Abstract Body: Fire-derived carbon, is a persistent organic carbon fraction due to its aromatic nature (Wiedemeier et al., 2015). It is globally produced on large scales by biomass burning and by combustion of fossil fuel. As it is an inherently terrestrial product it has been investigated in soils and the atmosphere, then in rivers and oceans. However, different analytical approaches produced results which could not be compared directly, thus inhibiting the calculation of a combined global budget.

The question therefore remains: how much fire-derived carbon is produced, and then transported from terrestrial systems, through rivers to coastal and abyssal sediments? We need to exploit our analytical possibilities consistently on all environmental compartments in order to estimate integrated budgets.

In this presentation, we highlight the capabilities of a state-of-the-art molecular marker method (Wiedemeier et al., 2013, Gierga et al., 2014) to globally trace quantity, quality as well as ^{13}C and ^{14}C signals of fire-derived carbon. We show its use across small model lake systems, as well as major river systems of the world, e.g. to investigate size fractions of particulate suspended sediment. First results and important implications for the understanding of global carbon cycle will be discussed.

Wiedemeier, D.B. et al. 2015. Aromaticity and degree of aromatic condensation of char. Organic Geochemistry 78, 135-143.

Wiedemeier, D.B. 2013. Improved assessment of pyrogenic carbon quantity and quality in environmental samples by high-performance liquid chromatography. Journal of Chromatography A 1304, 246-250.

Gierga, M. et al. 2014. Purification of fire-derived markers for µg scale isotope analysis ($\delta^{13}C$, $\Delta^{14}C$) using high-performance liquid chromatography (HPLC). Organic Geochemistry 70, 1-9.

Abstract ID: 34373

Final Number: B24E-0103

Title: Investigating Preservation of Organic Matter Through Complexation with Iron Oxides

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Abstract Body: The biogeochemical cycles of iron (Fe) and organic carbon (OC) are closely interconnected. The concentration of reactive Fe is tightly controlled by soluble organic ligands in oceanic waters. In sediments however, the role of Fe in the preservation of organic compounds is only starting to be explored. We recently developed an approach based on the reductive dissolution of reactive solid phase Fe to quantify the amount of OC retained in the solid phase through its interaction with Fe. This method was applied to a series of aquatic sediments of contrasting OC contents and mineralogies collected from a broad range of deposition environments. On average, 21.5 ± 8.6% of the total OC in sediments was released to the liquid phase upon dissolution of iron and was thus directly attached to reactive solid iron phases. Interestingly, the only lake sediment in our sample set, collected in the boreal forest, had the highest percentage of OC bound to Fe. We investigated Fe-OC interactions in lake sediments to verify whether the high percentage of OC bound to Fe is characteristic of lake sediments, and to assess the importance of redox conditions/interfaces in the formation of Fe-OC aggregates. We used sediments from Lake Tantaré, a system with two basins characterized by contrasting bottom water redox conditions in the summer. We found a high percentage of OC directly associated with Fe minerals (30.1 ± 6.4%), with no significant difference between the two basins, which confirmed our previous results obtained from boreal lake sediments. Total nitrogen

(TN) followed the same trend, although with lower percentages of TN associated with Fe minerals (20.7 ± 6.7%). We characterized the Fe-associated and the non-Fe-associated OC pools at the elemental (OC, TN), isotopic ($\delta^{13}C$, $\delta^{15}N$) and functional group (FTIR) levels. Differences in reducible Fe content and in OC:Fe and TN:Fe ratios were found between the two basins; they will be discussed in relation with our working hypothesis.

Abstract ID: 34677

Final Number: B24E-0104

Title: The Role of Iron in the Diagenesis of Organic Carbon and Nitrogen in Sediments: A Long-term Incubation Experiment

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Published Material: The bulk of the work presented here was published in Marine Chemistry in 2014 (Barber et al., 2014) and has been presented at the 2014 Goldschmidt in Sacramento California.

Abstract Body: Marine sediments have long been proposed as a major sink of organic matter (OM) on the planet with the bulk of this OM being sequestered within coastal and deltaic sediments. The long-term storage of reduced organic compounds within these environments helps maintain the global redox balance at the surface of the planet. As a dominant constituent of the sediment mineral matrix, redox-sensitive nanophase iron (Fe) oxides play an important role in the preservation of OM through the formation of metastable Fe-OM complexes that sequester approximately 20% of the total sediment OM pool upon burial. Using a long-term sediment slurry incubation approach we examined the effect of iron on the preservation and degradation of OM. The fate of freshly deposited algal dissolved OM was monitored by tracking its depleted stable carbon isotopic signature ($\delta^{13}C$) relative to the native sediment OM. We demonstrate the incorporation of the tracer's depleted $\delta^{13}C$ signature into the sediment within the first hour of the incubation; this is consistent with the timeframe for sorptive processes and co-precipitation. In the presence of iron (oxy)hydroxides we see increased incorporation of the algal tracer's depleted isotopic signature within the solid phase demonstrating a shuttling effect of OM from the sediment pore waters into sediment particles. The effect of iron oxides on the fate of organic matter was found to be twofold, showing increased preservation of organic carbon species while increasing the rate of nitrogen removal through a process known as Feammox, short circuiting traditional nitrogen removal pathways. This study is the first study of its kind that demonstrates the dual role of iron oxides, by decoupling the elemental cycles of carbon and nitrogen within sediments originating from coastal regions.

Abstract ID: 34415

Final Number: B24E-0105

Title: Evaluation of Accelerated Solvent Extraction and Solid-Phase Micro Extraction for the Analysis of Brevetoxins in Marine Sediments

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Abstract Body: Harmful algal blooms (HAB), caused by the proliferation of certain biotoxin releasing species of algae, have increased in occurrence, cellular concentration and global distribution over the last 20 years. These toxins persist within the environments of affected areas and act as biomarkers for the spatial and temporal distribution of HAB occurrences. One such suite of biomarkers, known as brevetoxins (PbTx), are produced by the marine dinoflagellate *Karenia brevis* and are of interest for the reconstruction of the history of red tide HABs. No method currently exists to fully extract and quantify brevetoxins found within marine sediments, a prerequisite for assessment of the environmental conditions that lead to the proliferation of harmful algae using the sedimentary record and other biological proxies.

In this work, a method based on Accelerated Solvent Extraction (ASE) followed by liquid chromatography-mass spectrometry (LC-MS) was optimised for the measurement of brevetoxins in sediments. ASE uses solvents at high temperature and high pressure to maximize extraction efficiency, but also leads to the co-extraction of a large quantity of compounds with properties similar to those of brevetoxins. The result is the formation of a precipitate in the extract that leads to a decrease in brevetoxin recoveries by removing them from solution through flocculation and coagulation. A post-extraction cleaning step was thus developed using solid-phase micro extraction (SPME) fiber probes that minimize sample manipulation and maximize sample throughput. Although we believe that the accelerated solvent extraction of brevetoxins from sediments will be more efficient than conventional extraction methods, more work is required to fully assess the figures-of-merit of the complete ASE-SPME-LC-MS protocol. The preliminary findings are promising, with measured brevetoxin recoveries of 69.1 ± 1.1% for PbTx-3 and 71.9 ± 8.2 % for PbTx-2 using SPME fiber probes, and an absolute detection limit of 1 ng/ml using the optimized LC-MS method.

This newly developed ASE-SPME-LC-MS method, when combined with other sedimentary proxies used to reconstruct paleo-environmental conditions, will further our understanding of the factors that induce the onset of toxic algal blooms and aid in predicting future occurrences.

Abstract ID: 35458

Final Number: B24E-0106

Title: Modeling the Molecular Weight and Age Distribution of Marine Dissolved Organic Carbon

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Abstract Body: With 662 GtC, the dissolved organic carbon (DOC) pool in the ocean is an important carbon reservoir for the Earth system, but the processes that control its cycling rate are poorly understood. Recent measurements have reported a possible relationship between the molecular size and radiocarbon age of the material. As a step towards exploring this relationship, we combine a random scission model and the Smoluchowski mean-field coagulation equations to derive a mathematical model for the molecular size distribution and radiocarbon content of DOC. The model allows us to predict the transient and equilibrium joint distribution for molecular size and age of DOC. We use the model to

explore the sensitivity of the equilibrium distribution to changes in the size dependent random scission and coagulation rates.

Abstract ID: 33525

Final Number: B24E-0107

Title: Controls on Temporal and Spatial Variations of Nutrients and Metabolic States in a River Associated Coastal Sea in Taiwan

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Abstract Body:

Abstract ID: 35626

Final Number: B33B-05

Title: Long-range correlations in redox potential distinguish bacterial ferrous iron oxidation

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Abstract Body: Circumneutral ferrous iron-oxidizing bacteria eke out a living precariously balanced between opposing chemical gradients: the reduced iron which acts as their energy source and dissolved oxygen that, while necessary as a terminal electron acceptor for cellular metabolism, will out-compete the bacteria at atmospheric concentrations. In this study, detrended fluctuation analysis was used to quantify changes in redox potential that occurred over time in microcosms with different amounts of bacteriogenic iron oxides (BIOS); concomitant measurements of dissolved iron concentrations were used to determine accompanying rates of iron oxidation. The BIOS and water for the microcosms were obtained from a reduced anoxic groundwater seep where the microbial community consists of mat-forming iron-oxidizing bacteria, predominantly *Gallionella ferruginea* with a small amount of *Leptothrix ocrachea*. XRD analysis confirms that the iron precipitates from the live systems consist of x-ray amorphous material. Two abiotic control systems were also tested; one with killed BIOS and one consisting only of filtered creek water. SEM analyses of the live and autoclaved precipitates reveal that iron oxide precipitates were associated with bacterial cells found only in the live systems. Rates of iron oxidation in the living systems were similar to previously reported values for bacterial ferrous iron oxidation. At the same time, the microcosms were distinguished by the presence of persistent long-range correlations in redox potential that are indicative of anomalous diffusion behavior. At the beginning of the experiment, the live systems exhibited strong fractional Brownian motion and superdiffusion; however, as the bacterial consumed ferrous iron, the redox potential scaling exponents shifted to an apparent subdiffusive regime, which resembles a different dynamic state than when the microcosms started.

Abstract ID: 35311

Final Number: B33B-06

Title: Development of a Genome-Informed Trait-Based Model for Microbial Biogeochemistry within Terrestrial and Aquatic Ecosystems

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Published Material: As this is a work in progress, portions of this abstract were presented at the AGU conference in December 2014 in San Francisco. This abstract focusses on the advancements since then as well as on how this technique can be applied to specific situations.

Abstract Body: In extreme environments, microorganisms persist in systems characterized by low energy production, nutrient fluxes, and microbial growth. Understanding and predicting the biogeochemical dynamics within these systems necessitates an understanding of the metabolism and physiology of organisms that are often uncultured or studied *in situ* under conditions that vary greatly from those seen in low energy environments. Cultivation independent approaches are therefore important and have greatly enhanced our ability to characterize functional microbial diversity. With the capability to reconstruct thousands of genomes from microbial populations using metagenomic techniques, one needs to develop an understanding of how these metabolic blueprints influence the fitness of organisms and how populations emerge and impact the physical and chemical properties of their environment.

Here, we discuss the development of a trait-based model of microbial activity that simulates coupled guilds of microorganisms, parameterized including traits extracted from large-scale metagenomic data. Each group within a functional guild is parameterized with a unique combination of traits governing organism fitness under dynamic environmental conditions. Using a reactive transport framework, we simulate the thermodynamics of coupled electron donor and acceptor reactions to predict the energy available for cellular maintenance, respiration, biomass development, and exo-enzyme production. This presentation will address our latest developments in the estimation of trait values related to growth and the use of metagenomic data to identify and link key fitness traits associated with respiratory and fermentative pathways, macromolecule depolymerization enzymes, and nitrogen fixation. Simulations explore abiotic controls on community emergence including identification of the processes regulating aquifer oxygen concentrations during seasonally fluctuating water table regimes at the Rifle floodplain.

Abstract ID: 33658

Final Number: B33B-07

Title: Bioenergetic Limitations on Slow Microbial Growth in the Subsurface: What is the Burden of Maintenance on the Overall Energy Budget?

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Abstract Body: In low energy environments such as the subsurface, the minimum energy required to maintain cellular integrity and function (maintenance energy) may represent a significant fraction of the total energy available to microbial communities. However, traditional kinetic and thermodynamic models incorporating key microbial processes are often developed using data collected in nutrient rich growth media. In this study, slow microbial growth in the subsurface was simulated using a flow through bioreactor system in experiments designed to determine the maintenance energy requirement of the model subsurface bacterium *Shewanella oneidensis*. An existing bioreactor system (Applikon EZ-control®, 2.4 L) was modified to include a biomass retention filtration unit (retentostat) resulting in biomass accumulation over time. An artificial low-nutrient groundwater medium was optimized for slow *S. oneidensis* growth and was supplied and removed from the reactor at flow rates on the order of 1 mL min^{-1} with a dilution rate of 0.025 h^{-1}. The retentostat was run under electron donor limited conditions with nitrate, a common groundwater contaminant, supplied at 0.025 mM h^{-1} and lactate supplied in excess at 0.125 mM h^{-1}. Respiratory ammonification of nitrate by *S. oneidensis* and cell growth was monitored over time (40 days) and compared to parallel incubations in batch reactors. Initial rates of ammonification were similar in the bioreactor and batch reactors, however, optical density and ATP measurements showed a slow yet increasing microbial growth over time (generation time = 17 days) in the retentostat. In contrast, cells in the batch reactors did not grow significantly and died within 2 weeks of inoculation. A maintenance energy demand was estimated (0.5 kJ C-mol biomass h^{-1}) by fitting the biomass data to the van Verseveld equation. The low maintenance energy demand of *S. oneidensis* as compared to typical maintenance energies reported in the literature (>10 kJ C-mol biomass h^{-1}) likely reflects its metabolic versatility and ability to persist in low energy environments. In addition to the retentostat results, we will also discuss our efforts to develop a kinetic and thermodynamic based biogeochemical model which explicitly accounts for energy used for both microbial maintenance and growth.

Abstract ID: 34271

Final Number: B34A-0048

Title: Nitrous Oxide Emissions from Irrigated Cotton in the Southwest USA: Assessment and Mitigation Strategies.

Presenter/First Author: Kevin F Bronson, USDA Agricultural Research Service, Maricopa, AZ

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Published Material: American Society of Agronomy-Soil Science Society of America-Crop Science Society of America Annual Meetings, Long Beach, CA 2-5 November 2014.

Abstract Body: Nitrogen fertilizer is an important source of the greenhouse gas nitrous oxide (N_2O) in irrigated cropping systems. However, little data exists for row crops in the desert southwest of North America, where seasonal irrigation amounts on farms can exceed 1.2 m. The objective of these studies was to assess the effect of N fertilizer rates on N_2O emissions from furrow- and sprinkler-irrigated cotton (*Gossypium hirsutum*) in Central Arizona and to test some mitigation management options. Cotton was planted from late April to May 1 from 2012 to 2014 on 1-m wide beds. Nitrogen fertilizer as liquid urea ammonium nitrate (320 g N kg^{-1}) varied from 0 to 233 kg N ha^{-1} per season. There were two split applications of N fertilizer in surface irrigation, and three splits under the sprinkler. Emissions were measured weekly with 1-L vented chambers placed for 24 minute periods in the bottom of furrows. Fifty-ml samples were taken at 0, 12, and 24 minutes and analyzed for N_2O with an ECD-GC. During the cotton growing season N_2O emissions were measured from May to August. Nitrous oxide emissions were not agronomically significant, i.e. < than 0.5 % of applied N, but increased several-fold with the addition of N fertilizer. In 2012 and 2013 with furrow irrigation, knifing-in of N fertilizer resulted in lower N_2O emissions than fertigating into the header irrigation line. In 2014 under the sprinkler, the addition of the enhanced efficiency N source Agrotain Plus to N fertilizer had inconsistent mitigation effects on N_2O emissions. Emissions were positively correlated with soil moisture and temperature. Nitrous oxide fluxes ended 2-3 d after irrigation events that were as high as 125 mm in furrow irrigation, and declined during the season, as plant N uptake progressed. Agrotain Plus apparently breaks down quickly in the desert environment, making its use an N_2O emission inhibitor not consistent.

Abstract ID: 35609

Final Number: B34A-0049

Title: Nitrous Oxide Emissions from Cropland Soils with Different Management Regimes in Manitoba, Canada

Presenter/First Author: Aaron J Glenn, Agriculture and Agri Food Canada, Brandon, MB

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Published Material: Preliminary results from the 2013 growing season for one of our study sites were presented in a poster titled "Nitrous oxide flux from a clay loam under mature no-till and variable rate N fertilizer management in western Manitoba" at the 57th Annual Manitoba Soil Science Society Conference held in Winnipeg in February 2014.

Abstract Body: Globally, the agricultural sector is the largest anthropogenic source of nitrous oxide (N_2O) to the atmosphere, the majority of which can be attributed to biogeochemical transformations of nitrogen (N) added to cropland soils. The Canadian Tier II methodology used for national GHG inventory reporting implicates the application of synthetic N fertilizer to cropland soils as the largest anthropogenic source of N_2O nationally and indicates that emissions from this source have increased by more than 70% between 1990 and 2012. As synthetic N fertilizer application is the main source of anthropogenic N_2O globally and nationally, efforts to use fertilizer more efficiently have a significant potential to reduce overall emissions from this source. The objectives of this study are to identify the relative influence of environment, management and climate on soil N_2O emissions and to measure the emission per unit production for a range of cropping systems in the region. In ongoing studies beginning in 2012, soil N_2O fluxes have been measured using the static-chamber technique in various agroecosystems in southern Manitoba. The farm characteristics vary from integrated crop-livestock operations with beef cattle manure and compost applied to soil as nutrient amendments, to a mature no-till cropland with variable rate N fertilizer management. Surface soil textures are similar at the majority of the sites but the organic C content and inorganic N availability of surface soils vary considerably. Soil temperature and moisture content were monitored during the measurement periods and related to the timing and magnitude of N_2O emissions. These measurements of soil N_2O emissions from cropland in the subhumid eastern Canadian Prairies may help to refine and revise estimates for regional inventories, particularly with regards to coefficients related to hydrology, soil texture, climate, and soil management activities. Current results from the research will be shared and discussed.

Abstract ID: 33617

Final Number: B34A-0050

Title: N_2O emissions and N-Leaching from Spring and Fall Applications of Digestate, Raw Dairy Manure and Urea

Presenter: Andrew VanderZaag, Agriculture and Agri-Food Canada, Ottawa, ON

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Abstract Body: Anaerobic digestion (AD) is a manure treatment technology that reduces CH_4 emissions from manure storage and provides a nitrogen rich fertilizer for field crops. However, few studies have evaluated the environmental impacts of applying AD effluent (digestate) to agricultural soils, and interactions between soil type, climate and timing of application. In this study, N_2O fluxes and N-leaching losses were measured for 2.5 years (October 2011 to May 2014) in Alfred, Ontario. The site consisted of two nearby fields with contrasting soil textures (sandy-loam vs. clay). Treatments included: fall- and spring-applied digestate (DG), fall- and spring-applied raw dairy manure (RM), spring urea (UR) and a zero-N control. N_2O fluxes were measured using static chambers and N-leaching was estimated by sampling isolated tile drains (clay field) and zero-tension lysimeters in both fields. N_2O emissions were higher in the second year of study (wet year) compared to the first (dry year). Peak N_2O emissions occurred during spring thaw (March-April) and ~2 weeks following spring applications and tillage. There was no overall effect of timing (spring vs. fall) on annual N_2O emissions, only a change on when emissions took place (at spring thaw for fall application and in late spring after spring manure application). DG had significantly higher N_2O emissions compared to RM and UR in the sandy-loam field (pH=6.2), but there were no N source effects on N_2O emissions in the clay field (pH=7.1). DG and RM treatments showed similar annual NO_3 losses, while UR had the highest annual NO_3 mass load in both fields measured using lysimeters and tile drains As such, lower N_2O emissions from UR were potentially the result of greater NO_3 leaching. Thus, simultaneous measurements of N_2O and NO_3 provide insight into potential pollutant trade-offs. Overall, N source effects were strongly linked to interactions with soil type and climate.

Abstract ID: 34782

Final Number: B34A-0051

Title: Low but variable nitrous oxide emissions from rapeseed: Results from a two-year field experiment at five sites in Germany

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Abstract Body: Biodiesel from rapeseed is one of the major renewable resources in Germany used for fuel production. According to the Renewables Directive of the European Union, biofuels have to fulfill strict sustainability requirements, such as reductions of 35% and 50% (starting in 2017) of greenhouse gases (GHG) in comparison to fossil fuels. Thus, the mitigation of field nitrous oxide (N_2O) emissions is still challenging and depends on numerous interacting factors, such as climatic (temperature and soil moisture) and management factors, e.g. fertilizer type (organic vs. mineral fertilizer) and fertilizer rate, as well as tillage practices. Since 2012, measurements were conducted at 5 study sites throughout Germany located in the major precipitation-frost classes identified as relevant for N_2O production (Jungkunst et al. 2006). A semi-randomized block design was established at each study site investigating the complex effects of i) crop rotation of winter rape - winter wheat - winter barley and ii) 5 fertilizer regimes (100% biogas residue application with and without nitrification inhibitor, 100% mineral fertilizer, 67% mineral fertilizer, non-N fertilized control) on N_2O emissions. At each study site, nitrous oxide field emissions were measured by the same approach daily for 3-5 days following fertilization and subsequently weekly using a manual *non-flow-through non-steady-state* closed chamber system and 20-minute interval sampling. We present results from cropping seasons 2012-2013 and 2013-2014, featuring two climatically contrasting winter seasons. In 2013, the weather conditions were characterized by a cold and long winter with snow until mid-spring, whereas almost no freezing events occurred in 2014. Annual N_2O emissions as well as yield-normalized N_2O emissions from rape were low in both seasons. Nevertheless, annual differences between treatments and sites occurred. For both cropping seasons, emissions were smaller than predicted by the IPCC emission factors or by the model of Stehfest & Bouwman (2006), but were still dependent on nitrogen input.

Abstract ID: 34390

Final Number: B34A-0052

Title: Effectiveness of 4R Mitigation Practices to Reduce N_2O Emissions of Corn Production Systems: A Modelling Approach

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Co-authors: Lianhai Wu, , , ; Anna Chemeris, , , ; Claudia Wagner-Riddle, University of Guelph, Guelph, ON, Canada

Abstract Body: Agricultural soils are the dominant source of nitrous oxide (N_2O), a potent greenhouse gas and a major cause of ozone layer depletion. Process-based models are increasingly being used to explore the impacts of management and climate in N_2O emissions from agriculture. Models used to establish emissions under current management practices can also be used to compare alternative management scenarios intended to reduce emissions.

SPACSYS is a multi-dimensional, field scale, weather-driven dynamic simulation model of C and N cycling, which operates with a daily time-step and outputs N_2O emissions (Wu, 2007). The objective of this study is to analyse the effect of different fertilizer management practices on corn as means to control N_2O emissions without incurring in yield penalties, using SPACSYS. The evaluated management practices are part of the 4R Nutrient Stewardship Program, which proposes a framework to increase agricultural production and improve environmental sustainability by maximizing fertilizer-use efficiency.

N_2O measurements were carried out at two field sites in southern Ontario with climate and soil conditions representative of the agricultural region where the sites are located (e.g. Wagner-Riddle et al., 2007). Field data covers different years from 2000 to 2010, contrasting fertilizer types (both mineral and organic) and application depths, providing suitable datasets for testing the sensitivity of SPACSYS to changes in environmental and management factors at a regional scale. Preliminary results of the statistical analysis used to test the model for cumulative N_2O fluxes showed no statistically significant total error ($RMSE_{95}$) or bias (E_{95}) when compared to measured estimates. A strong association was found between measured and simulated values (R = 0.95).

Our results will promote effective policies to achieve more sustainable corn agro-ecosystems by showing which management practices have the greatest potential to reduce N losses and how they can be prioritized.

Abstract ID: 35617

Final Number: B34A-0053

Title: Evaluating random error in long-term, multi-plot flux-gradient measurements of N_2O emissions

Presenter/First Author: Shannon E Brown, University of Guelph, Guelph, ON

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Co-authors: Claudia Wagner-Riddle, University of Guelph, Guelph, ON, Canada; Mingshu Sun, University of Guelph, Guelph, ON, Canada

Abstract Body: The Pointe-Escuminac raised bog is located on the eastern shore of New Brunswick and is affected by coastal erosion which created a peat cliff. The bog margins display several distinct layers of thin charred bands in the peat. We selected three profiles on the southwest section of the cliff to assess fire intervals from these charred layers. The first one is 170 cm thick and has 25 charred layers; we radiocarbon dated six samples at various depth from this profile, the bottom layer being aged at 4780 yrs BP (uncalibrated). The second profile is at an eight meter distance from the first (towards the center of the bog), is 210 cm thick, has 19 charred layers and seven radiocarbon dates with the bottom peat aged at 5090 yrs BP. The third profile is 58 m from the first and is 320 cm thick. The bottom layer could not be dated, but the lowermost of the four radiocarbon dated samples is 5350 yrs BP at a depth of roughly 265 cm. We found 22 charred layers between that point and the topmost peat. Comparison between the three profiles suggests a total of 27 distinct charred layers with an average time interval of 175 radiocarbon years varying between 60 and 630 years. Five alternating periods of longer (330, 340 yrs) and shorter (110, 160 and 160 yrs) mean fire intervals are detected. Comparison with vegetation content of peat strata suggest they are not related to local vegetation changes. It is more likely that the variations in fire intervals were caused by external factors such as climate conditions or regional vegetation changes. Another study discussing micro-charcoal content in a peat profile from a bog located 70 km from Pointe-Escuminac further supports a regional signal and the possibility to use bog margins as suitable long-term regional fire records.

Abstract ID: 35278

Final Number: B34D-0065

Title: Climate Change, Wildfire, and Landscape Homogenization in Western Canada

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Co-authors: Lori Daniels, University of British Columbia, Vancouver, BC, Canada; Eric DaSilva, , , ; Theresa Dinh, University of Guelph, Guelph, ON, Canada; Hélène Marcoux, , , ; Vanessa Stretch, University of Guelph, Guelph, ON, Canada

Published Material: This paper brings together the work of several graduate students that were previously presented individually at meetings of the ESA, AAG, and CAG.

Abstract Body: Wildfire is the most important disturbance agent in forests of Western Canada, affecting stand structure and composition, biodiversity, biogeochemical cycling, hydrologic processes, and natural resource extraction. Despite considerable research, consensus on the frequency and severity of historical fire occurrence has been elusive in much of the Canadian Cordillera. Much of this uncertainty derives from methodological limitations. One area of particular contention has focused on the degree to which surface versus crown fires were historically important; a second relates to how disproportionately effective suppression of surface fires may have homogenized the landscape and altered the modern and future fire regimes. We have endeavored to overcome these uncertainties by employing a multiproxy approach to reconstructing fire history, and by using randomized site and sample selection. Drawing from a network of fire scar and tree cohort samples throughout western Canada we show that mixed severity fire was historically more frequent. We further show that in some forests the fire season has shifted significantly, and forests have become more homogenous. These findings have import ant implications for land management strategies that aim to restore historical conditions, or aim to mimic the natural disturbance regime.

Abstract ID: 35518

Final Number: B34D-0066

Title: Using a multi-proxy approach in fire history studies: Some advantages and challenges from Jasper National Park

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Published Material: The results presented here have been presented in various forms at other academic conferences -AAG 2014 - Tampa, FloridaCAG 2014 - Brock University, Ontario, Canada PALS 2014 - Québec City, Québec, Canada

Abstract Body: Using a multi-proxy approach is an effective strategy for studying processes operating on multiple temporal and spatial scales such as those controlling wildfires. The research presented here uses a recently completed fire history study from Jasper National Park that incorporates lake sediment and tree ring records to exemplify some of the advantages and challenges of using a multi-proxy approach to develop and interpret fire history records.

A 3,600-year record of fire events and vegetation change was established for the area surrounding Little Trefoil Lake, Jasper, AB, using a combination of lake sediment analysis (macroscopic charcoal and pollen analyses) and fire scar and cohort establishment dates from tree-ring data. Combining macroscopic charcoal and tree-ring fire evidence enabled a thorough characterization of the local fire history that addressed aspects of both frequency and severity. Moreover, high-severity fires recorded in the tree-ring record were used to calibrate the sedimentation rates for Little Trefoil Lake and provided support for the interpretation of peaks in charcoal

accumulation as being representative of local fire events. Through a pollen analysis performed on the same sediment core, the relationship between vegetation composition and the local fire history was assessed and determined to be of secondary importance to climatic and human influences. Although integrating proxy records representative of different spatial and temporal scales is challenging, using multiple lines of evidence to understand the processes controlling fire activity inspires a greater level of confidence in the interpretation of the results.

Abstract ID: 36230

Final Number: B34D-0067

Title: Understanding Historic Wildfire Dynamics in Jasper National Park Using Fire-Scar Dendroecology

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Co-authors: Ze'ev Gedalof, University of Guelph, Guelph, ON, Canada; Lori Daniels, University of British Columbia, Vancouver, BC, Canada

Abstract Body: A fire-scar based dendroecological reconstruction of wildfire history was used to detect the influence of climatic variability and land-use change on wildfire dynamics in the lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) forests of Jasper National Park in the Canadian Rocky Mountains. New original analyses were performed on 170 cross-section samples collected in the 1970s from 52 fire history sites from around Jasper, Alberta. The updated fire record reveals that fire occurrence was highly variable such that mean fire return intervals ranged from 4.9 to 52.5 years. Most fires were small and locally occurring. These fires occurred under a wide range of climatic conditions; although the largest and most widespread fires (n=18, events occurring across at least 10% of sites) were primarily driven by dry and warm climate conditions (e.g. El Niño years). Large regional fires burned across almost all sites, although some remnant patches (i.e. sites) remained unburned thus providing evidence for a historically mixed-severity fire regime. Fire activity (i.e. fire size and frequency) decreased through time with fire exclusion becoming widespread during the 1950s. Along with less fire activity on the landscape, there were also shifts in fire seasonality from early human-ignited "spring burns" to more natural lightning-ignited "summer" fires. To be consistent with historic patterns, large-scale restoration via prescribed burning should be scheduled to promote a frequent, patchy, and mixed-severity wildfire regime.

Abstract ID: 36734

Final Number: B34D-0068

Title: Historical Wildfire Variability in the Foothills of Alberta: A Dendropyrochronological Case Study

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Co-authors: Ze'ev Gedalof, University of Guelph, Guelph, ON, Canada; Lori Daniels, University of British Columbia, Vancouver, BC, Canada

Abstract Body: Using dendropyrochronological proxy methods, we reconstructed ~200 years of wildfire variability in the eastern foothills of the Rocky Mountains near Hinton, Alberta, Canada – an area where little fire research has been conducted but is currently at high risk of fire and is intensively managed. We combined fire scar (a low-severity fire proxy) and stand establishment records (high-severity proxy) to reconstruct the mixed-severity nature of fire history in this landscape. The record of wildfire shows no evidence of landscape-scale fire events over the last ~150 years. Instead, we found evidence of increased low-severity fire activity in the early 1900s that is not explained by climate alone. Overall, our research shows the foothills experienced variability in fire severity over both time and space. We have found evidence for intricate connections between the complex landscape characteristics (bottom-up controls) and climate trends that drive wildfire activity in this unique and understudied landscape.

Abstract ID: 33560

Final Number: B34E-0069

Title: Nutrient Addition Leads to Higher Methane Emissions in a Boreal Bog in Response to Changes in Vegetation and Microtopography

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Co-authors: Tim R Moore, McGill Univ, Montreal, QC, Canada; Veronica DeJesus, , ,

Abstract Body: Atmospheric nitrogen (N) deposition has led to nutrient enrichment in wetlands globally, affecting plant community composition, carbon cycling, and microbial dynamics. Nutrient-limited boreal bogs are long-term sinks of carbon dioxide (CO_2), but sources of methane (CH_4), an important greenhouse gas. We hypothesized that CH_4 emissions would increase in response to nutrient addition owing to changes in vegetation and microtopography. We fertilized Mer Bleue Bog, a *Sphagnum* moss and shrub-dominated ombrotrophic bog near Ottawa, Ontario, for 10-15 years with N as NO_3 and NH_4 at 5, 10 and 20 times ambient N deposition (0.6-0.8 g N m^{-2} y^{-1}), with and without phosphorus (P) and potassium (K). Treatments were applied to triplicate plots (3 x 3 m) from May – August 2000-2014 and control plots received distilled water. We measured methane (CH_4) flux with static chambers from early June until the end of July 2014. Depth to water table and as well as peat/air temperature were measured concurrently with CH_4 sampling. Seasonal mean methane flux ranged from 7 to 150 mg CH_4 m^{-2} d^{-1} with emissions from the 5NPK and 20NPK treatments 3 and 11 times higher than controls, respectively. Water table position was closer to the peat surface in these treated plots owing to loss of *Sphagnum* moss and compression of the peat. Laboratory incubations of peat samples showed that the rates of potential methane production under anaerobic conditions in samples from 30 – 40 cm were three times larger under the 5NPK and 20NPK treatments than the controls. Potential rates of methane consumption under aerobic conditions showed no significant differences among fertilizer treatments nor between 0-10 and 30-40 cm depths. These results suggest that increased methane emissions are the result of a complex suite of feedbacks among vegetation change, microbial dynamics and hydrology in response to nutrient addition.

Abstract ID: 36694

Final Number: B34E-0070

Title: Mycorrhizal Networks Inhibit Decomposition in Boreal Bogs

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Co-authors: Melanie A Vile, Villanova University, Villanova, PA; R. Kelman Wieder, , ,

Published Material: I gave an oral presentation at MassMyco, a mycology meeting for New England fall 2014.

Abstract Body: Nitrogen (N) deposition has resulted in the loss of mycorrhizal fungi from diverse sites around the globe. Mycorrhizal fungi are symbiotic organisms that associate with the roots of the majority of plants, providing nutrients in exchange for host plant photosynthates. N enrichment inhibits mycorrhiza formation in plants associating with fungi specialized in N acquisition, leading to a decline of the symbiosis. I hypothesized that the inhibition of mycorrhizal networks will allow saprotrophic fungi to degrade carbon (C) more freely in ombrotrophic peatlands. With ample supplies of C provided directly by host plants, mycorrhizal fungi do not need to break down complex C substrates and instead, they focus their scavenging efforts on obtaining essential nutrients. In order to assess potential repercussions of mycorrhizal decline due to N deposition, I experimentally excluded the networks of mycorrhizal fungi while simultaneously fertilizing with ammonium nitrate. This manipulative experiment was conducted in two bogs in Alberta Canada, one mature and the other recently burned. Mycorrhizal colonization responses to N fertilization and peat litter decomposition responses to mycorrhizal network exclusion were assessed *in-situ* for *Picea mariana* seedlings growing in native *Sphagnum* peat. My results agreed with the hypothesis of N-induced reductions in mycorrhizal colonization diversity. Morphotype density (number of different mycorrhizal phenotypes per tree) was reduced ($p < 0.0001$) at the highest N addition level (20 kg N ha^{-1} yr^{-1}). Mycorrhizal network exclusion resulted in 1% higher litter decomposition in the recently burned bog over two years. This research illustrates the importance of mycorrhizal symbiosis in boreal bog *Picea mariana* N acquisition and peatland C sequestration.

Abstract ID: 35438

Final Number: B34E-0071

Title: *Sphagnum* moss enzymatic activities indicate nitrogen and phosphorus co-limitation in a pristine boreal bog and poor fen

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Co-authors: R. Kelman Wieder, Villanova University, Villanova, PA

Published Material: A portion of this research has been presented at AGU December 2013. Not yet submitted to a journal.

Abstract Body: Emissions of NO_x associated with Alberta oil sands development are leading to increased atmospheric nitrogen deposition in a pristine region (<1kg N ha^{-1} yr^{-1}). Excess anthropogenic nitrogen deposition has the potential to alter ecosystem function, which can be manifested by changes in plant and microbial enzymatic activities. Since 2011, we experimentally added nitrogen in simulated precipitation to an Alberta bog and poor fen in order to predict future peatland ecosystem responses under high nitrogen deposition scenarios. We assessed the potential alleviation of nitrogen limitation with the addition of up to 25 kg N ha^{-1} yr^{-1} in a pristine bog and poor fen. After three years of nitrogen addition, phosphorus and nitrogen mineralization enzymatic activities of *Sphagnum angustifolium*, *Sphagnum* fuscum, and *Sphagnum magellanicum* were quantified using methylumbelliferone fluorescent detection. *Sphagnum* moss enzymatic responses to nitrogen addition were assessed with regards to season, species, and peatland type (poor fen or bog). Phosphatase activities increased from the control to the 25 kg N ha^{-1} yr^{-1} up to five-folds in all three species and in both peatlands. Chitinase activity also increased with nitrogen addition for *Sphagnum magellanicum* in the poor fen but not the bog. Increasing enzymatic activities suggest nitrogen and phosphorus co-limitation and nutrient limitations unique to specific *Sphagnum* species in bogs and poor fens. This sensitivity to increasing nitrogen addition indicates potential consequences for peatland nutrient cycling in the oil sands development area.

Abstract ID: 33631

Final Number: B34E-0072

Title: Nutrient availability in the Mer Bleue bog as indicated by Plant Root Simulator probes

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Abstract Body: There are a variety of methods employed to assess nutrient availability from soils, such as total analyses, differential extractions, laboratory incubations and pore-water analyses. The adsorption of nutrient cations and anions onto exchange resins placed in the soil provides an alternative approach. We used Plant Root Simulators (PRS™) at the Mer Bleue bog to provide some baseline data on nutrient availability and its variability. In particular, we focused on ammonium, nitrate, phosphate, calcium, magnesium and potassium, expressed as µg/cm^2/week. We placed PRS probes at a depth of 5 – 15 cm in the bog for 4 weeks and determined the availability of these nutrients, from spring through to fall. Probes were also placed beneath the water table in hummock and hollow and along a transect including part of the bog which had been drained through the creation of a ditch 80 years ago. Probes were placed in the long term N (P+K) fertilization experiment. The result showed the paucity of available ammonium, nitrate and phosphate in the bog, a seasonal pattern associated with rates of mineralization driven by temperature, an increase in the availability of some nutrients as a result of drainage, and the relative availability of nutrients compared to the input from fertilization. We suggest that careful placement of the probes (e.g. exposure period, depth relative to water table etc.) may provide valuable information on variations in nutrient availability within and among wetlands.

Abstract ID: 36541

Final Number: B34F-0073

Title: Effect of Urban Developments on the Lake Simcoe Water Resources

Presenter/First Author: Stephen Kayode Oni, SLU Swedish University of Agricultural Sciences Uppsala, Uppsala,

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Co-authors: Martyn N Futter, Swedish University of Agricultural Science, Uppsala, Sweden; James M Buttle, Trent University, Peterborough, ON, Canada; Peter Dillon, Trent University, Peterborough, ON, Canada

Published Material: Hydrological Footprints of Urban Developments in the Lake Simcoe Watersheds, Canada: a combined paired-catchment and change detection approach. Hydrological Processes, doi: 10.1002/hyp.10290

Abstract Body: Urban sprawl and regional climate variability are major stresses on surface water resources in many places. The Lake Simcoe watershed (LSW) Ontario, Canada, is no exception. The LSW is predominantly agricultural but is experiencing rapid population growth due to its proximity to the greater Toronto area. This has led to extensive land use changes which have impacted its water resources and altered runoff patterns in some rivers draining to the lake. Here, we use a paired-catchment approach, hydrological change detection modelling and remote sensing analysis of satellite images to evaluate the impacts of land use change on the hydrology of the LSW (1994 to 2008). Results show that urbanization increased up to 16% in Lovers Creek, the most-urban impacted catchment. Annual runoff from Lovers Creek increased from 239 to 442 mm/yr in contrast to the reference catchment (Black River at Washago) where runoff was relatively stable with an annual mean of 474 mm/yr. Increased annual runoff from Lovers Creek was not accompanied by an increase in annual precipitation. Discriminant function analysis suggests that early (1992-1997; pre-major development) and late (2004-2009; fully urbanized) periods for Lovers Creek separated mainly based on model parameter sets related to runoff flashiness and evapotranspiration. As a result, parameterization in either period cannot be used interchangeably to produce credible runoff simulations in Lovers Creek due to greater scatter between the parameters in canonical space. Separation of early and late period parameter sets for the reference catchment was based on climate and snowmelt related processes. This suggests that regional climatic variability could be influencing hydrologic change in the reference catchment, whereas urbanization amplified the regional natural hydrologic changes in urbanizing catchments of the LSW.

Abstract ID: 35724

Final Number: B41A-01

Title: Temperature controls inter-annual variability of summer methane emission from polygonal tundra in the Lena River Delta, Siberia

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Published Material: We plan to present our analysis of the multi-annual CH4 flux data set from the Siberian Lena River Delta also at the General Assembly 2015 of the European Geosciences Union (12 – 17 April 2015, abstract submitted).

Abstract Body: Methane (CH_4) emissions from northern wetlands are thought to be at least partly responsible for the observed recent rise in the growth rate of atmospheric CH_4 concentrations. The suggested causal relationship between northern wetland CH_4 fluxes and atmospheric CH_4 concentrations is so far only substantiated by indirect evidence, e.g. by space-for-time approaches using compilations of chamber flux measurements across different climates or by outcome of deterministic CH_4 process models. However, empirical data covering the inter-annual variability of CH_4 emissions are still rare. Here we present multi-annual CH_4 flux data from the Lena River Delta in the Siberian Arctic (72°N, 126°E). The study site is characterized by polygonal wet tundra and a vegetation dominated by mosses and sedges. Seasonal eddy covariance CH_4 flux measurements were conducted during the period 2002-2014. CH_4 flux data overlap during 25 days (28 July - 21 August) for 9 years. Median CH_4 fluxes during the overlap periods of the 9 years ranged between 36 and 64 µmol m^{-2} h^{-1} and were found to be positively linearly correlated to the date of thaw ($r^2 = 0.57$, $p < 0.05$) and soil temperature at 10 cm depth ($r^2 = 0.66$, $p < 0.01$) in wet polygon centers. These results are in line with plot-scale measurements and stable isotope signatures of emitted CH_4, which indicate that (i) wet polygon centers contribute most to landscape-scale CH_4 emissions and (ii) the bulk CH_4 emitted from vegetated polygon centers is not significantly modified by CH_4 oxidation during soil-atmosphere transport. Together, these findings suggest that a warmer climate and longer thaw periods stimulate the production of CH_4, which is directly reflected in increased CH_4 emissions. On the other hand, warming effects on CH_4 oxidation appear limited because transport processes that bypass the soil oxidation zone, i.e. plant-mediated transport and ebullition, dominate CH_4 emission from wet polygonal tundra.

Abstract ID: 36622

Final Number: B41A-03

Title: Carbon and energy fluxes from a spatially heterogeneous permafrost peatland

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Abstract Body: Various microforms, created by spatially differential thawing of permafrost, make up the subarctic heterogeneous Stordalen peatland (68°22'N, 19°03'E), near Abisko, Sweden. This results in significantly different peatland vegetation communities across short distances, as well as differences in wetness, peat temperatures, snow distribution and therefore carbon and energy fluxes. In recent decades, the permafrost extent of Stordalen has been markedly shrinking with warming air temperatures as well as differential snow distribution. When snow accumulates along the margins of the permafrost peat plateaus and palsas, the increased insulation maintains warmer ground temperatures as compared to the tops of the peat plateaus and palsas where the snow is blown clear. This insulation can advance permafrost thaw, leading to changes in vegetation communities and local hydrology as well as impacts to both the energy and carbon balances at this peatland.

Since 2012, we have been measuring the spatially integrated CO_2, energy and water vapour fluxes from this peatland complex using eddy covariance (EC). We have also been examining the CO_2 exchange from specific plant communities within the EC tower footprint (autochambers). LIDAR was used to produce a 1 m resolution digital evaluation model of the complex and the spatial distribution of plant functional types (PFTs) across the peatland was obtained from concurrent high-resolution digital colour air photography trained from vegetation surveys. The EC footprint is calculated for every half-hour and PFT based models are run with the corresponding environmental variables. These models calculate light use efficiency as well as ecosystem respiration for the different PFTs.

Our results show that the Sphagnum, palsa, and sedge PFTs have distinctly different light use efficiency models, and that the tower fluxes are dominated by a blend of the Sphagnum and palsa PFTs. We also see a distinctly different energy partitioning between the fetches containing intact permafrost and those where the permafrost has thawed: the evaporative efficiency is higher and the Bowen ration lower for the thawed fetches.

Abstract ID: 36731

Final Number: B41A-04

Title: Critical Changes to Peatland Carbon Biogeochemistry Following Permafrost Thaw

Presenter/First Author: Avni Malhotra, McGill University, Montreal, QC

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Co-authors: Nigel T Roulet, McGill University, Montreal, QC, Canada; Tim R Moore, McGill Univ, Montreal, QC, Canada

Published Material: A small subset of the proposed presentation is from a manuscript that has been submitted and is currently under review. Data from this manuscript was also presented at the following conferences:

AGU fall meeting 2014 and EUCOP 2014.Majority of the presentation material is new and based on another manuscript that is currently in preparation for submission. The proposed presentation will synthesize and build upon the 2 aforementioned manuscripts, drawing big-picture conclusions on biogeochemical changes in peatlands following permafrost.

Abstract Body: Permafrost peatlands contain significant stores of soil carbon (C) and the fate of this C is uncertain in light of the warming north. With ongoing and projected degradation of permafrost, release of permafrost C is considered a highly likely positive feedback to climate change. To quantify the magnitude of C loss following permafrost thaw in peatlands, several studies have investigated changes in ecosystem structure (vegetation and hydrology) and associated function (C cycling). Based on current literature, we developed a conceptual framework to summarize key changes in structure and function after thaw. Subsequently, we tested hypotheses generated from this conceptual framework, along a wide range of permafrost thaw conditions. Data will be presented on the abiotic and biotic correlates of litter decomposition as well as carbon dioxide and methane fluxes in a thawing landscape. Our results suggest that the dominant controls on C cycling vary significantly, depending on the degree of permafrost thaw. Across the thaw gradient, indirect pathways (change in vegetation due to change in moisture and temperature) have a more pronounced effect on litter decomposition rates than direct pathways (change in temperature and moisture). We will present a revised conceptual framework of peatland C biogeochemistry following permafrost thaw and propose landscape level integrator variables of C function for these spatially heterogeneous landscapes.

Abstract ID: 36752

Final Number: B41A-05

Title: Dissolved Organic Carbon Concentration Affected by Warming and Water Table Lowering in a Boreal Continental Bog

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Abstract Body: Mid-latitude peatlands have accumulated significant carbon (C) stocks as a result of their persistent C sink function. The large C stocks are predicted to respond to global climate changes with increased C losses from these ecosystems. An increase in air and soil temperature and subsequent lowering of water level in bogs may elevate dissolved organic carbon (DOC) concentration in the pore water and can add to the ecosystem C losses in the forms of peat respiration and hydrologic export. During the growing seasons (May to October) of 2012 and 2013, we compared pore water DOC concentration across hummock-hollow microtopography among three sites situated in a continental boreal treed bog located near the town of Wandering River, Alberta. The three sites were; control, recent (2-3 years; experimental) and older drained (12-13 years; drained) with water levels on average at 38, 74 and 120 cm below peat surface, respectively. Pore water DOC concentration was significantly different among the sites with the highest at the drained site (111 mg l^{-1}) followed by 95 mg l^{-1} at the experimental and the lowest at the control site (81 mg l^{-1}). A peat surface warming of ~ 1°C significantly increased DOC concentration and interacted with microform to result in highest concentration at the drained warmed hummocks. Therefore, we conclude that warming and water table lowering may influence the concentration and chemistry of pore water DOC and feedback to carbon biogeochemical cycling both within the peatland and downstream ecosystems.

Abstract ID: 35380

Final Number: B41A-06

Title: Biogeochemical iron cycling in subalpine wetlands: Kinetics and impact on organic carbon transport

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Published Material: Some preliminary data were presented at the 2014 SSSA meeting in Long Beach (Nov. 2014)

Abstract Body: Located at the interface between terrestrial and aquatic ecosystems, wetlands are key biogeochemical hotspots. The intersection of hydrologic flow paths and organic-rich, anoxic substrates create a unique array of conditions where the biogeochemical cycling of carbon (C) and nutrients differ from the surrounding ecosystems. In these environments, transformation and movement of C and iron (Fe) are closely linked. We investigated how contrasting hydrologic conditions and varying temperature influence microbial Fe(III) reduction kinetics and its consequences on the mobilization/retention of organic C in subalpine wetlands.

Within the USDA Fraser Experimental Forest in Colorado (USA), we studied a depressional wetland that provides a hydrologic gradient from constantly waterlogged soils to soils undergoing typical wetting/drying cycles. The effect of temperature on potential rates of Fe(III) reduction and dissolved organic carbon (DOC) release, as well as on the kinetics of Fe(III) reduction (maximum reaction rate, R_{max}, and affinity constant, K_m) were obtained using flow-through reactor experiments run at three temperatures (6, 12 and 18°C) mimicking field conditions.

We showed that Fe(III) reduction is a temperature sensitive and hydrology dependent process in subalpine wetland soils. R_{max} values ranged from 55.6 to 449.4 nmol cm^3 h^{-1}, with the highest values observed for the highest temperatures (Q_{10} of 1.1-2.6), the waterlogged sites, and the more C-rich shallower soil depths. K_m values ranged from 0.3 to 3.7 mM and indicated a higher affinity for Fe(III) at ~12°C, which corresponds to the yearly average field temperature. In addition, our results showed a positive correlation between rates of Fe(III) reduction and of DOC release. Such findings suggest that there is a local adaptation of microbial kinetics to temperature and that soil warming could lead to decreasing water quality in subalpine wetlands, as a result of increased Fe(III) reduction-mediated DOC release.

Abstract ID: 36194

Final Number: B42A-01

Title: Implications of land management practices for greenhouse gas fluxes from tropical peatland oil palm plantations

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Co-authors: Frances Manning, University of Aberdeen, Dundee, United Kingdom; Norliyana binti Haji Zin Zawawi, University of Aberdeen, Dundee, United Kingdom; Timothy Hill, University of St Andrews, St Andrews, United Kingdom; Melanie Chocholek, , , ; Lip Khoon Kho, , ,

Published Material: Some of these findings will also be reported at the European Geosciences Union General Assembly meeting in April 2015.

Abstract Body: Tropical peatlands are one the largest terrestrial reserves of C and are experiencing some of the most rapid rates of land-use change globally. Conversion of tropical peatlands to oil palm are one of the dominant forms of land-use change in the Southeast Asian tropics, with potentially significant implications for regional and global atmospheric budgets of biogenic trace gases. Here we report preliminary findings from a long-term, multi-scale project in Sarawak, Malaysian Borneo that aims to evaluate the impacts of oil palm conversion on ecosystem greenhouse gas budgets, and investigate how alternate management practices could mitigate the negative environmental impacts of land-use change. Flux chamber measurements indicate that soil CO_2, CH_4 and N_2O fluxes averaged 20.0 ± 16.0 Mg CO_2-C ha^{-1} yr^{-1}, 37.4 ± 29.9 kg CH_4-C ha^{-1} yr^{-1} and 4.7 ± 4.2 g N_2O-N ha^{-1} yr^{-1}, respectively. Fluxes of soil CO_2 and N_2O were spatially stratified, and linked to the distribution of palms, harvest residues and soil moisture. Soil CO_2 fluxes were most strongly influenced by the distribution of palms. On average, autotrophic respiration accounted for approximately 78 % of total soil CO_2 flux, and total soil respiration declined steeply away from palms; e.g. soil respiration in the immediate 1 m radius around palms were up to 6 times greater than fluxes in inter-palm spaces. Harvest residue placement also played an important role in modulating soil CO_2 fluxes; soil respiration rates doubled in areas where harvest residues were deposited, reflecting an enhanced input of labile organic matter for decomposition. In contrast, N_2O fluxes were best-predicted by the distribution of harvest residues, and were only weakly related to plant distributions or soil moisture. N_2O fluxes from harvest residue piles were up to twice of the overall plot-average, suggesting that N_2O fluxes were at least partially constrained by the availability of labile substrates for denitrification. In contrast, N_2O fluxes showed no clear pattern around palms; this is surprising because N fertilizers are applied near palm stems, and we predicted that N_2O fluxes would be greatest in areas of high fertilizer input. This suggests that palms may be a strong competitor for inorganic N in these ecosystems, and that fertilizer application may closely match overall plant demand.

Abstract ID: 34281

Final Number: B42A-02

Title: Fourteen Year Carbon Balance For A Raised Temperate Bog

Presenter/First Author: Nigel T Roulet, McGill University, Montreal, QC

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Co-authors: Elyn Humphreys, Carleton University, Ottawa, ON, Canada; Peter Lafleur, Trent University, Peterborough, ON, Canada; Tim R Moore, McGill Univ, Montreal, QC, Canada

Abstract Body: Continuous eddy flux measurements of water, energy and CO_2, and the export of dissolved organic carbon (DOC) have been made since May 1, 1998 on a raised, ombrogenic, oligotrophic, shrub and *Sphagnum* covered bog, the Mer Bleue peatland, near Ottawa, Ontario, Canada. Measurements of the CH_4 flux have also been made from 1998 to the present time using a combination of manual and automated chambers, and eddy covariance. In 2007 we published a six-year (1999-2006) net ecosystem carbon balance (NECB) for Mer Bleue of ~20 ± 40 g C m^{-2} yr^{-1}. The average NEE was ~40 g C m^{-2} yr^{-1} over this period and the net loss of C via the CH_4 and DOC fluxes were 4 and 15 g C m^{-2} yr^{-1}, respectively. The six-year average NECB was remarkably similar to the long-term C accumulation rate, estimated from peat cores, for the last 3,000 years. The post 2006 NEE at Mer Bleue has increased to an average of ~60 g C m^{-2} yr^{-1}. The loss of C via DOC and CH_4, while showing considerable year-to-year variable, has not been significantly different post 2006 than it was in the first six years. Hence, the proportional loss of C as CH_4 and DOC was slightly less post 2006 than it was before 2006. As a result the NECB has increased to ~ 80 g C m^{-2} yr^{-1} post 2006 yielding a 14 year contemporary NECB that is ~50% greater than the long-term accumulation rate of C.

Abstract ID: 33637

Final Number: B42A-03

Title: Distinctive Patterns of Carbon and Nitrogen Fractions in a Deforested and Converted Tropical Peat Dome

Presenter/First Author: Gusti Z Anshari, , Pontianak,

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Co-authors: Evi Gusmayanti, , , ; M Afifudin, , ,

Abstract Body: A deforested, drained and converted peat is recently common in Indonesia. This study aims at assessing patterns of Carbon and Nitrogen densities in disturbed peat dome in the equatorial Borneo of West Kalimantan Province, Indonesia. We investigated 160 peat cores samples from community oil palm (LU1); open peat dominated by ferns (LU2); and degraded forest (LU3). Research variables include Carbon, Nitrogen, bulk density, C:N ratio, and Carbon and Nitrogen densities. We categorized the samples into upper depth section (D1 = 0-50 cm); mid section (D2=50-100 cm); and bottom section (D3>100 cm). All data do not have normal distribution and unequal variances. We employed traditional single factor and Brown Forsythe Anovas prior to Welch-t comparisons. Carbon concentration distinctively decreases in the upper depth section and in oil palm. Nitrogen concentration substantially increases in the upper depth section but is lower in oil palm (*Elaeis guineensis*) than in open peats and degraded forest. C:N ratio is substantially lower in the upper depth section than in mid and bottom sections, and is slightly higher in oil palm than in other two land uses. Due to anthropogenic influence, bulk density is high in the upper depth section and in oil palm, leading to an increase of bulk, Carbon and Nitrogen densities. Results of statistical analyses indicate non-significant difference on Carbon fraction according to these depth clusters, and land uses, and significant difference on Nitrogen concentration according to depth sections only. Decline of C:N ratio in surface peats suggests rapid peat decomposition. A high C:N ratio in oil palm due to loss of Nitrogen and rapid absorption by this plant. High bulk density leads to an increase of Nitrogen availability, which enhances the breakdown of selected organic matters. We assume Carbon stock in this peat is unstable.

Keywords: disturbance, tropical peat properties

Abstract ID: 34999

Final Number: B42A-04

Title: Simulating long-term carbon dynamics in disturbed and restored peatlands

Presenter/First Author: Anne Quillet, McGill University, Montréal, QC

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Co-authors: Nigel T Roulet, McGill University, Montreal, QC, Canada; Jianghua Wu, Memorial University of Newfoundland, Corner Brook, NF, Canada

Abstract Body: Around 25% of the global peatlands have been exploited either for agricultural purposes, forestry, peat extraction or infrastructure development (Parish et al. 2008). Exploitation of peatlands is still on-going. Modelling current and future carbon exchanges in peatlands thus requires further understanding of carbon dynamics in drained, exploited and restored peatlands.

This projects aims at quantifying the carbon balance in disturbed and restored peatlands. Since no long-term (i.e. > 15 years) datasets are available, the chosen approach is the development of a new model. The

developed model, suitable for disturbed and restored peatlands, is based on the millennial scale Holocene Peat Model (Frolking et al. 2010) and the centennial scale McGill Wetland Model (Wu et al. 2012), which simulates carbon fluxes (i.e. CO_2, CH_4 and DOC).

This new model simulating peatland dynamics in restored peatlands accounts for peat mining and the specific vegetation succession occurring during the restoration process. It includes a new representation of vegetation dynamics and interactions between vegetation and ecohydrology. Simulation results give an estimate of the amount of carbon accumulated in the peatland prior to its exploitation as well as the carbon loss during exploitation. This model allows the estimation of current and future carbon fluxes associated with various scenarios of restoration.

Abstract ID: 36366

Final Number: B42A-05

Title: Testing model assumptions in the field: peatland carbon cycling, vegetation, and water table depth

Presenter/First Author: Ellie Goud, Cornell University, Ithaca, NY

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Co-authors: Tim R Moore, McGill Univ, Montreal, QC, Canada; Nigel T Roulet, McGill University, Montreal, QC, Canada

Abstract Body: Peatland biogeochemical models represent vegetation as plant functional types (PFTs), and carbon fluxes are calculated for each PFT as a unimodal function of water table depth. However, field data has rarely supported such unimodal relationships. Moreover, models assume single PFTs but field studies typically measure vegetation that contains a mixture of PFTs. It is uncertain whether it's reasonable to characterize a vegetation group by its dominant PFT. In order to test these assumptions, we measured species abundance and CO_2 exchange in 27 sites from May – September in 2012 and 2013 along a gradient from ombrotrophic bog to beaver pond. Plant species and PFTs fell into six vegetation groups: hummock, hollow, bog moss, bog margin, pond moss and pond margin. For each vegetation group we found unimodal relationships between weekly water table depth and gross ecosystem photosynthesis (GEP). The water table optima and range that we found for each group generally corresponded to values previously reported for that group's dominant PFT, implying that peatland vegetation groups can usually be characterized by their dominant PFT. We also found unimodal relationships between species abundance and annual water table depth. We compared the water table range from species abundance curves to the water table range of the corresponding GEP curves. For hollow, bog moss and bog margin groups, the abundance and GEP ranges were statistically indistinguishable, implying that environmental factors are the dominant controls on species abundance and carbon exchange for these vegetation groups. For hummock, pond moss and pond margin the abundance and GEP ranges were significantly different, implying that biotic factors such as physiological tradeoffs and competitive interactions are more dominant in these vegetation groups. Overall, our work helps to bridge the gap between model assumptions and field studies.

Abstract ID: 36082

Final Number: B42B-01

Title: Unlocking the Power of Many – Why Inter-Catchment Comparisons Can Advance Our Understanding of Forest Hydrological Resilience to Climate Warming

Presenter/First Author: Irena F Creed, University of Western Ontario, London, ON

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Co-authors: Taehee Hwang, National Yunlin University, Touliu Yulin, Taiwan; Chris Brimacombe, , ,

Published Material: About 10% of the results were presented at the Fall AGU in 2011.

Abstract Body: A predictive understanding of forest hydrological resilience in the face of climate change is important because substantial changes to historical water yields place communities that depend of forest water supplies at risk. Hydrological resilience is the ability of a forested catchment to absorb change and maintain or quickly regain hydrological function. Capitalizing on investments into catchment monitoring from provincial/state and federal governments over the past 50+ years, we use novel techniques to explore the hydrological resilience of water yields in natural forested landscapes. In a recent study, we used the theoretical framework of the Budyko curve to explore the elasticity of water yields and changes in water yields related to climate warming – high elasticity indicates resilient water yields, and low elasticity indicates non-resilient water yields. In this study, we consider additional metrics of elasticity [e.g., incorporating stationary (natural, oscillating) vs. non-stationary (anthropogenic, trends) signals in water yields and exploring if catchments with more pronounced oscillations (indicating a system regularly exposed to larger amplitude and/or shorter duration cycles) are more or less vulnerable to climate change]. We then explore hydrological mechanisms (changes in the accessibility of water storages for evapotranspiration) and ecological mechanisms (changes in forest compositions, structure and function) that may contribute to forest expressions of elasticity in response to climate warming. We demonstrate the power of using long-term hydrological monitoring catchments across a range of scales – from a single watershed, to the temperate forest biome, to a range of forest biomes across North America – to "unpack" the complexity and help predict the potential hydrological resilience of catchment water yields to climate change.

Abstract ID: 33471

Final Number: B42B-02

Title: The role of long-term monitoring in meeting science and policy needs: Lessons from 35 years of research at the Turkey Lakes Watershed

Presenter/First Author: Kara L Webster, Canadian Forest Service, Sault Ste. Marie, ON

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Co-authors: Paul W Hazlett, , , ; Ray Semkin, Environment Canada, Burlington, ON, Canada

Published Material: Some aspects included in a talk at Fall AGU 2014

Abstract Body: The Turkey Lakes Watershed (TLW) is located on the Precambrian Shield in central Ontario, Canada and has been the site of multi-discipline ecosystem research since 1979. The 10.5 km^2 watershed is within the Great Lakes - St. Lawrence forest region with an uneven-aged tolerant hardwood forest having 90% of the basal area as mature to over-mature sugar maple. Within the watershed, 4 lakes, 13 first-order catchments, hundreds of permanent sample plots have been monitored to elucidate spatio-temporal processes controlling hydrological and biogeochemical patterns. While acid rain was the initial focus of the watershed study it has proven to be an important outdoor laboratory to study many topics such as forest harvesting, climate change, carbon accounting, fate of nitrogen and calcium depletion, among others. The TLW study has proven effective due to its partnership between 3 federal departments (NRCan, EC and DFO) and provincial government (Ministry of Natural Resources and Forestry), which provide the core funding and Crown Land reserve to keep the facilities open and collect long-term

baseline data. Universities have contributed with shorter-term graduate student projects and provided additional funding for equipment and infrastructure for tremendous value-added research. Ongoing success of watershed studies such as TLW involve strengthening internal partnerships among government, university, local stakeholders and formalizing linkages with other watershed studies to ensure it can continue to address new and emerging scientific concepts and policy-driven hypotheses.

Abstract ID: 33819

Final Number: B42B-03

Title: Long-term Observations of the Recovery from Acid Deposition in Central Ontario

Presenter/First Author: S.a. Watmough, Trent University, Peterborough, ON

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Abstract Body: Long-term (mid-1970s – present) measurements of bulk deposition and stream chemistry by the Ontario Ministry of Environment have enhanced our understanding of the impacts of acid-rain and subsequent recovery in acid-sensitive forested catchments in central Ontario. In response to large emission reductions, sulphate concentrations in precipitation and streams have declined markedly over the past 40 years. However, sulphate levels in streams are also greatly affected by climate, with high acid and metal pulses occurring in stream water following summer droughts. A decrease in atmospheric nitrate deposition has occurred more recently (from mid-1990s) and although most N is retained in catchments, streams draining predominately upland catchments have exhibited a decline in nitrate concentration as well. Despite past decreases in acid deposition, chemical recovery (increase in pH) of surface waters has been less than expected, primarily due to losses of base cations from the shallow, base-poor soils. The combined influence of soil acidification and climate-mediated biogeochemical changes is causing acid deposition related issues to persist long after emission reductions have occurred.

Abstract ID: 36219

Final Number: B42B-04

Title: Long-term monitoring in Kejimkujik National Park Nova Scotia reveals increasing aluminium concentrations in rivers

Presenter/First Author: Shannon M Sterling, Dalhousie University, Halifax, NS

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Abstract Body: Elevated aluminum levels in rivers is known to be toxic for aquatic species, in particular *Salmo salar*; however it was only recently aluminium has been identified as a potential threat to *Salmo salar* populations in South Western Nova Scotia, Canada (SWNS) (Dennis and Clair 2012). Previously, it was thought SWNS rivers contained enough DOC to render the aluminium in rivers inactive. A key remaining question is whether aluminium levels are declining following atmospheric pollution reductions. Here we make a first assessment of long term (1980-2011) aluminium concentration trends in three watersheds located in SWNS, as measured by weekly grab samples. Our results show that total aluminium levels have significantly increased from 1980-2011 in all three sites. Estimates of ionic aluminium levels indicate that the ionic aluminum concentration frequently exceeds the threshold for the level of aquatic health determined by the European Inland Fisheries Advisory Commission (Howells et al. 1990). Data also indicates that calcium levels have yet to recover even with declining concentrations of riverine sulfate. This new knowledge that aluminium is at toxic levels and is worsening will have implications for policy on acidification mitigation in SWNS; this is an urgent issue as the local salmon population numbers currently are declining to near extirpation levels.

Abstract ID: 35927

Final Number: B42B-05

Title: Long term monitoring of forested catchments in Québec, Canada

Presenter/First Author: Daniel Houle, Ministère des Ressources Naturelles, Québec,

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Published Material: Some data have been published in scientific papers, some are unpublished.

Abstract Body: Forested and aquatic ecosystems are submitted to important environmental changes. While acidic atmospheric deposition of sulfur has significantly increased from the sixties to the eighties and is now declining since, climate has been warming. At the same time, a steep decline in nitrate deposition is now observed in eastern North-America. Separating the effects of these large scale drivers on forest growth and surface water chemistry is not a simple task. Among the calibrated catchments in Quebec, the lake Laflamme catchment is one of the most intensively studied since 1981. Routine measurements of precipitation, throughfall, soil solution and stream chemistry as well as tree growth measurements and forest dynamics are being conducted. In addition, experiments of N addition and soil warming are taking place to assess specifics impacts of environmental changes on tree growth and soil chemistry. The long term data gathered at the site as well as the result of the ongoing experiment will be used to portray the impact of environmental changes on forested ecosystems and surface water chemistry.

Abstract ID: 34627

Final Number: B42B-06

Title: The Value of Long-term Gauged Watershed Experiments in Forest Hydrology: lessons from the South African Experience.

Presenter/First Author: David Findlay Scott, Jet Propulsion Laboratory, Pasadena, CA

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Published Material: A version of this presentation (without the specific South African reference) was presented at the IAHS Workshop HW05 held 6-8 July 2011 in Melbourne, Australia, 'Revisiting Experimental Catchment Studies in Forest Hydrology'.

Abstract Body: Much of what we know about the hydrology effect of forestry has come from gauged watershed experiments conducted over the last 80 years. These experiments have been enormously useful, but there are many critics who consider the paired-catchment experiment to be an out-dated technology. Their argument is based on many valid points: catchment experiments are costly, take a long time, do not provide a detailed understanding of the individual hydrological processes ("catchments are a black box"), are empirical and results are difficult to transfer (size or extrapolation issues). This paper argues that despite the problems there is a need for long-term watershed studies, and uses the South African experience to illustrate the case.

- Gauged watersheds are the ultimate integrators of all hydrological processes. The catchment experiments therefore

provide the definite answer to the study of changes in factors that influence the hydrology at a particular location.

- Catchment experiments are the proper setting for hydrological process studies, as the catchment provides the boundaries and limits within which process studies can be best tested and extended.
- Long term data from gauged watersheds provide a firm baseline for modelling studies, which are being used more and more, but are much more valuable if set within the bounds provided by a gauged watershed.
- As hydrological questions change, so the paired-catchment experiments can be adjusted to answer new questions.
- Long-term catchment experiments provide an historic reference which is needed now, and will be needed in the future, to investigate questions relating to changing climate, land use effects, and other questions which are yet to arise.

Abstract ID: 36719

Final Number: B42B-07

Title: The Role of Long-Term Observatories and Networks for Advancing the Frontiers of Science: Linking Networks and Promoting Scientific Engagement Nationally and Internationally.

Presenter/First Author: Charlotte L Roehm, National Ecological Observatory Network, Boulder, CO

Presenter/First Author Email: croehm@neoninc.org

Published Material: The generic information about NEON has been presented, however, the majority of this talk will focus on opportunities for interoperability specific to Canadian networks and scientific engagement models.

Abstract Body: In an era of 'Big Data', linking research networks and observatories through interoperability standards can provide a model for universal access to accurate scientific data and the tools needed to interpret data for informing new scientific discoveries. Building a community, developing discovery and interoperability solutions and supporting the community with tools are some approaches for addressing the increasing availability of and demand for Big Data. This talk will focus on the role of long term networks and observatories for pushing the frontiers of science. The National Ecological Observatory Network is poised to start operations in 2017 to provide a platform for collecting and freely distributing long term ecological data to enable the forecasting of the impacts of climate and land use change and invasive species on ecosystems across the United States. Opportunities for collaborating on national and international interoperability standards and for defining scientific engagement will also be discussed.

Abstract ID: 36703

Final Number: B43A-01

Title: Groundwater – Surface Water Interactions in Mountain Environments: Comprehending Heterogeneity

Presenter/First Author: Jeffrey M McKenzie, McGill University, Montreal, QC

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Co-authors: Ryan Gordon, Syracuse University, Syracuse, NY; Devin Cairns, University of Lethbridge, Lethbridge, AB, Canada; Laura Lautz, Syracuse University, Syracuse, NY; James M Byrne, University of Lethbridge, Lethbridge, AB, Canada; Bryan G Mark, OSU-Byrd Polar Rsrch Ctr, Columbus, OH

Published Material: A subset of the Cordillera Blanca research was presented at AGU. The Blanca research is in review with J. Hydro. The DEM analysis research is on the cusp of being submitted to a journal.

Abstract Body: In glaciated mountain catchments, groundwater is critical in maintaining surface water flows at mid- to high-latitudes during winter and in low-latitudes during the dry season. In these systems, groundwater-surface water interactions are difficult to characterize due to the complex and heterogeneous nature of the hydrogeology. We present results from two groundwater – surface water studies that quantify the magnitude of these interactions and attempt to understand the role of spatial heterogeneity.

At a headwater and mid-valley site in the Cordillera Blanca, Peru, tracer measurements of stream and spring discharge were combined with synoptic sampling of water isotopic and geochemical composition to quantify streamflow contributions from different groundwater reservoirs. At the headwater site, groundwater supplies approximately half of the dry-season stream discharge across a small meadow, with most originating from an adjacent alluvial fan and little (6%) from the meadow itself. At the mid-valley site, with more extensive meadows, groundwater is a large component of streamflow. Although, the most focused inflow of groundwater occurred across a moraine between two meadows (200 L/s or 18% of average discharge). Heterogeneous features, such as valley-crossing moraines and alluvial fans, demonstrate the heterogenous nature of groundwater – surface water interactions.

In the headwaters of St. Mary River Watershed in Glacier National Park, Montana, we have applied an automated geomorphometric model to a 10-m DEM in order to identify the approximate spatial distribution of geomorphic features, considered to represent the subsurface geology, and to delineate each of these features based on relative hydrostratigraphic differences (e.g. glacial depositional features, bedrock outcrops, periglacial landforms, etc.). The results further demonstrate the complexity of the underlying hydrogeologic system and how it may affect subsurface storage and residence times.

Abstract ID: 34641

Final Number: B43A-02

Title: Surface Water and Groundwater Controls on Local Lake Water Chemistry and Water Balance in a Boreal Esker Complex

Presenter/First Author: Maxime P Boreux, Queen's University, Kingston, ON

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Co-authors: Scott F Lamoureux, Queen's University, Kingston, ON, Canada; Brian F Cumming, Queen's University, Kingston, ON, Canada

Published Material: Only early preliminary findings were reported in a poster session of the 2014 WATIF student meeting in May 2014. We now have a strong complete data set and hoping for an oral presentation

Abstract Body: Hydrological water balance and chemistry in lakes are critical to biogeochemical cycles and influence aquatic biota. Understanding the climatic controls on water balance and lake water chemistry is essential for ecosystem management and conservation,

especially in a time of rapid climate change from human activities. These controls were investigated in a set of 50 lakes located in an esker system near Timmins, Ontario. Water samples were collected in June 2013, June 2014 and August 2014 for stable isotopes of water (δ18O and δ2H), solutes, alkalinity, and dissolved organic carbon to assess how isotopic composition and water chemistry indicate variations in localized water balance between adjacent lakes.

Statistical analyses of the water from the studied lakes indicated a clear separation between two clusters of lakes based on water geochemistry along an elevation gradient: (1) recharge lakes located at higher elevations that were low in solutes and isotopically enriched, and (2) discharge lakes situated at lower elevations that were high in dissolved solutes and isotopically depleted. Differences in lake trophic status and primary production were also observed between these two groups of lakes. Precipitation-fed upland lakes had higher trophic status and dissolved organic carbon concentrations compared to lower elevation groundwater discharge systems presumably in relation to longer water residence times in upland lakes that contribute to local groundwater recharge.

Results suggest that upland recharge lakes will be more prone to evaporative drawdown and therefore more sensitive to short-term climate change and droughts, while discharge lakes will be buffered by groundwater inflow and affected by hydroclimatological changes of greater duration and persistence.

Abstract ID: 34877

Final Number: B43A-03

Title: Water and nutrient fluxes at the sediment-water ecotone of lakes: How important is exchange with groundwater?

Presenter/First Author: Donald O Rosenberry, USGS Central Region Office, Lakewood, CO

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Co-authors: Joerg Lewandowski, Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany; Karin Meinikmann, , , ; Gunnar Nuetzmann, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

Published Material: Some of the results that will be presented have recently been accepted for publication in the journal Hydrological Processes.

Abstract Body: The stability and viability of the groundwater-surface-water ecotone depends largely on fluxes of water and nutrients across the sediment-water interface. Larger rates of groundwater discharge create a more stable environment at and near the interface. However, ecosystem viability suffers if groundwater delivers contaminants or excessive nutrient loads. A comprehensive literature survey was conducted to compile reported rates of water and nutrient exchange in lake settings. Exchange of lake water and groundwater is highly variable in space and time in nearly all lakes. Nutrient fluxes are further complicated by chemical processes that affect nitrogen differently from phosphorus (P) and depend on the redox state of the aquifer. Reported rates of flow from groundwater to lake water range from near 0 to 7.45 m/day. The median of 102 reported studies is 0.007 m/day. Reported flows from lake water to groundwater are far fewer and range from near 0 to 2.63 m/day with a median value of 0.006 m/day. Median discharge of phosphorus and nitrogen to lakes was 34.7 and 1310 $mg/m^2/year$, respectively. Uncontaminated groundwater approaching a sediment-water interface of a lake commonly contained less than 50 µg/L phosphate P. Reported phosphate-P values for nutrient-enriched groundwater ranged from 100 to 4900 µg/L. Nitrite, nitrate, and ammonium concentrations of groundwater approaching lakes were commonly less than 0.01, 10, and 0.2 mg/L, respectively, with nitrate having the greatest variance. Groundwater anthropogenically enriched with nitrogen had nitrite, nitrate, and ammonium concentrations approximately 2, 1, and 1 orders of magnitude larger, respectively. This comprehensive summary indicates that groundwater is an important influence for both the ecotone at the sediment-water interface and often the entire lake ecosystem.

Abstract ID: 36487

Final Number: B43A-04

Title: The Ubiquity of Artificial Sweeteners in the Aquatic Environment

Presenter/First Author: Kristen Alexandra Leal, University of Waterloo, Waterloo,

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Co-authors: John Spoelstra, Environment Canada, Burlington, ON, Canada; Sherry L Schiff, University of Waterloo, Waterloo, ON, Canada

Abstract Body: Artificial sweeteners have been used in food, beverage and pharmaceutical products for more than 30 years. Recent studies have documented relatively high concentrations of artificial sweeteners (e.g. acesulfame, saccharin, cyclamate and sucralose) in many aquatic environments including rivers, lakes, groundwater, and estuaries. The potential use of artificial sweeteners, especially acesulfame, as tracers of human wastewater in urban environments has been well documented since the first such study published in 2011, where acesulfame was found at all 8 urban sample sites investigated. There is currently minimal information regarding the toxicity of artificial sweeteners on aquatic organisms. As wastewater treatment plant effluents and leaky sewer systems are major sources of artificial sweeteners, it is not surprising that artificial sweeteners are being found in groundwater and surface waters in and near urban areas. However, in this study we demonstrate that even areas without municipal effluent sources have measureable concentrations of artificial sweeteners. In small agricultural and forested catchments, artificial sweeteners were found in 20 of the 25 catchments sampled. Acesulfame and saccharin were found in concentrations ranging from below detection limits to 117 ng/L and 390 ng/L, respectively, with sucralose and cyclamate less commonly found. Analysis of land use and spatial data suggest that both intensive livestock operations and septic systems are sources of different artificial sweeteners. As a consequence, artificial sweeteners were found in streams and rivers that do not have municipal wastewater effluent discharges. The presence of artificial sweeteners in these agricultural dominated watersheds may offer a new method of apportioning nitrogen and phosphorus loading in mixed-use watersheds.

Abstract ID: 36630

Final Number: B43A-05

Title: Surface water-groundwater interactions buffer seasonal changes in urban stream water quality

Presenter/First Author: Laura Lautz, Syracuse University, Syracuse, NY

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Co-authors: Sarah Holderness Ledford, Syracuse University, Syracuse, NY

Published Material: Some elements of this presentation have been published in a paper in Hydrological Processes (accepted and in press) and presented at prior Geological Society of America and AGU meetings. Other elements of the presentation are new findings.

Abstract Body: Urban streams commonly suffer from degraded stream water quality and limited surface water-groundwater (SW-GW) interaction due to channel incision and straightening, armoring of the stream bed and banks, and degradation of riparian floodplains and wetlands. Reestablishing hydrologic connection between urban streams and their hyporheic and riparian zones may be effective for naturally attenuating nutrients and salts. To investigate the impact of SW-GW interactions on urban stream water quality, we observed longitudinal and seasonal changes in stream water quality in an urban stream in Syracuse, New York. The stream is heavily degraded (channelized, armored, no riparian floodplain) for the upper 4 km and then transitions to being hydrologically connected to a broad, intact riparian floodplain, with a meandering channel, geomorphically complex bedforms, and large woody debris for the most downstream 1.5 km. We collected grab samples of stream water every 2 weeks from May 2012 to June 2013 at 24 sites positioned longitudinally along the stream and in a transect of riparian groundwater wells in the downstream floodplain. We also quantified the discharge profile along the 5 km stream in August 2012 using a constant rate injection of Rhodamine WT. Results show water quality in the urban stream is heavily impacted by road salt runoff and groundwater discharge along the lower, connected reach buffers seasonal changes in chloride. Groundwater discharge dilutes high in-stream chloride concentrations in winter; but, chloride storage in the riparian flood plain elevates in-stream chloride concentrations in non-winter months. Nitrate concentrations in the degraded reach are highly variable seasonally. In summer, direct exposure to sunlight, elevated stream temperatures, and rapid primary productivity promote nitrate uptake. In winter, stream nitrate concentrations increase as nitrate uptake by biota and denitrification are at a minimum. Groundwater modeling illustrates the mechanisms of salt storage in and discharge from the riparian aquifer. In-stream nitrate injection experiments quantify seasonal changes in nitrate uptake rates in the degraded and connected stream sections. Results indicate intact riparian floodplains can regulate urban stream water quality and should be preserved or restored.

Abstract ID: 36750

Final Number: B43A-06

Title: Impact of Direct Nutrient Inputs via Groundwater on Near-shore Zones of Large Water Bodies: Regional Scale Approaches

Presenter/First Author: Hans Hermann Dürr, University of Waterloo, Waterloo, ON

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Co-authors: Nils Moosdorf, University of Hamburg, Hamburg, Germany; Philippe Van Cappellen, University of Waterloo, Waterloo, ON, Canada

Published Material: Approaches on tropical islands have been published recently by 'Grundwasser'. This makes up about 30% of the material to be presented.

Abstract Body: Direct groundwater discharge to near-shore zones of large water bodies (lakes and oceans) is a pathway for freshwater and associated dissolved nutrients. However, it is hard to quantify, especially at regional to continental scales. Some coastal ecosystems are at particular risk through eutrophication, hypoxia, or harmful algal blooms, and while local field methods or models are available, targeted research at larger scales is scarce. Here, we review available assessments of direct groundwater discharge and solute transport, using examples from large inland water bodies (here, the Laurentian Great Lakes), as well as coastal areas surrounding tropical islands. We demonstrate example approaches, reaching from the use of the ratio of coastline length to hinterland area as first-order approach to estimate the importance of direct groundwater discharge compared to rivers (Moosdorf et al. 2015), to the use of large-scale hydrological and hydrogeological models. Information on near-shore groundwater quantity and/or baseflow, combined with assessments of nutrient concentrations in groundwater bodies, can set an upper boundary for the potential contribution, and identify likely hotspots of nutrient delivery via this discharge pathway.

Moosdorf N., Stieglitz T., Waska H., Dürr H.H., Hartmann J., (2015). Submarine groundwater discharge from tropical islands: a review. Grundwasser, doi:10.1007/s00767-014-0275-3.

Abstract ID: 35255

Final Number: B43A-07

Title: Hydrologic controls on the fate of contaminants at the groundwater-lake interface at freshwater beaches

Presenter/First Author: Clare E Robinson, University of Western Ontario, London, ON

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Co-authors: Laura Jill Vogel, University of Western Ontario, London, ON, Canada; Spencer S Malott, University of Western Ontario, London, ON, Canada; Sabina Rakhimbekova, , , ; Denis M O'Carroll, University of Western Ontario, London, ON, Canada

Published Material: This paper will present a review of field data that has been collected over the last 5 years examining the impact of dynamic groundwater-lake interactions on different contaminants along freshwater shorelines. The data related to E. coli fate was presented at the AGU Fall 2014 meeting. The data at one site (Port Stanley) that examined the fate of arsenic was published in ES&T (2014) however in the proposed presentation data will be presented from multiple beaches across the Great lakes.

Abstract Body: The role of groundwater-surface water interactions in controlling the delivery of contaminants to surface waters in freshwater beach environments is not well understood. These environments are ubiquitous on large inland lakes and nearshore water quality is often deteriorated due to fecal pollution (e.g., *E. coli*) and algal fouling. Field data obtained at sandy beaches on the Great Lakes provide important insight into the important influence of dynamic groundwater-lake interactions on the fate of contaminants, including trace elements (arsenic), nutrients, and fecal indicator bacteria (*E. coli*), in beach groundwater and subsequent fluxes to the lake. The data illustrate the role of wave-induced groundwater recirculations in accumulating *E. coli* in shallow foreshore beach sand and groundwater, and, in combination with sand erosion, later delivering *E. coli* from this reservoir back to the lake during periods of intensified wave activity. In addition, wave-induced recirculations across the sediment-water interface, which vary with wave intensity, set up sharp redox and pH gradients in beach groundwater that promote precipitation of iron (hydr)oxides and subsequent sequestration of chemical species including arsenic and phosphate. For instance, elevated dissolved arsenic below the shoreline (up to 56 μg/L) has been observed in beach groundwater at multiple beaches around the Great Lakes suggesting that this arsenic enrichment may be naturally occurring and linked with geochemical conditions set up by wave-induced recirculations. The interacting hydrologic and geochemical processes revealed have important implications for the flux of a wide range of contaminants across the groundwater-lake interface in freshwater coastal environments.

Abstract ID: 35901

Final Number: B43A-08

Title: Connectivity and Nitrogen Transport of Two Wetland-Rich Boreal Sites in the Athabasca Oil Sands Region

Presenter/First Author: Mikaela Lynn Cherry, University of Victoria, Victoria, BC

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Co-authors: John J Gibson, University of Victoria, Victoria, BC, Canada; S Jean Birks, Alberta Innovates-Technology Futures, Calgary, AB, Canada

Abstract Body: Development of the Athabasca Oil Sands Region (AOSR) has increased atmospheric nitrogen emissions. The area surrounding development is comprised of Boreal forests and peatlands. Improved understanding of the hydrological connectivity between Boreal peatlands and uplands is needed to predict the fate and transport of atmospheric N deposited across the region. Two wetlands sites: Jack Pine High (JPH, located 45 km north of Fort McMurray) and Mariana Lakes (ML, located 100 km south of Fort McMurray) were instrumented with piezometers nests and water table wells for this study (n= 108 sampling locations). The wells were placed along transects that cover target landscape units (bog, fen, upland). Wells were sampled for water isotopes and geochemical variables during the summers of 2011-2014 to characterize the baseline geochemistry of groundwater in the different landscape units. Inorganic (nitrate, ammonium) and organic forms of nitrogen (dissolved organic nitrogen), major and minor ions and water isotope tracers (d^{18}O, d^{2}H and ^{3}H) were measured to identify the various forms of nitrogen in the different landscape units, as well as to assess connectivity and potential for nitrogen transport between the different units. At JPH the connectivity between the uplands and fens is a simple recharge from the upland to the fen. There was little (<0.1-1.5 mg/L) nitrate, ammonium, or dissolved organic nitrate (DON) found throughout JPH. Concentrations of ammonium and DON increased at depths throughout ML. The distribution of ^{3}H with depth within the peatland have shown limited connectivity between the peat and underlying mineral soils.

Abstract ID: 34184

Final Number: B43B-01

Title: Using Artificial Soils as Simplified Model Systems to gain insight into the effect of Mineral Composition on Microbial Community Development and Soil Organic Matter Formation

Presenter/First Author: Geertje Johanna Pronk, Lehrstuhl für Bodenkunde, Technische Universität München, Freising,

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Co-authors: Doreen Babin, , , ; Franziska Ditterich, , , ; Julia Giebler, , , ; Katja Heister, , , ; Michael Hemkemeyer, , , ; Ellen Kandeler, , , ; Ingrid Kogel-Knabner, Soil Science - TU München, Freising, ; Yamuna Kunhi Mouvenchery, , , ; Christian Poll, , , ; Anja Miltner, , , ; Gabriele Schaumann, , , ; Michael Schloter, , , ; Kornelia Smalla, Institut fur Epidemiologie und Pathogendiagnostik, Braunschweig, Germany; Annelie Steinbach, , , ; Christoph Tebbe, , , ; Kai Uwe Totsche, Friedrich Schiller University of Jena, Jena, Germany; Susanne Woche, , , ; Cordula Vogel, , , ; Lukas Wick, , ,

Published Material: The findings were previously reported at the World Congress of Soil Science in Jeju, Korea, 2014. The presentation contains a syntesis of various results, which are already publised in several different journals.

Abstract Body: Soils represent a very complex materials where mineral, organic and biological components closely interact. It is difficult to gain complete understanding of biogeochemical processes in soils, as the initial conditions and development history are usually unknown and soil composition is usually not well defined. Therefore, we composed simplified artificial soils to study in particular the effect of mineral composition and charcoal presence on soil organic matter and microbial community development.

The artificial soils contained 8 different mixtures of the minerals illite, montmorillonite, ferrihydrite and boehmite, and charcoal. Sand and silt-sized quartz were used to provide texture, the mixtures were inoculated with an extract from a natural arable soil, and sterilized manure was added as a substrate. The mixtures were incubated in the dark at 20°C and constant water content, and sampled after 3, 6, 12 and 18 months incubation. They were then analysed in an extensive interdisciplinary study for e.g. microbial abundance and diversity, functionality, as determined by respiration and enzyme activity, organic matter composition, physical structure and surface properties.The mixtures quickly developed into soil-like systems with an established microbial community, macroaggregation and developing organo-mineral associations. Different microbial communities were established in the artificial soils depending on artificial soil composition. However, the development of soil organic matter and organo-mineral associations was similar for all mixtures.

Overall, the artificial soils used in this study provide a new approach to gain a mechanistic understanding of biogeochemical processes in well-defined soil-like systems. Furthermore, the combination of interdisciplinary methods illustrates how microbial communities interacted with, and were affected by, the OM, mineral and charcoal surfaces present in their habitats.

Abstract ID: 34912

Final Number: B43B-02

Title: Soil Oxygen Dynamics under Freeze-Thaw Cycles

Presenter/First Author: Tatjana Milojevic, University of Waterloo, Waterloo, ON

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Abstract Body: Freezing and thawing cycles are a natural climate forcing acting on soils at middle to high latitudes. Freezing and thawing affect a soil's physical properties, biogeochemistry, microbial activity, carbon and nutrient turnover rates, and modulate gas exchanges between the soil and atmosphere, which, in turn, exerts a strong influence on oxygen (O_2) availability within soil environments. The ability to monitor changes in O_2 levels in both the gas and aqueous phase is key to understanding how changes in frequency and amplitude of freeze-thaw cycles affect a soil's geochemical conditions and microbial activity. In this study, we perform soil column experiments in a temperature-controlled environmental chamber. The air temperature of the chamber determines the soil's surface temperature, while a band-heater keeps the lower part of the column at a constant groundwater temperature. This design allows us to reproduce realistic, time- and depth-dependent temperature gradients in the soil column. High-resolution, luminescence-based, *Multi Fiber Optode* (MuFO) microsensors are used to enable continuous O_2 detection at a high degree of spatial flexibility in the column. High-resolution digital images of the sensor-emitted light are recorded and light intensity is converted to O_2 concentration via signal image-processing techniques. Headspace gas measurements are used to derive the effluxes of CO_2, CH_4 and N_2O during the experiment. In this presentation, we will present preliminary results to assess the hypothesis that freeze-thaw cycles regulate the fluxes of the greenhouse gases (GHG) not only by acting on the physical transport of gases, but also on soil microbial respiration via the variations in O_2 availability. The next step of our research will be to identify diagnostic geochemical and microbial signatures of the fluctuations in soil O_2 concentrations.

Abstract ID: 34159

Final Number: B43B-03

Title: Impact of precipitation intensity and riparian geomorphic characteristics on greenhouse gas emissions at the soil-atmosphere interface in a water limited North Carolina riparian zone

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Co-authors: Sara M Marchese, , Corning, NY; Sara K McMillan, UNC Charlotte, Charlotte, NC; Molly Welsh, , ,

Abstract Body: As greenhouse gas concentrations (GHG: N_2O, CO_2, CH_4) continue to increase in the earth atmosphere, there is a critical need to fully quantify GHG emissions from natural systems. In particular, rapidly changing moisture conditions often observed following precipitation events have the potential to create short periods (a few days) during which anaerobic conditions dominate in the riparian zone. These hot moments of denitrification and methanogenesis have the potential to significantly alter net GHG emissions at the soil-atmosphere interface in these systems. In this study, we use a combination of natural and artificial precipitation to investigate the impact of precipitation on overall GHG emission over a 3-day period in a forested riparian zone in North Carolina, USA, and characterize how GHG (CO_2, N_2O, CH_4) fluxes change as a function of location within the riparian zone. No significant differences in CO_2, CH_4, and N_2O fluxes in response to increased moisture were observed between a depression, a sand bar, and an upland forested area. However, in this well-drained site where water-limited aerobic conditions dominated before the onset of precipitation, methane oxidation decreased and aerobic respiration increased following precipitation. Although a short term burst in N_2O emission was observed 5 and 24 hours after precipitation occurred, elevated N_2O emissions did not persist long enough to turn the site from the N_2O sink to a N_2O source in the 3 days following the beginning of the experiment. Although in contrast with some previously published work where water limitation was unlikely to play a strong role on riparian biogeochemistry, our results are consistent with our current understanding of the impact of soil moisture on GHG emission at the soil atmosphere interface, and illustrate the complexity of riparian biogeochemistry and GHG dynamics. We present a conceptual model illustrating our findings in relation to previously published work.

Abstract ID: 34807

Final Number: B43B-04

Title: Early Diagenesis of Fe and Mn in the Laurentian Trough: Influence of Environmental Variables

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Abstract Body: We determined the vertical distributions of dissolved Fe and Mn and solid phase ascorbate-extractible Fe and Mn (Fe_{asc} and Mn_{asc}) in six sediment cores recovered on a transect along the Laurentian Trough and extending from the Lower St. Lawrence Estuary through the Gulf of St. Lawrence to the edge of the continental shelf. At all sites, the sediment surface layer is enriched in both Fe_{asc} and Mn_{asc}. Manganese cycles both within the sediment column and across the sediment-water interface with a net loss of Mn to the overlying water. In contrast, Fe cycles entirely within the sediment column, without loss. The inventories of dissolved Fe and Fe_{asc} are strongly correlated to the reactivity of the sedimentary organic matter and its exposure time to oxygen. The peak concentration of dissolved Fe within a given core as well as the sum of dissolved Fe upward and downward flux (from dissolved Fe maximum at each core) show the comparable correlations. Despite a seaward increase in the relative contribution of autochthonous organic matter to the seafloor, the correlations indicate that the reducing capacity of the sediments (inferred from the strength of the Fe diagenetic cycles) nearly follow the track of the transect, as the sedimentation rate decreases and the bottom-water oxygen concentration and water depth increase seaward.

Abstract ID: 36209

Final Number: B43B-05

Title: Early diagenesis, methylmercury production and total mercury deposition in North American Arctic Margin sediments

Presenter/First Author: Charles Gobeil, INRS-ETE, Quebec, QC

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Co-authors: Zou Zou A Kuzyk, University of Manitoba, Winnipeg, MB, Canada; Robie W Macdonald, Institute of Ocean Sciences, Sidney, BC, Canada; Daniel Cossa, Ifremer Biblio Perouse, Grenoble, France

Published Material: Our findings have not been submitted to a journal yet. Some aspects of our mercury results were presented at a national conference but, here, we want to propose for the first time a thorough interpretation for the total mercury and methylmercury distribution in arctic margin sediments taking into account early diagenetic processes.

Abstract Body: The profiles of total Hg (HgT) and methylmercury (MeHg), i.e. the toxic form of Hg that biomagnifies in aquatic food webs and can be produced in marine sediments, were determined in sediment cores collected across the North American Arctic Margin (NAAM). To provide a diagenetic context to interpret these profiles, Mn, Fe, total S, reduced inorganic S (S-Red) and radioisotopes (Pb-210, Ra-226, Cs-137) were also determined. The cores from the Beaufort Sea, Canadian Archipelago and Baffin Bay are characterized by high levels of Mn and Fe oxyhydroxides down to several cm below the sediment-water interface and low levels of total S, S-Red and MeHg. In contrast, sediments from the Bering and Chukchi Seas contain negligible amount of Mn and Fe oxyhydroxides but high levels of S-Red and MeHg. In these highly productive regions of the NAAM, S-Red increases with depth in the sediments and reaches concentrations at the bottom of the cores (~40 cm) that are about 10 times higher than in the Beaufort Sea, Canadian Archipelago and Baffin Bay. Likewise, MeHg increases with depth in Bering and Chukchi Seas sediments to concentrations significantly higher (1-2 ng g^{-1}; 2-4% of HgT) than those measured in the other regions of the NAAM (<0.2 ng g^{-1}; 0.3% of HgT). From these results we submit 1) that the anaerobic oxidation of organic C is mainly driven by the reduction of sulfate in Bering and Chukchi shelves sediments and by that of Mn and Fe oxyhydroxides in the sediments of the others regions of the NAAM, 2) that significant accumulation of MeHg in NAAM sediments only occurs in the Bering and Chukchi Seas and 3) that sulfate-reducing bacteria are likely the key microorganisms responsible for the conversion of inorganic Hg to MeHg in the sediments from these two marginal seas. Lastly, assuming negligible post-depositional redistribution of HgT, we propose that the depositional flux of HgT in surface sediments across the NAAM is higher than in preindustrial time by 1±0.9 ng cm^{-2} a^{-1}.

Abstract ID: 36592

Final Number: B43B-06

Title: How do tides impact on groundwater flows and biogeochemical transformations in an unconfined beach aquifer?

Presenter: Frédérike Lemay-Borduas, University of Quebec at Rimouski UQAR, Rimouski, QC

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Abstract Body: Sandy beaches are key environments of biogeochemical dynamic at the land-sea interface, where fresh and salt waters mix. Multiple physical forces that drive groundwater flows and residence times control the reaction rates and thus the chemical transformations in this active biogeochemical zone. Terrestrial drivers and marine processes interplay in a complex way to modify the subsurface transport pathway and local geochemical conditions. Understanding how these local flow regimes influence chemical transformations in subterranean estuary is important to estimating regional chemical fluxes from aquifers to coastal waters. Here, we combine physical and geochemical approaches to explore the impact of tidal oscillations on hydrogeological and biogeochemical mixing in a subterranean estuary of a microtidal beach located in Magdalen Islands (Gulf of St. Lawrence, Canada).

Tidal propagations in the beach were investigated via a harmonic analysis of piezometric level fluctuations recorded over 20 days. In addition, high-resolution depth profiles were sampled in a cross-shore transect and a suite of biogeochemically cycled elements and stable isotope tracers were analyzed. We use the abundance of δD and $\delta^{18}O$ to discriminate the mixing of nearshore fresh and saline groundwaters over tidal cycles. Tidal effect is also examined on the distribution of reactive biogenic compounds in the subterranean estuary. Preliminary results reveal that tidal oscillations decrease landward with increasing phase lags as observed in other isotropic shallow aquifers. Tides components induce water level fluctuations are completely damped 35 m landward of the shoreline. In the subterranean estuary, these piezometric level fluctuations seem to have only a limited effect on fresh groundwater – saltwater mixing. The downward transport of the saltwater and the subsequent water mixing may be mainly controlled by both the permeability of the beach aquifer and the frequency of tidal-forcing. This may also explain the temporal lag we observed between the tidal oscillation and the geochemical conditions measured in the subterranean estuary.

Abstract ID: 35042

Final Number: B43B-07

Title: Iron Isotope Systematics in a Eutrophic Lake

Presenter/First Author: Lingling Wu, University of Waterloo, Waterloo, ON

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Co-authors: Sherry L Schiff, University of Waterloo, Waterloo, ON, Canada; Jason J Venkiteswaran, Wilfrid Laurier University, Waterloo, ON, Canada; Kai Liu, , , ; Lewis A Molot, York University, Toronto, ON, Canada; Josh D Neufeld, University of Waterloo, Waterloo, ON, Canada

Abstract Body: Iron isotopes are a useful tracer of biogeochemical processes in a variety of environments. This study investigated the iron isotope signatures in eutrophic Lake 227 in the Experimental Lakes Area, which was experimentally fertilized with phosphorus and nitrogen for more than 45 years. The aim was to use iron isotope tools to shed light on processes such as cyanobacterial blooms and anoxygenic photosynthesis by photoferrotrophs. The iron isotope compositions of the dissolved fraction and suspended loads in lake waters are clearly different in the two thermal layers: in the upper mixed layer above the oxycline where there is a cyanobacteria bloom, dissolved Fe showed $\delta^{56}Fe$ values about 0.8‰ heavier than the suspended particles, reflecting association with colloids and organic matter and possibly uptake of isotopically light Fe by cyanobacteria; in the anoxic hypolimnion where photoferrotrophs thrive, the fractionation between dissolved and suspended Fe is reversed with dissolved Fe about 1.0 to 1.5‰ lighter than the suspended solids, consistent with results of laboratory cultures of photoferrotrophs. The uniform isotope signature of dissolved Fe with depth in the hypolimnion is consistent with diffusion of Fe(II) from complete microbial reduction in the sediments. Alternatively, the isotope fractionation between dissolved and suspended Fe in the hypolimnion may reflect microbial reduction of Fe oxyhydroxides settling down from the oxycline. Sequencing of DNA obtained from water column samples provided additional data implicating photoferrotrophs in Lake 227 biogeochemistry. More data are needed to further understand the dynamic cycling of Fe in the system.

Abstract ID: 35653

Final Number: B43B-08

Title: Stochastic Resonance: A New Mechanism for the Formation of Banded Patterns in Limestone-Marl Sequences

Presenter/First Author: Ivan L'Heureux, University of Ottawa, Ottawa, ON

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Published Material: I gave an one-hour long seminar on this topic at GEOMAR (Kiel, Germany) in August 2014.

Abstract Body: The origin of banded sequences in calcareous-marl deposits is not yet completely understood. Are they only due to systematic external variations in the environment (such as the 100 ka climate cycle)? Are they due to self-organized recurrent conditions generated by the nonlinearity of the diagenetic processes? Or a combination of both, as suggested by cellular automata modelling approaches available in the literature? In this contribution, a simple diagenetic reactive-transport model (RTM) is presented, following the conceptual model of Munneke et al. (Int. J. Earth Sciences (2001): 90, 795-812). This RTM differs from cellular automata approaches by explicitly considering diffusion of dissolved calcium and carbonate ions. However, no self-organized diagenetic oscillations were found in the RTM. Nevertheless, it was established that a parameter regime exists for which the system is multistable, indicating that different steady-state solutions are reached according to which initial sediment condition is chosen. When the system is driven by a weak external periodic forcing and a random external signal, it can then exhibit stochastic resonance, whereby the system undergoes noise-induced transitions from one state to another in synchronicity with the periodic external signal, even though the latter is not sufficiently strong to induce such transitions by itself. As a result, it is possible that small systematic variations in the external environment (superposed with a random component) trigger substantial transitions in the sediment sequences between a limestone-rich state and a limestone-poor one.

Abstract ID: 34265

Final Number: B44A-0076

Title: Greenhouse Gas Exchange from Sites Used as a Source of Vegetation Donor Material for Peatland Restoration

Presenter/First Author: Kimberley Robyn Murray, University of Waterloo, Waterloo,

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Co-authors: Andrea Borkenhagen, , , ; David J Cooper, Colorado State University, Fort Collins, CO; Maria Strack, University of Calgary, Calgary, AB, Canada

Abstract Body:

Horticultural extraction of peatlands converts them from carbon and greenhouse gas (GHG) sinks to sources. The moss layer transfer technique for peatland restoration may return the GHG sink function, but requires a source of vegetation donor material. This technique may also be incorporated into fen construction projects following oil sands extraction. Collecting this donor material creates an additional disturbance, often in a previously undisturbed peatland, and the recovery of these “donor sites” and the impact on their GHG emissions is unknown. We monitored growing season GHG fluxes and plant communities on donor sites in an ombrotrophic bog and minerotrophic fen in Alberta, Canada from which material was removed between 1-6 year prior to the study and compared results to neighbouring undisturbed peatland.

Plant recovery on both donor sites was rapid with 70% and 120% total plant cover after two growing seasons at the fen and bog, respectively. Of this, moss cover also returned, reaching 83% cover after 5 years at the bog. On the other hand, the majority of undisturbed peatlands in western Canada are treed and tree recruitment on the donor sites remained low likely due to higher water tables resulting from the removal of surface material. The strong vegetation recovery led to a growing season carbon sink at the 5-year bog donor site. However, methane emissions were higher from both donor sites than undisturbed areas due to the high water table and large cover of sedges that colonized the sites.

Abstract ID: 36478

Final Number: B44A-0078

Title: From 10 Hz to 30 Minutes: Standardized Procedures for (Post)-Processing Eddy Covariance Measurements of the Taiga Plains Flux Tower Meso-Network in Northwestern Canada

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Abstract Body: Warming air temperatures and widespread degradation of permafrost in the Taiga Plains in northwestern Canada potentially alters biosphere-atmosphere interactions by modifying the net exchanges of greenhouse gases and energy. To enhance our understanding of the underlying biophysical and biogeochemical ecosystem processes, we are establishing a meso-network of four micrometeorological towers along a 1000-km permafrost gradient ranging from the sporadic/discontinuous permafrost zone experiencing continental climate to the continuous permafrost zone with a coastal climate. Identical low power-low maintenance micrometeorological instrumentation and standardized procedures for processing high-frequency measurements and for post-processing half-hour flux data are crucial to ensure consistency and inter-site comparability.

The open-path flux tower at the southern margin of permafrost is located in a highly heterogeneous boreal forest-peatland landscape. Detailed footprint analyses are conducted combining a 2D-footprint model (Kljun et al. 2002), landcover classification maps, and canopy structure information derived from high-resolution LiDAR data. In addition, to better interpret the mixed signal obtained form the heterogeneous landscape, a nearby shorter nested tower collects flux data from a homogeneous footprint within the heterogeneous footprint of the taller tower. With this contribution, we outline the development of standardized (post-) processing procedures for eddy covariance measurements across the evolving flux tower meso-network, highlighting the importance to incorporate site-specific conditions characteristic to different permafrost regimes (e.g., landscape heterogeneity).

Abstract ID: 35471

Final Number: B44A-0079

Title: Throughfall and Stemflow as Hot Phenomena of Biogeochemical Fluxes in Temperate Swamps

Presenter/First Author: Matthew Malone, University of Toronto, Mississauga,

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Abstract Body: The production of throughfall (TF) and stemflow (SF) is precipitation-driven and has been shown to acquire various plant leachates as these hydrologic fluxes pass through a tree canopy. Enrichment of TF and SF with dissolved organic carbon (DOC), nitrogen (N) and various other compounds increase the ability of these hydrological fluxes to bring chemicals, beneficial or potentially harmful, to the soils present under the vegetative canopy. TF and SF have the potential to induce hot phenomena upon reaching the soil below due to the biogeochemical pulses provided by them. This is especially true for SF, which has been proven to contain higher DOC and nutrient concentrations than precipitation (P) and TF and has preferential access to the soil matrix via the root system of the tree. This study presents the investigation of the biogeochemical fluxes of TF and SF during P events in two swamps of southern Ontario. These biogeochemical fluxes and resulting hot phenomena impact nutrient cycling, species composition and water quality in wetlands, with this study providing a unique look at these fluxes during the growing season in two temperate mixed-deciduous swamps. With the aid of this research, wetland conservation and management authorities can obtain important information regarding the fluxes of DOC and N species into temperate swamps, as well as the dissolved organic matter (DOM) character of TF and SF. The objectives for this study were to determine the quantity of DOC and N present in TF and SF and how they differ between different stands and different tree species. Additionally, an analysis of DOM character in TF and SF was performed to determine the amount of bioavailable organic material (relative molecular mass), aromaticity and fluorescence properties (fluorescence index, EEM’s, PARAFAC) of each.

Abstract ID: 36191

Final Number: B44A-0080

Title: Spatial and Temporal Variability of CO2, CH4 and N2O Emissions from the Soils of a Subtropical Mangrove Wetland

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Co-authors: Jiaxing Xu, The Chinese University of Hong Kong, Hong Kong SAR, Hong Kong

Abstract Body: The concept of "blue carbon" has received increasing attention recently, which points to the potential role of vegetated coastal wetlands in carbon sequestration. Yet, the magnitude and controls of greenhouse gas emissions from coastal wetland ecosystems, especially mangroves in the subtropical regions, are still largely unknown. In this study, we conducted chamber measurements in the Mai Po Marshes Nature Reserve of Hong Kong at monthly intervals to characterize the spatial and temporal variability of the emission of greenhouse gases, including CO_2, CH_4 and N_2O from mangrove soils, and examine the influence of environmental and biotic variables on greenhouse gas fluxes. We found the highest mean CH_4 and N_2O emissions in autumn and the highest CO_2 flux in summer. Along the tidal gradient, we observed significantly higher CH_4 and N_2O emissions from the middle zones and landward zones, respectively, while no clear spatial variation of CO_2 emissions was observed. There were significantly higher soil greenhouse gas emissions from sites dominated by *Avicennia marina* than those dominated by *Kandelia obovata*, which might be due to the presence of pneumatophores which facilitated gas transport. We found a significant, negative correlation between CH_4 flux and soil NO_3-N concentration, while CO_2 flux was positively correlation with total Kjeldahl nitrogen content. Soil temperature was positively correlated with the emissions of all three greenhouse gases, while water table depth was positively and negatively correlated with CH_4 and N_2O emissions, respectively. Our findings demonstrate the high spatial and temporal variability of greenhouse gas emissions from mangrove soils which could be attributed in part to the differences in environmental conditions and dominant plant species.

Abstract ID: 34330

Final Number: B44A-0081

Title: Changes of carbon fluxes and major carbon sources after palsa thawed into pond

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Abstract Body: Permafrost thaw is pronounced in peatlands across the discontinuous permafrost zone. Our research assesses the carbon (C) fluxes before and after palsa peatlands thaw. The terminal point of the thaw sequence is often thawed ponds, which is believed to be a major source of C gases to the atmosphere. At our study site in northern Quebec near Kuujjuarapik, the thawed ponds (~3 m in depth) were strongly stratified with thick anoxic hypolimnias from 0.5 m to the pond bottoms. The CO_2 flux and most the CH_4 fluxes from the ponds were positive to the atmosphere, while the palsas took up CO_2 and CH_4 for most of the growing season. The average seasonal C losses from the ponds were 9.46 mmol CO_2 m^{-2} h^{-1} and 1.69 to 2.00 µmol CH_4 m^{-2} d^{-1}. Over the summer larger pond had significantly higher CO_2 efflux, while the smallest pond had significantly higher CH_4 efflux. Bubble emission accounted a large part of pond CH_4 emission, with greater ebullition at the pond edges. The dissolved CO_2 and CH_4 concentrations increased ~ 10 fold from 10 to 50 cm deep, and more than 100 fold at 230 cm depth. The $\delta^{13}CH_4$ indicated CH_4 production shifted from acetoclastic methanogenesis dominated at the surface to CO_2 reduction dominated at the bottom. DOC mass and biodegradability (SUVA/FI) strongly correlated with pond C gas effluxes, suggesting pond surface DOC may be a C source supporting pond C gas effluxes. Comparing $\delta^{13}C$ of surface dissolved CO_2 and CH_4, DOC, peat, sediments, and plant litter & exudates, we determined that plant exudates was the main source of the labile DOC that decomposed into C gas fluxes. Palsa thaw to ponds leads to large CO_2 and CH_4 emissions, supported by newly produced labile DOC from the plant communities surrounding the ponds rather than the peat and pond sediments.

Abstract ID: 34366

Final Number: B44A-0082

Title: Methanotrophs Contribute to Peatland Nitrogen

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Published Material: Part of these findings were reported at AGU Annual Meeting in December 2014 and at EGU General Assembly in April 2014, and published in *Proceedings of the National Academy of Sciences USA*, but my presentation will include some new results that have not been reported previously.

Abstract Body: Atmospheric nitrogen (N_2) fixation is potentially an important N input mechanism to peatland ecosystems, but the extent of this process may have been underestimated because of the methods traditionally used inhibit the activity of methanothrophs. We examined the linkage of methane (CH_4) oxidation and N_2 fixation using $^{15}N_2$ technique. Dominant flark and hummock *Sphagnum* species were collected from twelve pristine peatlands in Siikajoki, Finland, which varied in age from 200 to 2,500 y due to the postglacial rebound. The mosses were incubated in a two-day field $^{15}N_2$ and $^{13}CH_4$ pulse labelling experiment and the incorporation of $^{15}N_2$ and $^{13}CH_4$ in biomass was measured with Isotope Ratio Mass Spectrometer. The rates of *Sphagnum*-associated N_2 fixation (0.1-2.9 g N m^2 y^{-1}) were up to 10 times the current N deposition rates. Methane-induced N_2 fixation contributed to over 1/3 of moss-associated N_2 fixation in younger stages, but was switched off in old successional stages, despite active CH_4 oxidation in these stages. Both the N_2 fixation rates and the methanotrophic contribution to N_2 fixation during peatland succession were primarily constrained by phosphorus availability. Previously overlooked methanotrophic N contribution may explain rapid peat and N accumulation during fen stages of peatland development. Reference. Larmola T., Leppänen S.M., Tuittila E.-S, Aarva M., Merilä P., Fritze H., Tiirola M. (2014) Methanotrophy induces nitrogen fixation during peatland development. *Proceedings of the National Academy of Sciences USA* 111 (2): 734-739.

Abstract ID: 33115

Final Number: B44A-0083

Title: Experimental Studies on Nitrogen Compounds Fate and Transport in Groundwater Systems -Impacts of Wastewater Irrigation

Presenter: Indumathi Manivannan Nambi, Indian Institute of Technology Madras, Chennai 600036,

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Abstract Body: Abstract: Inorder to meet the water demand by population growth and urbanization, many countries started using untreated or partially treated wastewater for irrigation, groundwater recharge, landscaping and other purposes. On the other hand, the use of nitrogen-based fertilizers in agriculture has helped to feed millions of people but it's also disrupted the nitrogen cycle, and resulted in nitrate contamination in groundwater creating various health issues. A scientific investigation on the nitrogen dynamics in the subsurface, its sources, sinks, transformations and transport is essential to device proper wastewater reuse strategies and to ensure safe groundwater. The major nitrogen transformation process in soil like adsorption, chemical and biological transformations namely nitrification and denitrification, plant uptake and others will control the final release of nitrates into the groundwater. Therefore, it is very important to study the fate and transport of nitrogen species from fertilizer and/or wastewater irrigation in order to predict the spatial and temporal distributions of concentrations in the vadose zone and groundwater. In this aspect, experimental evidences are needed to quantify the individual reaction rates of all the processes by batch and bench scale column studies. The data from batch experiments will be used to propose a mathematical model for simulating the processes of nitrogen dynamics spatially and temporally in real scenario. Finally, a comprehensive, replicating the field conditions will be helpful in validating the model and thereby applying it for predictions, scenario analysis and guidelines development for wastewater irrigation and fertilizer management.

Keywords: Nitrogen compounds, Transport, Biotransformation, Nitrification, Denitrification

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Abstract ID: 33157

Final Number: B44A-0084

Title: Use of Bioremediated Sewage Effluent in Constructed Wetlands for Fish Survival

Presenter/First Author: Kanwal Waqar, Organization Not Listed, Rawalpindi,

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Abstract Body: Use of Bioremediated Sewage Effluent in Constructed Wetlands for Fish Survival

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Abstract

Two fresh water fish species Tilapia (*Oreochromis mossambicus*) and Common Carp (*Cyprinus carpio*) were cultured to investigate the survival rate in bioremediated sewage effluent of Shehzad town, Islamabad, Pakistan. Two earthen ponds one with fresh water and second with bioremediated sewage effluent with dimension of 20×40 m were selected at Fisheries and Aquaculture Programme, NARC. Fish survival was investigated after fortnight sampling. Physicochemical parameters of bioremediated water were within permissible limit recommended for fish. Less than one percent survival was observed in bioremdiated water pond whereas 100% fish survival was recorded in fresh water pond. Further investigation and results showed the higher level of ammonical-nitrogen (NH4+-N; 31.08 mg/L), nitrate-nitrogen (NO3--N; 18.58 mg/L) and chlorides (Cl-; 39.61mg/L) in bioremediated sewage water that were main cause of fish mortality. Complete fish survival was recorded in bioremediated sewage effluent after phytoremediation with Coontail (*Ceratophyllum demersum*) plant that has potential of removing NH4+, NO3- and Cl- from sewage waste water. This study showed that this treated sewage water required further treatment for removal of NH4+-N, NO3--N and Cl- by using phytoremdiater Coontail (*C. demersum*).

Keywords: CRD; Ammonical nitrogen; Coontail

Abstract ID: 34964

Final Number: B44B-0085

Title: Effect of Water Table Fluctuations on the Fate and Distribution of *Escherichia coli* in a Freshwater Beach Environment: An Experimental Study

Presenter/First Author: Avid Banihashemi, University of Waterloo, Waterloo,

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Abstract Body: To investigate the role of water table dynamics on the distribution of *E. coli* in sandy lake beaches, an automated column system was used to simulate the effect of water table fluctuations. Four undisturbed cores were collected perpendicular to the shoreline at Burlington beach site in Ontario, yielding four sand columns. The water table regime in the columns was designed to mimic the dynamic water table fluctuations observed at variable distances from the shoreline. The columns were inoculated with a naturally occurring nalidixic acid resistant *E. coli* strain every 48 hrs. A one time inoculation of 1.0µm fluorescent microspheres as bacterial surrogates was also carried out. A mini-auger system was used to periodically retrieve small amounts of sand (< 1.0 g) from the columns, hence making it possible to monitor changes in the *E. coli* concentrations. Changes in pore water composition were monitored by collecting water with micro-Rhizon samplers from different depths of the columns. The experiment ran for 35 days in total and at the end of the experiment, the columns were sliced and analysed for microspheres, *E. coli* and solid phase chemistry. High level of *E. coli* and microspheres were observed at the top of the columns. By the end of the experiment, only less than 5% of the total *E. coli* introduced to the columns reached 25cm deep below the sand surface. These results suggests that in-situ depth distributions of *E. coli* in beach environments are strongly controlled by the input and transport properties of the bacteria. Nitrification occurred more intensively at the layers of sand columns with higher *E. coli* concentrations under aerobic conditions controlled mainly by water table fluctuations. This can be explained by *E. coli* aging and subsequent die-off releasing organic N in the sand.

Abstract ID: 35002

Final Number: B44B-0086

Title: Hydrochemistry, $^{18}O/^{16}O$ and $^{2}H/^{1}H$ Ratios of Groundwater and Surface water in Raya Valley, Northern Ethiopia.

Presenter/First Author: Merhawi GebreEgziabher GebreMichael, Addis Ababa University, Addis Ababa,

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Published Material: Ayenew, T., GebreEgziabher, M., Kebede, S., & Mamo, S. (2013). Integrated assessment of hydrogeology and water quality for groundwater-based irrigation development in the Raya Valley, northern Ethiopia. Water International, 38(4), 480–492. doi: 10.1080/02508060.2013.821640.

Abstract Body: The uses of groundwater for irrigation, domestic supply and livestock water is increasing in the Raya Valley. Raya valley has been affected by recurrent draught and famine in few years back. Recent, study shows that the groundwater potential of the study area is high. The volcanic aquifer and alluvial aquifers are the host geological formation to hold and transmit groundwater.

In this study, we used the application of isotope hydrology and hydrochemistry to understand the possible interconnections between groundwater with surface water. A total of 128 water samples were collected from groundwater, river, swamp, lake and rainfall. Most of the groundwater samples from volcanic aquifers are characterized by fresh, low salt content and depleted isotopic composition, however, the low-lying alluvial aquifer is characterized by high dissolved chemical constituents, high salt content and enriched isotopic composition. A moderate salt content and slightly enriched groundwater samples are found from the foot of the escarpment, showing possible groundwater mixing. Almost all of the groundwater samples are plotted just below Local Meteoric Water Line, which indicates the groundwater origin is meteoric origin and undergoes significant evaporative fractionation prior to recharge.The surface water shows distinct physiochemical, hydrochemical and isotopic values. The average stable isotopes values for Lake Ashenge samples were found to be 4.27 ‰ for δ18O and from 29.23 ‰ for δ2H. Lake water sample plotted below the LMWL and shifting toward the right this shows the lake undergoes high level of evaporation.

The local evaporation line for Lake Ashenge (LEL) is constructed based on isotopic data and given as δ2H = 5.16 δ 18O + 8.5 with regression coefficient of 0.89. The LEL crosses the LMWL at the isotopic values of 1‰ in δ2H and -1.5 ‰ in δ18O. This input signal indicates the dominant groundwater inflow from the lake is from the groundwater and local rainfall. The slight enrichment of the input signal relative to the mean precipitation in the study area could be evaporation of river flowing toward lake during rainy season. The Isotopic signature for the Gerjale wampy water, which supports a lots of ecological fauna and flora, indicates the principal source from the local perched aquifer.

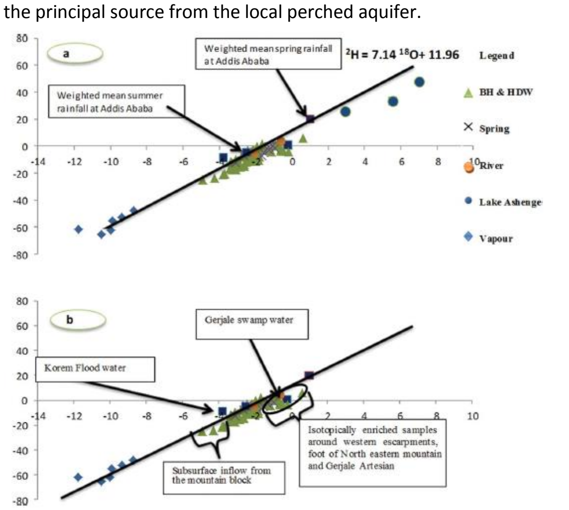

Figure 4. (a) Isotopic compositions of all water samples with weighted mean spring and summer rainfall. (b) Plot of concentrations of deuterium (δ^2H) and oxygen-18 ($\delta^{18}O$) isotopes for groundwater samples classified based on isotopic value.

Abstract ID: 34323

Final Number: B44C-0087

Title: Temporal Redox Fluctuations in Sediments: Pulsed Phosphorus Loadings in Freshwater Marsh Systems?

Presenter/First Author: Chris Thomas Parsons, University of Waterloo, Waterloo,

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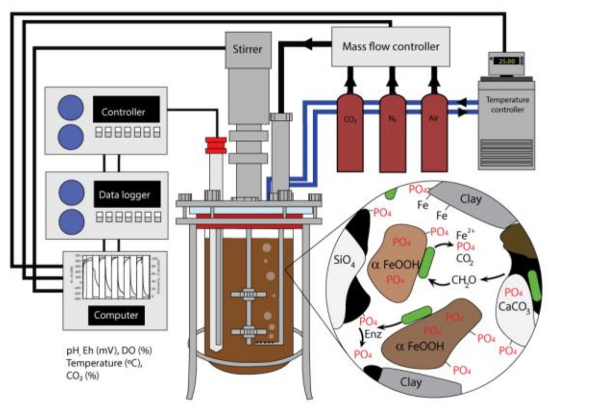
Abstract Body: Phosphorus concentrations in many surficial wetland sediments have increased substantially over the last century due to excessive anthropogenic loading of phosphorus to surface water. Wetland sediments are also often subject to rapidly oscillating redox conditions, driven by bioturbation or fluctuating dissolved oxygen concentrations in surface water. We used *in situ* mesocosms, alongside bioreactor sediment suspension experiments, to evaluate the effect of short temporal redox fluctuations on sedimentary phosphorus speciation and mobility in Cootes Paradise, a hypereutrophic coastal marsh which drains into Hamilton Harbour.

Results from bioreactor experiments show that repetitive re-oxidation of surficial wetland sediment (0-15cm) results in rapid degradation of organic phosphorus species (P_o) in autochthonous algal material to orthophosphate. Therefore, there is little accumulation of P_o in sediments (P_o = 13% of total sediment P). Despite enhanced extracellular phosphatase activities under oxic conditions (e.g. phosphomonoesterase activity of 2.4 mmol hr^{-1} kg^{-1}), maximum phosphorus mobilization occurs during reducing conditions due to a strong metal oxide control. Reductive dissolution of iron oxides under anoxic conditions results in the reversible redistribution of iron oxide bound P to other solid phase pools and the aqueous phase.

Preliminary *in situ* mesocosms suggest that diurnal cycling of dissolved oxygen concentrations, controlled by photosynthesis and respiration, does not exert a strong influence on internal phosphorus loading to surface water. This is due to excessive nitrate concentrations (~200 µM) in surface water which inhibit iron reduction at the sediment water interface during short periods of water column anoxia and prevent pulsed phosphorus release.



Abstract ID: 34530

Final Number: B44C-0088

Title: Impact of soil freezing and thawing dynamics on greenhouse gas emission and nutrient fluxes

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Abstract Body: Freezing and thawing is an abiotic stress applied to soils that affect the physical properties, biogeochemistry, microbial activity, and the rates of carbon and nitrogen cycling in soils. A better mechanistic understanding of how freezing and thawing influences soil respiration, greenhouse gas emissions, and leaching of nutrients to groundwater is needed to predict how soils will respond to climate change. To enhance this understanding, a highly instrumented soil column experiment was designed to realistically simulate freeze-thaw dynamics under controlled conditions. This approach combines the acquisition of integrated physical, chemical and microbial data collected periodically from different depths in which time-dependent, vertical temperature profiles are generated that mimic temperature distributions in real soils under freeze-thaw conditions. In this presentation, we focus on soil-specific physical, chemical, microbial factors (e.g. redox conditions, respiration, fermentation) and the mechanisms that drive greenhouse gases emission and nutrient cycling in soils under freeze-thaw cycles. The results indicate that changes in the soil microbial community and activity, driven by the fluctuations in temperature and oxygen availability, together with the recurrent development of a physical barrier preventing exchange of gaseous compounds between the soil and atmosphere during freezing conditions, modulate the time-dependent release of greenhouse gases from the soil surface. In other words, both physical and biogeochemical processes regulate the belowground soil carbon and nitrogen allocation and respiration during the alternating frost and thaw periods.

Abstract ID: 35481

Final Number: B44C-0089

Title: Carbon isotope signature of CH_4 and CO_2 as a tool to unravel diagenetic pathways in lake sediments

Presenter/First Author: Francois Clayer, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Québec, QC

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Co-authors: Anja Moritz, Concordia University, Montréal, QC, Canada; Yves Gelinas, Concordia University, Montreal, QC, Canada; André Tessier, , , ; Charles Gobeil, INRS-ETE, Quebec, QC, Canada

Published Material: A part of these findings were reported at the 17th Annual Chemistry and Biochemistry Graduate Research Conference at Concordia University, Montréal.

Abstract Body: In aquatic sediments, methane (CH_4), a potent greenhouse gas, is produced through the microbial breakdown of organic matter (OM) once sulfate is depleted, and can be consumed by aerobic and anaerobic oxidation (methanotrophy). It is well known that methanotrophy as well as methanogenesis, i.e. acetate fermentation (acetoclasty) and CO_2 reduction with H_2 (hydrogenotrophy), are processes that modify the carbon isotopic composition ($\delta^{13}C$) of CH_4 and CO_2 contained in the sediments. To unravel methane diagenetic pathways in the sediments of an oligotrophic and seasonally anoxic Canadian Shield lake, we determined high-resolution vertical profiles of dissolved CH_4 and CO_2, as well as their $\delta^{13}C$. The concentration profiles of CH_4 and CO_2 were modeled, using a one-dimensional transport-reaction equation, to constrain the depth-intervals (zones) where these species are produced or consumed in the first 25 cm of the sedimentary column, and to estimate their net production/consumption rates in each of the zones. The comparison of CH_4 and CO_2 net reaction rates enables us to constrain, in each zone, rates for acetoclasty, hydrogenotrophy, methanotrophy and OM fermentation. Then, fitting the measured $\delta^{13}C$ profiles with those simulated by a steady-state transport-reaction model allows us to clarify the relative contribution of acetoclasty and hydrogenotrophy. The model takes into account the constrained rates and established isotope fractionation factors reported in the literature for all the above-mentioned processes. We conclude that nearly 100% of CH_4 was produced by hydrogenotrophy following the non-fractionating fermentation of humic substances to CO_2 and H_2.

Abstract ID: 36073

Final Number: B44C-0090

Title: Geochemical Behavior of Cadimum during Early Diagenesis in Tidal Sediment from the Shuangtaizi Estuary, China

Presenter/First Author: Baolin Liu, China University of Geosciences Beijing, Beijing,

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Co-authors: Yongsheng Nie, , ,

Abstract Body: A sediment core and pore-water samples were taken in the Shuangtaizi Estuary for a study on early diagenesis in sediment and its influence on geochemical behavior of cadimum. Sulfate, Fe and Mn ions in the pore-water were analysed to better understand the depth ranges and reactions related to the early diagenesis. In addition, three different types of sulfur, acid volatile sulfur (AVS), pyrite sulfur (PS) and elemental sulfur (ES), and their transformations during early diagenesis were also studied.

<span"> Results showed that low concentrations of both sulfate and organic carbon have occurred between 0-30cm depth of the sediment core, suggesting a reaction between sulfate and organic carbon. The concentration of ES is lower than its detection limitation between 0-25cm, as well as the low concentration of AVS, which is consistent to high PS content in this depth interval, suggesting the production of pyrite will lead to the reduction of ES and AVS. With the reaction between sulfate ion and organic matter, hydrogen ion content in the pore-water also increased accordingly, resulting in a decrease of pH value in the pore-water, and suggesting an influence of early diagenesis. A low concentration of dissolved cadimum ion occurred in the pore-water at a depth interval from 0 to 30cm, while total cadimum concentration in the sediment reached its maximum in this depth interval, indicating that cadimum in the pore-water has been absorbed on the surface of mineral particle and/or combined with the Fe/Mn oxides in the sediment. High percentage of exchangeable cadimum speciation reinforced this presumption. Exchangeable cadimum was the dominant phase in the sediment (57.6%), followed by Fe/Mn oxides phase (25.9%), residual phase (12.5%) and organic/sulfide phase (4.0%).

<span"> Correlation, cluster and factor analysis showed that cadimum is mainly originated from weathering of rock on land. The absorption of clay mineral, Fe/Mn oxides in the sediment and pH values variaton in the pore-water are main influencing factors for the mobilization,migration and transformation of cadimum in sediment. Total diffuse flux of cadimum in the sediment is 0.042 mgm-2a-1. Almost 50% of cadimum in the sediment is redissolved into pore-water and another 50% cadimum is deposited or adsorbed on the surface of solid sediment.

EDUCATION

Abstract ID: 33072

Final Number: ED14A-0116

Title: Does Science Improve The General Public Information? The Example of Preparedness Actions For The Seismic Risk in Martinique (FWI).

Presenter/First Author: Jean-Christophe Audru, ACFAS, Montreal, QC

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Published Material: Audru J.C, Vernier J.L., Capdeville, B., Salindre, J.J. and Mouly É. (2013)–Preparedness actions towards seismic risk mitigation for the general public in Martinique, French Lesser Antilles: a mid-term appraisal. Natural Hazards and Earth System Sciences 13, 2031-2039

Abstract Body: Martinique is a French Overseas island of the Lesser Antilles archipelago; it straddles the subduction of the North American plate beneath the Caribbean plate. This geodynamic position implies a high seismic hazard, and several strong intensity events have hit the island in the past until the recent 2007 earthquake (Mw = 7.4 and EMS98 int.VI–VII). Since 2006, Martinican stakeholders involved in seismic safety formed the "Réplik" ("Aftershock" in French) working group; it includes state and regional councils representatives, mayors, architects, geoscientists, civil defense and consultants specialized in media, communication and social psychology. This poster presents a mid-term appraisal of the seismic awareness campaigns organized by the Réplik group from 2006 to 2011, and how it has modified, or not, the public education and preparedness to a high magnitude earthquake.
Despite efforts from the Réplik team to improve its efficiency through surveys, a growing gap is noted between the reported awareness and the actual preparedness of the public. As observed elsewhere, gender, age, educational level, then boredom and saturation contribute to this discrepancy; strong cultural items probably also influence the perception of actions. To remain efficient, to respond to security standards and to public's expectations, Réplik actions must evolve: consideration of religion and local beliefs, comprehensive messages on TV and radio featuring families, use of Creole language, participatory experiences and drills, with only a little bit of science. So that, the Réplik campaign can hope to increase the Martinique public's efficiency and involvement into the preparedness process.

Abstract ID: 35263

Final Number: ED14A-0117

Title: Interactive Mapping of Mars (iMARS): A New Interactive Online Educational Resource

Presenter/First Author: Gordon Richard Osinski, University of Western Ontario, London, ON

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Co-authors: Melissa Battler, , , ; Tanya N Harrison, Malin Space Science Systems, San Diego, CA; Eric Pilles, University of Western Ontario, London, Canada; Haley M Sapers, University of Western Ontario, London, ON, Canada; Livio L Tornabene, University of Western Ontario, Washington, ON, Canada

Published Material: iMARS has been presented at two conferences in the past year.

Abstract Body: One of the major goals of The Centre for Planetary Science and Exploration (CPSX; http://cpsx.uwo.ca) at The University of Western Ontario is to strengthen and grow the Canadian and international space community through inspiring and training the next generation of scientists and engineers. With funding from the Natural Sciences and Engineering Research Council (NSERC) of Canada's PromoScience program and support from the Department of Earth Sciences at Western, the CPSX has developed a new web-based initiative called Interactive Mapping of Mars (iMARS). The centrepiece of the iMARS program is an interactive online activity in which users conduct and eventually plan missions to the Mars. To do so requires an understanding of the various landforms or features that shape the surface of Mars. iMARS integrates learning about the surface of Mars with the mission planning so that knowledge is gained in a fun and immersive way. Upon creating a simple login, users plan a series of series of increasingly complex mission scenarios, be-ginning with "Search for Ancient Riverbeds". Users collect badges along the way for successful completion of individual missions (Fig. 3). Ultimately, users are able to select and plan their own mission. Some key aspects are iMARS are: 1) users will learn the educational material as they go along, and earn rewards along the way; each mission will be designed to be only a few minutes long, to keep them interested and the missions as a whole will be designed to teach all of the surface features; they will get reward badges displayed in their user profile for accomplishments; after successfully accomplishing a number of missions, participants can design their own, with options including rover platform, etc. Training in image analysis and the recognition of landforms is provided through the Tutorial and Feature Example Pages. Once a mission is "launched," a mission control blog provides updates on the status of a mission and a "choose your rover" option provides the opportunity to unlock more advanced rovers by collaborating with other scientists and rating their missions.

Abstract ID: 36208

Final Number: ED14A-0118

Title: Twitter for Science Outreach: A Beginner's Experience of Communicating Fieldwork from a Remote Antarctic Glacier

Presenter/First Author: Trevor Williams, Lamont Doherty Earth Obs, Palisades, NY

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Co-authors: Rebecca Fowler, Lamont Doherty Earth Observatory, Palisades, NY

Abstract Body: Here we discuss the benefits of using Twitter to communicate the experience of doing geoscience fieldwork. Most of us will never visit Antarctica, but free social media tools, such as the micro-blogging platform Twitter, can increase understanding of the continent and research taking place there. In December 2014, a team of four from Lamont-Doherty Earth Observatory and Indiana University-Purdue University Indianapolis (IUPUI) spent three weeks based in Antarctica's remote Thomas Hills on a NSF-funded project to collect samples of rock debris from three of the region's major ice streams. We set up a Twitter account prior to the expedition with the aim of providing a window into the world of Antarctic science and fieldwork. Daily tweets, often with photos, shared the team's science activities, some of their initial findings, and a taste of life in Antarctica. An expedition hashtag, #AntarcticaG297, enabled Twitter users to follow along with the expedition narrative and ask questions. Photos and text were sent over a moderately reliable satellite phone data link and posted on Twitter by a communications officer at Lamont. This outreach initiative resulted in three outcomes: increasing awareness of the science goals and fieldwork with a broad audience of students, researchers, and the general public; facilitating dialogue between this audience and the scientists while they were at work in the field; and forging unexpected connections and collaborations with new colleagues in polar research.

Abstract ID: 35459

Final Number: ED14A-0119

Title: Creating Context for Learning About Minerals

Presenter/First Author: Erica Toni Williams, Retired, Maple Ridge,

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Abstract Body: Provincial science curricula tend to be disconnected theoretical and abstract little boxes, the complete antithesis of how we learn. An isolated Grade 7 Minerals unit will not lead to any significant learning of the connections with the multitudes of metal containing products that we use daily. We miss out the complex physics, chemistry and environmental issues of not just mining but of processing, extraction and refining of the metal, creation of alloys, of fabrication, pollution, recycling and community impact. At the end of the day we scratch our heads and continue with the same old practices of memorizing mineral properties, not realizing or understanding that by repeating traditional practices we are contributing to common disconnections with the bigger world.

Just attending a 3 h workshop on minerals for example will rarely lead to significant behavioral change in the classroom, as there will have typically been little contextual layering during the workshop process. Frequently the teacher goes away with an armful of goodies but on returning back to school my experience is that they just end up in a cupboard, and if they occasionally come out it is usually only to follow an isolated exercise in the textbook. The average teacher has not had a background of industrial processes through which they can embed context into their teaching. We have made little progress in trying to develop curricula that embed contextual multi-layered learning in our future populations. This in a time when some scientists are already deeply concerned about such issues as resource extraction, climate change and food supply in a world in which the population has increased 300% since I was born.

This session will describe a Grade 11 Science Unit focused on the processes by which common objects are made by developing a foundational approach to student understanding of the role of mineral resources in their daily lives. For evaluation each student had to choose a metallic object and present a report deconstructing how that object was made. Because of the lack of general print resources much of this research had to be done on line. For many students, it turned out to be a very powerful learning experience.

Abstract ID: 35832

Final Number: ED14A-0120

Title: Developing and Implementing Instruments for Measuring Scientific Reasoning Abilities using Online Intelligent Tutoring Systems

Presenter/First Author: Lev Horodyskyj, Arizona State Univ, Mesa, AZ

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Co-authors: Sanlyn Buxner, Planetary Science Institute Tucson, Tucson, AZ; Steven C Semken, Arizona State University, Tempe, AZ; Ariel D Anbar, Arizona State University, Tempe, AZ

Abstract Body: Evaluation of educational activities tends to focus on content knowledge, which is often relatively easy to evaluate. However, this is only one component of scientific reasoning and literacy. A student's inability to reason scientifically can be a result of high-level failures (linking concepts and building mental models), but can also be a result of low-level failures (basic literacy and numeracy). Different student difficulties require different interventions to help students succeed and ultimately improve scientific literacy in general education science courses, whether they are online, in-person, or hybrid.

Habitable Worlds is an introductory level online-only astrobiology lab course that has been offered at Arizona State University since Fall 2011. The course is built and offered through an intelligent tutoring system, Smart Sparrow's Adaptive eLearning Platform, which provides in-depth analytics that allow the instructor to investigate detailed student behavior, from time spent on question to number of attempts to patterns of answers.

Analysis of multiple semesters of course data has revealed deficiencies in lesson design, which have informed subsequent redesign efforts. Yet despite significant gains in content knowledge, we have failed to make gains in students' high-level concept comprehension. There are many points of failure between basic information and true concept comprehension, which we are currently not tracking. We are aiming to develop and will discuss our formal definition of scientific reasoning and literacy, its components, and metrics we can use to measure component competencies. This will allow us to develop a suite of generalized tools and activities that can be deployed in any context that can score a student's abilities in various core competencies before, during, and after a course to determine course effectiveness as well as provide instructors with deep insight into problematic skills for individual students.

Abstract ID: 34961

Final Number: ED32A-02

Title: Science at Phoenix ComiCon: Connecting with a Science-Attuned Audience

Presenter/First Author: Lev Horodyskyj, Arizona State Univ, Mesa, AZ

Presenter/First Author Email: LevH@asu.edu

Co-authors: Sara I Walker, Arizona State University, Tempe, AZ; Jennifer H Forrester, University of Wyoming, Laramie, WY

Published Material: Concept of participating in a ComiCon and initial data were presented at AGU's fall meeting. 2015 programming details and more robust data interpretations will be presented here.

Abstract Body: The Phoenix ComiCon (PCC) is a rapidly growing annual four-day pop culture event, featuring guests, costuming, exhibits, and discussion panels for popular sci-fi, fantasy, horror, and anime franchises. The 2014 show, which drew 77,818 attendees, featured 30 hours of science programming, which were coordinated and organized by Horodyskyj. Programming consisted of discussion panels, mixers, and signature events on topics ranging from planetary sciences to biotechnology to artificial intelligence. Activities were staffed by industry specialists, early career and established scientists, and STEM outreach enthusiasts.

Some panels were surveyed to determine audience reception of the scientific topic and panel scientists. Preliminary results indicate that the audience who attended the science programming were enthusiastic about science and walked away with an extremely positive impression of the presenting scientists. Attendance at science panels was statistically indistinguishable from non-science panels, indicating that "science" was as big a draw for the attending audience as *Star Trek*, *Doctor Who*, or *Game of Thrones*. Anecdotally, a number of attendees, panelists, and PCC management tracked down Horodyskyj and other scientists to praise the science programming, some even months after the convention ended. For some attendees, the science programming was their exclusive reason for attending the PCC.

PCC and other events like it provide a unique opportunity for scientists to connect with a science-attuned audience through pop culture. Public outreach at these events may not convey deep content knowledge, but may be useful in connecting enthusiasts more deeply with the scientific endeavor and scientists themselves.

Abstract ID: 36751

Final Number: ED32A-03

Title: Geoheritage Recognition in Canada and its Role in Defining Global Geoparks

Presenter/First Author: John Calder, Organization Not Listed, Halifax,

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Co-authors: Godfrey Nowlan, , ,

Abstract Body: As biotic creatures, humans do not intuitively connect with the abiotic world of geology. Here lies the eloquent power of the concept of geoheritage, the best vehicle for bridging this fundamental divide. At the core of a successful and impactful geoheritage strategy is a methodically developed list of geoheritage sites, one that can be universally applied across the provinces and territories of Canada. The purpose of a geoheritage list is to build public awareness of their geologic heritage and its influence on a region's cultural history. Geoheritage provides the best vehicle for geoscientists to engage the public, to help people better value geology and the role of geoscience in our lives, including two great issues facing humanity: i) access and limits of mineral and energy resources, by increasing public awareness of the connections between our cultural heritage and geology; and ii) better understanding of current and future global change by consulting the geologic record. The concept of geoheritage was given form in Digne, France, in 1991, in the eloquent Déclaration Internationale des Droits de la Mémoire de la Terre. Early on, the concept was embraced primarily in Europe, where it fueled the explosion of European Geoparks. The Global Geoparks Network has now become truly international, and here in Canada is receiving growing interest from communities seeking truly sustainable, community-based economic development. Geoparks and geoheritage are linked, but are not synonomous. Geoheritage establishes the intrinsic value of a region of sites, and requires the deep knowledge of geoscientists. Global Geoparks draw their identity from those established values to draw people to the region. A well-founded list of geoheritage sites is therefore key to identifying prospective Global Geoparks and in defining a strong, identifiable theme that embues a specific Geopark with unique character that will also serve interpretation and marketing. As interest in candidate Global Geoparks grows across Canada, the need for systematic inventory of geoheritage sites is pressing.

Abstract ID: 34202

Final Number: ED32A-04

Title: The Climate Voices Science Speakers Network: Connecting to Communities Through Non-partisan Conversations about Climate

Presenter/First Author: Kristin Wegner, University Corporation for Atmospheric Research, Boulder, CO

Presenter/First Author Email: kwegner@ucar.edu

Co-authors: Cynthia Schmidt, University Corporation for Atmospheric Research, Boulder, CO

Abstract Body: Scientific reports such as the National Climate Assessment (NCA) and the Intergovernmental Panel on Climate Change (IPCC) influence politics and inform the public about current scientific findings. But how can the general public connect with scientists to decipher this climate science research? And how can climate science research be used as a catalyst to meaningful community dialogues about climate change? Over the past two years, our Climate Voices Science Speakers Network (climatevoices.org) has grown to a robust network of nearly 400 speakers across the United States. In this presentation, we will discuss the various ways we have approached community groups, ranging from working with grassroots groups to establishing and fostering regional partnerships. We will present our processes of engaging in conversations with faith-based, service organizations, and general interest education groups to better understand how to meet the diverse needs of audiences. We will also share samples of techniques employed by our speakers, as well as some of the resources and "climate science coaching sessions" we provide to our network.

Abstract ID: 33068

Final Number: ED32A-05

Title: Digital Tools for Teaching and Learning about Non-renewable Resources in the K-12 School System

Presenter/First Author: Eileen Van der Flier-Keller, University of Victoria, Victoria, BC

Presenter/First Author Email: fkeller@uvic.ca

Co-authors: Tim Pelton, , , ; Leslee Francis-Pelton, , ,

Abstract Body: Earth science topics are identified in school curricula in most jurisdictions in Canada. In addition, many informal education environments such as museums and youth groups include Earth science in their exhibits and activities. Formal and informal educational settings can both provide accessible environments for Earth scientists to engage with communities to share their passion for Earth science. Societally relevant earth science topics are diverse and include natural hazards, global change, non-renewable resources, energy, surface processes, and water. In many Canadian communities non-renewable resources are particularly relevant, providing important common ground for communicating about Earth science.

Building on hands-on activities and resources for engaging the public with non-renewable resources, we have developed a suite of digital tools which can be used in the classroom or in informal education settings to teach young people about non-renewable resources. The resources "Mining in BC: Interactive Map", "Canada Resources Map App", "Household Minerals App", and "Materials in a Bicycle App" have been presented and tested with teachers and informal educators, and modified based on their input. Comparisons will be made between the responses of teachers, and their students, to more traditional hands-on activities as compared with the digital resources. Benefits and drawbacks of these different delivery modes as mechanisms for engaging local communities with Earth science include variable access to good rock and mineral specimens in different educational environments, level of technology support and resourcing in schools, teacher comfort levels with Earth science topics, background materials available, and support from experts.

Abstract ID: 33265

Final Number: ED32A-06

Title: EARLY WARNING SYSTEMS FOR CLIMATE CHANGE RELATED HAZARDS

Presenter/First Author: Asha Mutenyo Sitati, United Nations Environment Program, Nairobi,

Presenter/First Author Email: asha.sitati@unep.org

Published Material: The work was presented during the AGU Conference in San Francisco in December, 2014

Abstract Body: Early warning systems are a tool with which to minimize risks posed by climate related hazards. Although great strides have been made in developing early warning systems most deal with one hazard, only provide short-term warnings and do not reach the most vulnerable. This presentation will review research results of the United Nations Environment Programme's CLIM-WARN project. The project seeks to identify how governments can better communicate risks by designing multi-hazard early warning systems that deliver actionable warnings across timescales. Household surveys and focus group discussions were conducted in 36 communities in Kenya, Ghana and Burkina Faso in order to identify relevant climate related hazards, current response strategies and early warning needs. Preliminary results show significant variability in both risks and needs within and between countries. For instance, floods are more frequent in rural western parts of Kenya. Droughts are frequent in the north while populations in urban areas face a range of hazards - floods, droughts, disease outbreaks - that sometimes occur simultaneously. The majority of the rural population, especially women, the disabled and the elderly, do not have access to modern media such as radio, television, or internet. While 55% of rural populace never watches television, 64% of urban respondents watch television on a daily basis. Communities have different concepts of how to design warning systems. It will be a challenge for national governments to create systems that accommodate such diversity yet provide standard quality of service to all. There is a need for flexible and forward-looking early warning systems that deliver broader information about risks. Information disseminated through the system could not only include details of hazards, but also long-term adaptation options, general education, and health information, thus increasingly both capabilities and response options.

Abstract ID: 34414

Final Number: ED32A-07

Title: What We Think About - When We Try Not To Think About - Global Warming: The New Psychology of Climate Science Communication

Presenter/First Author: Per Espen Stoknes, Norwegian Business School, Oslo,

Presenter/First Author Email: per.espen@stoknes.com

Published Material: Energy Research and Social Sciences (2014)
DOI: 10.1016/j.erss.2014.03.007

Abstract Body: Climate science has provided ever more reliable data and models over the last 20–30 years, thereby indicating increasingly severe impacts in the coming decades and centuries. Nonetheless, public concern for climate change and the issue's perceived importance has been declining over the past few decades, thus giving less public support for ambitious climate policies. Conventional climate communication strategies have failed to resolve this "climate paradox." This presentations reviews research on the psychology of the climate paradox, and rethinks and presents new original strategies for how to resolve it in the coming decades.

Understanding human responses to climate change is now at least as urgent as understanding climate change itself. The time has come for a climate science communication that works with, rather than against, human nature. The new strategies are social, positive, and simple—making climate- friendly behaviors easy and convenient. This presentation gives an evidenced based overview of the social psychological barriers and connected solutions to overcome them.

Abstract ID: 35363

Final Number: ED32A-08

Title: The Ivory Tower of Song: Science and Live Arts Performance

Presenter/First Author: Sarah MB Beatty, McMaster University, Hamilton, ON

Presenter/First Author Email: beattysm@mcmaster.ca

Abstract Body: Science literacy is an important part of a well-functioning science culture. Community outreach helps to connect science and scientists with a wider public audience and nurtures science culture. Connecting, however, can be uniquely challenging for both scientists and the public; even when science literacy is high. Popular science publications, primetime television, and internet sources work directly or indirectly to communicate science concepts, discoveries and news to a broad public audience with equally broad interests. While useful in generating consumable science content, these mediums may sanitize the experience, limit the ability to engage, and fail to surmount underlying science literacy development needs – particularly in adults. Performing artists have a long history of presentation to audiences with diverse backgrounds. While the sciences and humanities are often considered disparate or culturally segregated subjects, many scientists are also performing artists (storytellers, comedians, musicians, dancers, thespians), presenting either professionally or in an amateur capacity. Such art practices already serve to communicate human experiences for artists and arts consumers, however, there is an opportunity to utilize these forms to 1) humanize and communicate contemporary science topics and concerns, and 2) increase interaction among science practitioners and the wider public.

Over the course of 100+ live performances, as a songwriter and a scientist, I have used music as a medium to communicate science and engage communities. By combining performance principles, artistic practice, and science language in an informal (non-institutional) setting, my work has facilitated discussions around complex scientific topics and personal science histories, while fostering meaningful interactions between scientists and the wider community. In doing so, science, particularly geoscience-based concepts have become more accessible, engaging, participatory, and transferrable in adult audiences that I interact with. In this presentation I will share personal anecdotes, examples, and relay practical insights on effective strategies that help to entertain, passively educate, and fully engage broad audiences through science songwriting and live arts performance.

Abstract ID: 36234

Final Number: ED34A-0091

Title: Mineral Project Disclosure on Web Sites and Corporate Presentations: The CSA's Perspective

Presenter/First Author: Luc Arsenault, Organization Not Listed, Montreal, QC

Presenter/First Author Email: luc.arsenault@lautorite.qc.ca

Abstract Body: L'Autorité des marchés financiers, the body mandated by the Quebec government to regulate the province's financial markets, will presents in this talk the requirements of *National Instrument 43-101 Standards of Disclosure for Mineral Projects ("NI 43-101")* as they apply to mining company websites and corporate presentations.

The knowledge and command of NI 43-101 is indispensable for any person working with mining issuers be it as a director, officer or as a geologist or engineer acting as qualified persons which mandate may include the review of an issuers' technical information.

The objective of this talk is to improve your knowledge of the NI-43-101 requirements in order to avoid situations where regulators are require to ask for the restating of previously filed documents.

Abstract ID: 34364

Final Number: ED34A-0092

Title: Quality control: An indispensable mindset in professional geosciences

Presenter/First Author: Réjean Réjean, Geoscientists IOS Services Inc, Saguenay, QC

Presenter/First Author Email: rejeang@iosgeo.com

Abstract Body: Implementation of a quality control program (QAQC) in exploration and mining project is a compulsory requirement in regard of NI 43-101 regulation. The necessity of this requirement is easy to understand considering the capital requirement of any of these projects, the inacceptable failure rate and the general lack of understanding of the consequences of errors by geoscientists. Brief review of NI-43-101 technical reports indicates that for most geoscientists, QAQC is merely synonymous of assays control. However, the rigorousness of data acquisition and verification is a process which needs to encompass any data acquisition, from drill core description to structural measurement. As example, calculating a resource, the ultimate geologist professional act, requires the multiplication of a volume, a density and a grade. While any NI 43-101 report describe extensively the controls on assays, description of the controls on density measurements are near inexistent. Error propagation needs to be understand, as well as the consequences of total error build-up on the decision making process. Thus, quality control shall be a mindset to any geoscientist, and shall be implemented to all level of data acquisition. Geoscientist must be educated regarding how errors are generated, both by human and machine, and how to test for and quantify these. Examples of catastrophic failures caused by minute errors will be presented.

Abstract ID: 34910

Final Number: ED41A-01

Title: Investigating Geoscience Competencies for a Better-Prepared Future Workforce

Presenter/First Author: Heather R Houlton, American Geological Institute, Alexandria, VA

Presenter/First Author Email: hrh@agiweb.org

Co-authors: Michael Solem, , , ; Christopher M Keane, American Geosciences Institute (AGI), Alexandria, VA; Jamie Ricci, American Geosciences Institute, Alexandria, VA

Published Material: Some of these findings have been previously presented at AGU Fall Meeting 2014, GSA Annual Meeting 2014

Abstract Body: Competency-based education has been moving slowly beyond its roots in business and medicine and into STEM (Science, Technology, Engineering and Mathematics) disciplines. With the retirements of the Baby Boomers, and current and projected job growth, according to the Bureau of Labor Statistics (BLS), the American Geosciences Institute (AGI) estimates that there will be a deficiency of nearly 135,000 geoscientists by 2022, in the United States. Employers and recent graduates are consistently reporting critical gaps between degree outcomes and initial workforce readiness, which further complicates addressing the emerging talent gap. Starting to investigate and adopt competency-based education to aptly prepare our graduates with the practical skills needed to meet workforce demand is becoming an imperative for the geosciences. The National Science Foundation (NSF) awarded funding to AGI and the Association of American Geographers (AAG) to investigate what competencies are being taught by faculty, learned by students in non-PhD preparatory Master's programs, and in turn compare those to what employers currently in the geoscience workforce indicate as important to their careers. The project is titled Geoscience Career Master's Preparation Survey (Geo Career MaPS). This presentation will describe the results from this study and how AGI and AAG are using these data to help departments and administrators prepare students.

Abstract ID: 36011

Final Number: ED41A-03

Title: Keeping Our Members Engaged and Informed – AIPG's Successes and Challenges

Presenter/First Author: Robert A Stewart, American Institute of Professional Geologists, Thornton, CO

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Abstract Body: AIPG is an international organization, with nearly 8,000 members, of which about 3,000 are students and young professionals. This demographic split is very significant in terms of how AIPG can best serve all its members, and to do so, AIPG must stay in touch with them. Traditionally, AIPG relied on its journal, ***The Professional Geologist (TPG)***, to inform the membership of news and events. With the advent of the Internet and online publishing, plus financial pressures, the publication frequency of TPG (issues per year) dropped from 10 in 2003 to four in 2014. AIPG established its eNews in 2013, which has been popular in its own right, without duplicating the contents of TPG. AIPG contemplated discontinuing the print version of TPG altogether; however, print media are recovering in popularity, due partly to the blizzard of online information leading to an overwhelmed audience. The print version of TPG has also been an excellent marketing "take-away" at conferences and trade shows.

Over the past decade, AIPG has developed a variety of programs to attract and engage our student members and also young professionals in their early careers, based on our student chapters. AIPG's programs for students have been highly successful due to the efforts of our established members, who volunteer their time to organize field demonstrations of geologic tools for field sampling and analytical testing, and trips to observe the practice of geology at mines, quarries, environmental restoration sites, and other venues. Also popular are conferences and colloquia dealing with professional practice and geoethics, allowing younger members a chance to discuss such matters with practitioners an informal basis. Of specific interest to students and practitioners are the disciplinary procedures and sanctions that may affect geologists through government licensure or private certification, such as the Certified Professional Geologist (CPG) granted by AIPG. Although the subject matter varies, all events have proved thoroughly rewarding to our younger participants and older volunteer members.

The key to these successes is the generosity of our volunteers, which is also one of our greatest challenges – finding the volunteers. With age comes a wealth of experience, an invaluable asset to be shared with future geoscientists.

Abstract ID: 35410

Final Number: ED41A-04

Title: Are Professional Geoscientists Equipped to Assume their Social Responsibilities?

Presenter/First Author: Jan A. Boon, Carleton University, OTTAWA, ON

Presenter/First Author Email: jboon@nrcan.gc.ca

Abstract Body: The social responsibility of organizations is to take responsibility for their social impacts on society, which requires that their employees are capable of acting in a socially responsible manner. This should apply especially to professional employees. Most of the problems on which professional geoscientists work have a social dimension, for example social conflicts may develop in relation to mineral exploration, groundwater, civil engineering, baseline geochemical studies and other projects. In all cases, there is significant potential for conflicting expectations and conflicting understandings, and often the actors involved adhere to widely different value systems. As earth underpins all human activity and has an important influence on cultural and social beliefs and practices it is not surprising that geoscientists' work frequently exposes them to social issues and associated struggles.

Are geoscience professionals ready to take responsibility for their social impacts on society? Much anecdotal evidence from my field of study (mineral exploration) suggests that while there are examples of stellar performance, there seem to be many more examples of lack of awareness and understanding that led to serious but avoidable problems. The Geoscientists Canada document "The Geoscience Knowledge and Experience Requirements for Professional Registration in Canada" makes no reference to social responsibility and scant reference to "geoscience and society". In view of this it is lamentably improbable that geoscientists' studies have prepared them to face social situations. Many risk making social mistakes that cause anxiety and grief to members of society and that can be very costly to their employers.

An impressive body of knowledge in Corporate Social Responsibility (CSR) has been developed and it is time to incorporate this treasure of knowledge into the education and capacity building of geoscience professionals, and into their professional profile. The Canadian Institute of Mining and Metallurgy (CIM) has established a Working Group to promote this concept for both engineers and geologists. It has been more difficult to "get this show on the road" than initially anticipated and any advice is appreciated.

Abstract ID: 36035

Final Number: ED41A-05

Title: Quality control: An indispensable mindset in professional geoscience.

Presenter/First Author: Réjean Réjean, Geoscientists IOS Services Inc, Saguenay, QC

Presenter/First Author Email: rejeang@iosgeo.com

Abstract Body: Implementation of a quality control program (QAQC) in exploration and mining project is a compulsory requirement in regard of NI 43-101 regulation. The necessity of this requirement is easy to understand considering the capital requirement of any of these projects, the inacceptable failure rate and the general lack of understanding of the consequences of errors by geoscientists. Brief review of NI-43-101 technical reports indicates that for most geoscientists, QAQC is merely synonymous of assays control. However, the rigorousness of data acquisition and verification is a process which needs to encompass any data acquisition, from drill core description to structural measurement. As example, calculating a resource, the ultimate geologist professional act, requires the multiplication of a volume, a density and a grade. While any NI 43-101 report describe extensively the controls on assays, description of the controls on density measurements are near inexistent. Error propagation needs to be understand, as well as the consequences of total error build-up on the decision making process. Thus, quality control shall be a mindset to any geoscientist, and shall be implemented to all level of data acquisition. Geoscientist must be educated regarding how errors are generated, both by human and machine, and how to test for and quantify these. Examples of catastrophic failures caused by minute errors will be presented.

Abstract ID: 36748

Final Number: ED41A-06

Title: SHOULD PROFESSORS TEACHING GEO STUDENTS TO BECOME P.GEO.'S, BE P.GEO.'S THEMSELVES?

Presenter/First Author: Gord White, Association of Professional Associations of Ontario, Toronto, ON

Presenter/First Author Email: gwhite@apgo.net

Abstract Body: Across Canada, Professional Geoscientists are regulated in ten jurisdictions. Through Geoscientists Canada, a set standard of general knowledge and experience requirements are set. This standard is accepted through all jurisdictions – to be accepted in one is to be accepted in all. This is a common approach with many professional designations in Canada.

It is also common in Canada and elsewhere that students are taught by accredited professionals for many of these professional designations. Lawyers to be are taught by lawyers. The same goes for engineers and doctors. These professions would see it as contraindicated to not have a licensed professional teach the next generation.

This is not the case for geoscientists. At least not in Ontario. Few Professional Geoscientists instructing tomorrow's P.Geo.'s are actually P.Geo.'s.

Issues to be discussed:

- Is it important that professors teaching geo students to become P.Geo.'s be P.Geo's?
- If it is important, how do can this issue be resolved going forward?
- Is there common ground between those that regulate Professional Geoscientists and those that train them?

The purpose of this session is to open this discussion, seek out different points of view, and purposely set a directional course. Opinions welcomed.

Abstract ID: 35095

Final Number: ED41A-07

Title: Geoscience Knowledge Requirements for Professional Registration: A 2015 Primer for Undergraduate and Graduate students as to the Use of the GKE Document

Presenter/First Author: Kevin Michael Ansdell, University of Saskatchewan, Saskatoon, SK

Presenter/First Author Email: kevin.ansdell@usask.ca

Co-authors: Cliff Stanley, , ,

Abstract Body: A goal for many geoscience (geology, geophysics, environmental geoscience) students in Canada is to become a Professional Geoscientist (PGeo) in order to practice as a licensed professional.

Requirements for professional registration are tabulated in the "Geoscience Knowledge and Experience Requirements for Professional Registration in Canada" (GKE). This document, developed by the Canadian Geoscience Standards Board, a committee of Geoscientists Canada (GC), provides a comprehensive summary of the foundation and elective science and geoscience curricula and work experience considered to be appropriate background for licensure as a PGeo. This presentation outlines how regulators across Canada use this document, which will be of interest to students. In addition, information will be provided on a recent project undertaken by GC designed to outline the skills or competencies that a PGeo should have by the time of registration. This may include the completion of a particular course or set of courses during a B.Sc. program; others may be demonstrated via specific work experience.

The fundamental assumption in the GKE is that geoscience knowledge is gained through the equivalent of a 4-year BSc. degree in Canada, which includes 9 courses in "foundational" science (e.g. chemistry, physics, mathematics), and 18 courses in specific "foundational geoscience" subjects. In Quebec, the provincial regulators have accredited the programs at Laval, McGill, UQAC, and UQAM. Elsewhere, there is no formal accreditation process and so local regulators develop a list of courses that are available in their province that cover the required areas. This set of courses is used as a check list for each individual applicant. Students who might not have majored in geoscience, but who have taken the necessary courses can satisfy the requirements for registration. Also, part of the time in a graduate program may count towards the geosciences experience requirement for registration.

Abstract ID: 33579

Final Number: ED42A-01

Title: Course Promotion for Ethics, Culture and Community-based Research for Graduate Student Training.

Presenter/First Author: Dianne P Quigley, Brown University, Wrentham, MA

Presenter/First Author Email: Dianne_Quigley_1@brown.edu

Published Material: Quigley, D. (2013) Promoting Human Subjects Training for Place-based Communities and Cultural Groups in Environmental Research – Curriculum Approaches for Graduate Student/Faculty Training. , *Science and Engineering Ethics*, Springer Science+ Business Media Dordrecht 2014 Under Review at Journal of Environmental Studies and Sciences: " Research Ethics and Cultural Competence Training for Environmental Research with Place-based Communities and Cultural Groups: Reflections from a Collaborative University Partnership Dianne Quigley, PhD, Adjunct Assistant Professor, Center for Environmental Studies, Brown University, Providence, RI* David A. Sonnenfeld, PhD, Professor of Environmental Studies, State University of New York College of Environmental Science and Forestry, Syracuse,NY Phil Brown, PhD, Distinguished Professor of Sociology, Northeastern University, Boston, MA Linda Silka, PhD, Professor of Community Psychology, University of Maine, Orono, ME Linlang He. Graduate Assistant, Brown University Qing Tian, Graduate Assistant, Brown University Under Review at Society for Natural Resources. Cultural Competence/Humility Applied to Environmental Sciences, Diann Quigley

Abstract Body: Abstract for Course Promotion for Ethics, Culture and Community-based Research for Graduate Student Training.

The Northeast Ethics Education Partnership (NEEP), at Brown University has developed course syllabi and curriculum materials for two new graduate courses in Ethics, Culture and Community-based Research for Environmental Studies/Sciences and Marine Science Ethics. NEEP is funded through the National Science Foundation (NSF) Ethics Education in Science and Engineering (EESE) Program. NEEP has developed short and long graduate courses and Certificate Training for research ethics, cultural competence, community-based research for environmental studies/sciences at Brown University, SUNY-ESF, Northeastern University and UMASS-Dartmouth. Additionally, NEEP has developed ethics courses for engineers at the above universities.

We would like to share our new course syllabi and PowerPoint training materials with other research scientists/teaching faculty to gain feedback on critical ethical challenges facing environmental sciences/studies and marine sciences for field research in place-based communities and with cultural groups. It is part of our NSF grant objectives to disseminate our work on training graduate students. We can provide an overview of our training emphases and a selection of these slide shows: individual/group human subjects protections, cultural competence for working with communities, informed consent with cultural groups, community-based research, environmental justice, ethics of sustainability, environmental ethics and research integrity in these various geosciences. This presentation can include critical reasons for conducting ethics training for graduate students who will conduct field studies in place-based communities so that researchers will maximize beneficence, reduce research risks/harms, allow commuinity consulation and partnership approaches and mimimize exploitation and unfair burdens/benefits.

Abstract ID: 35015

Final Number: ED42A-02

Title: A Pilot Study: Integrating Ethical Issues to a Physical Geology Course

Presenter/First Author: Catherine Pappas Maenz, Dawson College, Montréal, QC

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Abstract Body: There is a strong consensus amongst science educators that inclusion of ethics in sciences is necessary for the development of students into science professionals and well-rounded citizens. We need also to realise that science is changing rapidly, not only in its research techniques and organisational structures but also in its relationships with society at large. Overall ethical issues are either lacking or not sufficiently introduced in most geoscience courses. Undergraduate students should be adequately trained in ethics either within their earth science courses or in a specialized course elsewhere in the curriculum. The author is part of a working group involved with developing geo-ethical resources for geosciences. A pilot study was conducted at Dawson College using a new approach for teaching physical geology by integrating an ethical dimension to an existing physical geology course. This initiative incorporated case studies and class discussions to stimulate students to think creatively and critically about ethical issues emerging from a variety of geological topics. The primary objective being to increase students' awareness of ethical issues and dilemmas in many areas concerned with geology. The discussions and case studies were introduced during a two-hour "laboratory" period. The longer class period allowed students to watch a short video followed by a short discussion, or read through a short case study followed by small group discussions. The focus was on understanding the differing viewpoints of individuals within a case and identifying multiple courses of action for resolving the issue. The results of the ethics component to the existing course curriculum were assessed via a student survey. All students agreed that their awareness of ethical issues in earth science was enhanced by the inclusion of ethics and that there is a great need to include ethics in geology.

Abstract ID: 35958

Final Number: ED42A-03

Title: Connecting pedagogy to geology and ethics

Presenter/First Author: Anne Marie Ryan, Dalhousie University, Halifax,

Presenter/First Author Email: amryan@dal.ca

Co-authors: Carl-Georg Bank, University of Toronto, Toronto, ON, Canada

Abstract Body: The interface of ethics and geoscience, **geoethics**, links the science of geology directly with its societal responsibilities and connections. In a recent study the authors asked anonymous participants to suggest ways to teach geoethics in an undergraduate program. Responses varied from some suggesting that geoethics is not the perview of academic studies in geology, to those regarding it as an important aspect to include in the undergraduate curriculum. This latter group offered a variety of approaches for how best to achieve this. Among the suggestions raised were: use of case studies (either within a dedicated course or integrated into other courses), role-play, a course co-taught by experts from different disciplines, a series of seminars or workshops, use of professional ethics criteria as a starting point, and integration of ethics into specific courses such as mineral deposits or environmental geoscience courses. However, to be effective, it is not sufficient to simply link the geologic with the societal: it is important to also consider the pedagogical aspects of geoethics. The way in which we teach geoethics is crucial to effectively incorporating and encouraging geoethical behavior into disciplinary practice in its various forms. We review guiding principles to consider, both in terms of learning stages as well as content to include. These considerations involve: the development of decision-making skills, the fostering of critical thinking approaches to problem-solving, the importance of developing courage, open-mindedness, and tolerance for ambiguity, the significance of being cognizant of the societal implications of our science, and the concept of our own responsibility in working for the greater good.

Abstract ID: 34829

Final Number: ED42A-04

Title: Seeking Community Input to a Modular Course on GeoEthics

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Published Material: This author group presented a poster at the AGU Fall Meeting 2014 describing the idea of developing a modular course on geoethics. This presentation focuses more on our efforts to solicit input from the geoscience community related to that course. The overlap is primarily in the initial description of the course we are developing.

Abstract Body: Communities are defined in many ways: kinship, culture, common interests, shared sense of purpose, a common understanding of behavioral norms. The geoscience community is no different. Given the dynamic nature of the geosciences, ours is a vibrant community whose intellectual progress benefits all humankind.

It is the persistent responsibility of members of this community to articulate and share our ethical norms with students who are developing as geoscientists. It is also essential to help them develop an ability to assess and critically evaluate those values. There are enough examples of unethical choices made by geoscientists to warrant a more deliberate effort to promote the ethical development of geoscientists while they are still students.

We are engaged in a project to develop, test and make available educational resources to help geoscience students develop into ethical members of our community. We intend to develop these resources across the spectrum ranging from very compact activities (texts, discussion prompts, videos, writing projects) that might take just a few minutes of class time, all the way up to an entire course on geoethics. We recognize that shorter activities are easier to assimilate into existing courses throughout the geoscience curriculum, but we also recognize the utility of developing activities that might take an entire class period, or multiple classes, or a week or more. We plan to develop modules of 1-3 week duration on a variety of topics in applied geoethics that can be combined to form an entire course.

Our most important task at present is to gather input from members of the geoscience community about their ethical concerns. What ethical lapses seem to be common? What ethical issues are most important because of the significance of their effects? We learn from our mistakes, so we seek case studies that involve ethical choices by geoscientists. We recognize that there are ethical issues that are specific to particular segments of our community (participants in higher education and academic research, various types of applied geologists, regulators). These are no less important because they might not be universal. Accounts of ethical problems and concerns, provided to us by the broader geoscience community, are essential if we are to develop resources that are relevant to current practice.

Abstract ID: 34539

Final Number: ED42A-05

Title: Aldo Leopold, Deep Time, and the Ethics of Geoscience

Presenter/First Author: Gary David Rosenberg, , ,

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Published Material: Another aspect of this presentation was delivered orally at GSA Vancouver. That presentation focused on the evidence for Aldo Leopold's interest in deep time, but it did not focus on deep time as the basis of the ethics of geoscience and the consequence for the ethics of the science as a result of the diminishment of historical geology in the geology curriculum. None of this has yet been submitted for publication in a scientific journal.

Abstract Body: The concept of deep time is central to geoscience and its ethical concerns. The geologic record indicates that natural resources formed long ago over time spans vastly exceeding the lifespan of civilizations, under conditions that may no longer be extant, and in limited abundance that is never uniform among or within nations. Further, extracted resources are often out of equilibrium with, hence labile in and hazardous to, the existing environment that differs from the primordial environment in which the resources formed.

In other words, geologic history explains why natural resources are limited, non renewable, subject to depletion, and their use is not sustainable. The question is how to reconcile our need for them with the lessons of geological history?

Aldo Leopold raised this question in his book (1949), "A Sand County Almanac." His complaint was the excessive commodification of natural resources. He found the rationale for environmental stewardship in the evolution of the Earth and life. He could not have been more explicit about the ethics of deep time when he wrote that in our appreciation of geologic history "lies objective evidence of our superiority over the beasts."

Appreciation for deep time needs to be instilled in students from the start of their geology curriculum and reinforced throughout because it takes years to internalize and then apply to a career reconciling needs with geological realities.

Unfortunately, historical geology has become marginalized in the curriculum. Historical classes are disappearing and the enrollments have plunged. Consequently publishers are reluctant to produce historical texts even for the majors curriculum. As though immersion in fundamentals and active participation in the process of historical thinking are no longer material to the science.

If geoscience forsakes historical geology it will forsake its unique contribution to ethics, beginning with environmentalism.

Abstract ID: 35325

Final Number: ED42A-06

Title: Global Geoscience Professionalism - The Importance of Building a More Connected Professional Community and The Role of Professional Geoscience Organizations in Supporting How Geoscientists Can Better Serve Society.

Presenter/First Author: Oliver Bonham, Geoscientists Canada, Burnaby, BC

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Co-authors: Ruth Allington, , ,

Published Material: This presentation has not been given, or published, before, but it will cover matters that are either public policy or matters that may already be in the public domain. It parallels, in-part, a related contribution submitted for presentation at the European Geosciences Union, General Assembly meeting in Vienna, in April 2015 (Allington and Fernandez).

Abstract Body: In 2012, the International Union of Geological Sciences (IUGS) formed the Task Group on Global Geoscience Professionalism ("TG-GGP") to bring together the expanding network of organizations around the world whose primary purpose is self-regulation of geoscience practice. TG-GGP was also formed to foster a new "connecting up" of geoscience globally, around the concerns common to academia, industry, and government service: competence, ethics and professional accountability.

This talk will briefly introduce TG-GGP and will summarize the status of self-regulation of geoscience around the World. It will describe established approaches to setting minimum professional standards and assessing practice competence, codes of ethics and conduct, and obligations of the professional in a number of settings. It will touch on mechanisms to handle complaints and impose professional discipline. It will also explore how the emerging academic study of geoethics might best inform, and be informed by, the promotion and support of competent, professionally accountable and ethical geoscience practice.

Codes of Ethics, to which all registered professionals are bound, incorporate such foundational tenets as: safeguarding the health and safety of the public, scientific integrity, and fairness. Codes also increasingly include obligations concerning welfare of the environment and sustainability.

While legal regimes for the oversight of professions differ around the world, principles of peer-based self-regulation universally apply. This makes professional organizations ideal settings for geoscientists to openly consider what Society should expect of us in the range of roles we fulfill. They also provide the structures needed to best determine what expectations, in the public interest, are appropriate for us to collectively impose on each other as fellow professionals.

Abstract ID: 34465

Final Number: ED42A-08

Title: Social Responsibility in Mineral Exploration - Lessons from Nine Case Studies

Presenter/First Author: Jan A. Boon, Carleton University, OTTAWA, ON

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Published Material: The AGU presentation is based on my Ph. D. thesis that I will defend soon. I have used bits of my thesis research in presentations at Argentina Mining and to general audiences in Buenos Aires at events organized by the Canada-Argentina Chamber of Commerce in cooperation with the embassies of Canada and Australia

Abstract Body: Nine case studies of mineral exploration projects in Canada, Mexico, Ecuador, Peru and Argentina were conducted, involving over 220 interviews of members of the various actor groups. The results were analyzed and interpreted using a sociological theoretical framework. It was found that relationships exerted a significant influence on the course of social events and on the perceived present and future benefits and harms of mineral exploration projects. Key concepts used included: meeting transactional needs; trust building; meanings; reference communities; identities and relationships. Relationships were successfully operationalized using the indicators trust; respect; communication; mutual understanding; conflict resolution; goal compatibility; balance of power; focus; frequency; stability; and productivity. These indicators clearly differentiated the cases. The "scores" on the relationship indicators resulted from the underlying processes: meeting transactional needs and implementing the trust building dimensions: visibility; sincerity and personalization; showing face; and establishing routines. A seven-stage generalized model was developed that describes the sociological processes leading to the development of relationship patterns and new social structures surrounding mineral exploration projects, and determining the course of social events and the perceptions of present and future benefits and harms. The processes at the core of the proposed model are: creating dialogue space that enables meeting transactional needs; developing relationships; and continual adjustment of meanings through interactions. It is argued that knowledge and application of these social aspects is essential to the overall success of an exploration project if not more so, than is detailed knowledge of the geology of an area and of hydrothermal alteration processes. While the present study focused on mineral exploration, similar observations would apply to many other areas in which the geosciences find application. Unfortunately the present accreditation criteria for geoscientists do not touch on social responsibilities.

EARTH SURFACE PROCESSES

Abstract ID: 33926

Final Number: ES11A-01

Title: Hydropower Influences on River Ice Dynamics and Channel Morphology: A Matter of Thermal and Flow Scales

Presenter/First Author: Robert Ettema, University of Wyoming, Laramie, WY

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Abstract Body: Hydropower development of a river raises questions regarding the influences of the development on ice dynamics and channel morphology in the river downstream: Will the development change ice dynamics in the river; if so, how? If the changes are substantial, how will the modify channel morphology of the river; if so, how? My paper addresses these questions and shows how these questions revolve around the relative scales of thermal and flow processes at the development site. In simple terms, the scales define the volume of ice formed in the river relative to the volume of water flow passing through the channel during winter. Hydropower may alter the relative magnitude of the two scales, typically doing so by changing the quantities of water and water-borne heat entering the channel during winter. At the extremes of a hypothetical gauge formed by the relative magnitudes of the two scales, hydropower exerts little influence on river ice processes and channel morphology, because the volume of water flow dwarfs the volume of ice formed (large river, lower latitude), or conversely the volume of ice dwarfs the volume of water flow (small river, higher latitude). However, hydropower shifts the relative scales of ice and water, moving river conditions to a more dynamic, middle region of the gauge. When such a shift occurs ice potentially becomes a more active agent in shaping channel morphology, as it affects the distribution of an erosive flow, and the flow in turn has sufficient force to drive ice against channel boundaries. The nature of the material forming channel boundaries plays a substantial role limiting the extent to which the river ice and water flow influence channel morphology. More resistant boundary material will withstand higher levels of abrasion by water flow and ice, while boundaries formed in alluvium and weak soils are less able to do so. My paper discusses the hypothetical gauge concept and suggests topics for research.

Abstract ID: 36080

Final Number: ES11A-02

Title: Defining the state-of-the-art cold regions river engineering practice with fluvial morphology concepts

Presenter/First Author: Benoit Turcotte, Organization Not Listed, Québec,

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Abstract Body: Cold region river engineers work in an environment that is rarely accurately defined in textbooks. In cold countries, the formation of ice at the drainage system scale can depress the downstream discharge by over 50%, hydro-production peaking can generate a river ice breakup event, frazil ice can block water intakes, about 30% of all flooding events are caused by ice, the development of an ice jam may cause the water level to rise faster than 1 m/min, and ice jam release events can generate flow velocities up to 10 m/s. From freezeup to breakup, multiple river ice processes directly affect sediment transport rates, sediment supply and the overall stability of cold region channels. Because hydraulic conditions can explain the occurrence of specific ice processes, it is logical that a retroactive link exists between such winter processes and the morphology of a channel. This link has been documented in recent years and it is now possible to predict how an ice cover will form along a given channel knowing its morphology and simple climate parameters.

The impact of this research advance on cold regions river engineering is significant. Indeed, understanding the retroactive link between ice processes and the channel morphology fills up a gap in the engineering practice because identifying potential ice cover formation and breakup patterns is the first important step towards (1) the efficient monitoring of river ice processes using field instrumentation, (2) the accurate simulation of river ice processes using numerical ice-hydrodynamic models (in which multiple parameters need to be imposed) and (3) the appropriate design of hydraulic structures (for flood protection, transportation, hydro production, water consumption, ice control, etc.) and floodplain infrastructures (flood resilient constructions, transport systems, etc.). In past decades, the overdesign, failure, low efficiency, or unexpected undesirable effect of hydraulic and floodplain infrastructures due to river ice processes could be excused by a lack of scientific knowledge. In a nearby future, with the advances now documented in this field, cold region river engineers will become liable for their designs and decisions. Fluvial morphology concepts undoubtedly represent an important piece of the state-of-the-art cold regions river engineering puzzle.

Abstract ID: 34244

Final Number: ES11A-03

Title: A Numerical Model for Ice Influenced Sediment Transport and Bed Change

Presenter/First Author: Ian Michael Wood Knack, Clarkson University, Potsdam, NY

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Co-authors: Hung T Shen, Clarkson Univ, Potsdam, NY

Abstract Body: The presence of surface ice has significant effects on sediment transport and channel morphology. Studies on the interaction of sediment transport and surface ice are limited although it can be a significant period of bed change for rivers in cold regions. An improved understanding of the interaction of surface ice and sediment transport processes is essential for river engineering and morphological studies. This paper presents a two-dimensional coupled hydro-thermal-ice-sediment river dynamics numerical model. The ice model component considers the dynamics of ice transport and ice cover evolution, as well as thermal processes. The thermal component includes water temperature, frazil ice, anchor ice, and the thermal growth and decay of ice cover. The sediment transport and bed change model considers the effect of surface ice and water temperature on sediment transport capacity. The sediment transport equations were developed from an analysis of data from existing flume experiments, each with a limited range of flow, ice, and sediment transport conditions. The analysis showed that by expressing the flow strength in terms of the bed shear stress, bed load transport can be described by conventional relationships for the equivalent free-surface flow. It was also found that suspended sediment transport rates can be calculated using a modified Rouse formulation which considers the effect of surface ice on flow velocity and diffusion coefficient. Examples of simulations using the numerical model illustrating the ice effects on sediment transport and bed changes in ice influenced alluvial channels are presented.

Abstract ID: 35063

Final Number: ES11A-04

Title: MODELING RIVER ICE DYNAMICS USING MIKE11-ICE

Presenter: Tristan Aubel, Lasalle | NHC, Montreal, QC

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First Author: Wael Taha, Northwest Hydraulic Consultants, Montreal,

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First Author Student?: No

Co-authors: Isabelle Theriault, , ,

Abstract Body: Over the past decade, the close collaboration between LaSalle | NHC, Hydro-Québec and DHI Water&Environment has led to the joint development of river ice modules for the MIKE11 hydrodynamic modeling package, which represents today a state-of-the-art hydraulic modelling tool of Nordic rivers. Two separate modules were developed, the first is for ice generation, transport and accumulation, while the second for formation of ice jams. The ice generation, transport and accumulation module couples the unsteady, one-dimensional St. Venant flow equations with river ice processes. It simulates ice formation in a stretch of river throughout an entire winter season. At every time step and at every point along the river, the model makes a full balance of thermal exchanges between the water, the atmosphere, and stationary or moving ice. The net balance between the gain and loss of heat brings about changes in both water temperature and frazil production that is used to compute the ice discharge – all within the context of the growth of border ice. Typical studies performed with this module are concerned with problems related to flooding due to the formation of hanging dams, water level increase due to the presence of ice in a river reach, ice accumulations on surfaces due to supercooling and the extents and thicknesses of the ice cover for snowmobiling. The second module is for modeling the formation of ice jams following the breakup of an ice cover. The module formulation is based on a stationary mechanical stability of the jam transverse sections, enabling to calculate the ice jam geometry at a specific location along with the resulting water surface elevation profile and velocities. The studies performed with this module cover essentially winter and spring flooding problems caused by ice jams. Typical applications are presented for both modules.

Abstract ID: 35588

Final Number: ES11A-05

Title: Tree rings as indicators of ice jam regimes, triggering conditions and geomorphological impacts : the case of the Mistassini River (Eastern Canada)

Presenter/First Author: Etienne Boucher, GEOTOP-UQAM, Montreal,

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Co-authors: Stephanie Morin, , , ; Annie Lagadec, , , ; Thomas K Buffin-Belanger, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada; Daniel Germain, , ,

Abstract Body: Tree ring records provide invaluable sources of information concerning river ice jam dynamics. They can help researchers rely on a robust spatio-temporal framework that facilitates the analysis of triggering conditions, frequency-magnitude relationships, and geomorphological impacts associated with such extreme events. Here, we provide field evidences that dendrochronological markers have contributed to shed light on river ice jam dynamics in the Mistassini River watershed (Eastern Canada). First, an exhaustive sampling of ice scars along the banks of this highly problematic river revealed that hydro-climatic conditions prevailing during both freeze-up and break-up periods have a tremendous influence on the triggering of river ice jams in the watershed. Based on such relationships with climate, a predictive classification model was constructed and accurately predicted 88% of the events that occurred in the Mistassini River since AD 1960. Second, dendrochronological surveys were coupled to an extensive geomorphological description of river banks. This allowed linking the occurrence and distribution of ice-induced landforms to the properties of the ice jam regime (mostly downstream changes in frequency – magnitude). Among other things, our analysis revealed that extensive ice-related erosion did not necessarily occur where ice jams were the most frequent, but is maintained where events had the greatest magnitude. Our works revealed that tree ring markers may provide a strong basis that can orient risk management strategies, particularly in context where observations of past ice jams are scattered, if not inexistent.

Abstract ID: 36782

Final Number: ES11A-06

Title: Under ice cover roughness and flow structure.

Presenter/First Author: Thomas K Buffin-Belanger, University of Quebec at Rimouski UQAR, Rimouski, QC

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Co-authors: Sylvio Demers, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada; Taylor Olsen, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada

Published Material: Data were presented at the ACFAS meeting in Montréal in 2012. The presentation was in french.

Abstract Body: Quantifications of under ice roughness and flow structure under an ice cover are scarce but relevant to analyse the effects of ice cover on flow dynamics and to validate flow modelling. This paper documents the turbulent flow structure and the under ice cover roughness on two gravel-bed rivers. An ADV was used to measure twelve velocity profiles under various types of ice covers. A clear double turbulent boundary layer appears in most velocity profiles with an increase in turbulent intensity near the ice cover. Upstream from each velocity profile, the ice cover was subsequently exposed and scanned using a terrestrial laser to quantify the ice cover roughness. The under ice covers reveal great variability of forms that promote various scales of roughness. Forms are described and roughness is quantified by semivariance analysis. The under ice cover roughness affects the flow properties. The location where the highest velocity is found is further away from the ice cover when roughness is high, but the ice cover shear stress is not related with the under ice cover roughness. Scenarios describing the turbulence dynamics and structure of the boundary layer are proposed and discussed in the light of roughness conditions encountered in this study.

Abstract ID: 36579

Final Number: ES11A-07

Title: Sediment Tracking Throughout the Winter and Spring Breakup in a Gravel-bed River

Presenter/First Author: Daniel Alexandre Bleau, University of Sherbrooke, Longueuil,

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Co-authors: Jay Lacey, , , ; Robert Leconte, University of Sherbrooke, Sherbrooke, QC, Canada; Normand Bergeron, INRS, Quebec, QC, Canada

Abstract Body: A field study was conducted on two different reaches of a gravel-bed river (Stoke River) located in the Eastern Townships, Québec, Canada. The study was performed to quantitatively assess the mobility of the bed sediments due to ice. At both sites, PIT tags were placed in the river bed and were tracked via a dual antenna system. Fixed antennas were placed in the river bed and were connected to a data logger in order to follow the tagged particles over the winter and spring breakup. To complement this system surveys were made with a mobile antenna in order to measure the exact movement of the particles. The redundancy of our methodology was useful to overcome the difficulties of surveying tagged particles during winter time. This was especially effective during the spring thaw, at a time where most rivers are too active to be surveyed. The fixed antenna recorded, though not as precisely as the mobile antenna, the time of arrival and departure of each moving marker. After the water level decline, surveys with the mobile antenna were performed to record the precise location and 3D displacement of the marker. The only downfall of the fixed antenna system is in order to gain more precision (denser grid), a denser fixed antenna system is required, along with a higher number of equipment (batteries, loggers, antennas, etc.) which are difficult to maintain at a sufficient power level during winter time.

Abstract ID: 34020

Final Number: ES11A-08

Title: Influence of Dynamic Ice Cover on Sediment Transport in an Alluvial Channel

Presenter/First Author: Soheil Ghareh Aghaji Zare, University of Ottawa, Ottawa, ON

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Co-authors: Stephanie Astrid Moore, University of Ottawa, Ottawa, ON, Canada; Colin D Rennie, University of Ottawa, Ottawa, ON, Canada; Ousmane Seidou, University of Ottawa, Ottawa, ON, Canada; Jarrod Malenchak, , , ; Habib Ahmari, , , ; Saber Ansari, , ,

Published Material: 1. 21 st Canadian Hydrotechnical Conference- 2013- Published2. IAHR congress - 2013- Published3. River Flow conference- 2014- Published4. IAHR Ice symposium- 2014- Published5. ASCE journal of Hydraulic Engineering- under review6. Journal of water resources researches - under review

Abstract Body: Dynamic ice cover alters flow in ice covered rivers by adding a new boundary to the top of the stream. River hydraulics vary as a function of ice cover presence and condition. Amongst the important hydraulic characteristics influenced by ice cover, velocity magnitude and distribution, water stage and boundary shear stress are particularly consequential. Variation of these parameters has potential to affect the channel morphodynamics and morphology due to changes in sediment initiation and transport. On the other hand, dynamic ice cover conditions throughout the winter restrict field studies and thereby limit most research to laboratories. Hence, despite the importance of ice cover processes on river morphodynamics, it is poorly studied in rivers. This research studies ice cover effects on river hydraulics and morphodynamics by *in-situ* field investigations using acoustic techniques. Utilization of acoustic instruments provides the possibility of continuous measurement of water velocity and stage throughout the winter period. A 1200 kHz Teledyne RD Instruments Acoustic Doppler Current Profiler (ADCP) and 546 kHz ASL Shallow Water Ice Profiling Sonar (SWIPS) were deployed simultaneously on a bottom mount at Lower Nelson River, Northern Manitoba for four months (March-June, 2012). Different stages of the ice cover, its thickness and associated variation in water velocity and stage are demonstrated based on acoustic data. Variation in sediment transport is also estimated based on backscatter intensity of the emitted sound which can be interpreted as the concentration of suspended sediment particles. Considerable effect of ice cover on river hydraulics and sediment transport, especially during the break-up period, is concluded from the results. Data illustrate that average velocity and sediment flux respectively vary by factors of 2 and 10 compared to the open water condition.

Abstract ID: 33854

Final Number: ES12A-01

Title: Characterization of Arsenic Species in Lake Sediments Surrounding Giant Mine, NWT.

Presenter/First Author: Martin Didier Van Den Berghe, Queen's University, Kingston, ON

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Co-authors: Heather E. Jamieson, Queen's University, Kingston, ON, Canada; Mike Palmer, , ,

Published Material: This presentation was first shown at the Yellowknife Geoscience Forum (Yellowknite, NT) in November 2014.It will also be presented at the Gananoque Environmental Engineering and Science Conference (Gananoque, ON) in February 2015.

Abstract Body: Giant Mine is was gold mine a few kilometers north of Yellowknife, NT that operated between 1948 to 1999. Roasting of arsenopyrite at Giant Mine released approximately 20,000 tonnes of arsenic aerosols to the environment from roaster stack emissions, 86% of which was released in the first 14 years of operations. Recent studies have shown elevated levels of arsenic in lake sediments beyond the boundary of the property, raising questions about their origin and associated risks to local ecosystems and public health.

The purpose of this study is to determine whether the arsenic present in regional lake sediments is of natural or anthropogenic origin, and whether these lakes act as a sink (capture) or a source (release) of arsenic in the overlying lake waters. This may be done by assessing the speciation of arsenic in both lake sediments and associated porewaters using dialysis arrays, major and trace elements analysis, synchrotron-based analysis, and advanced scanning electron microscopy. From there we can evaluate the relative stability of arsenic species in these different chemical media, and thus establish the long term trends of arsenic in the aquatic environment.

A field program was completed in July 2014 during which three local lakes were sampled downwind of the roaster stacks. These lakes offer a range of physical and chemical characteristics such as lake depth, organic contents and nature of substrate and immediate catchment. Focusing on these lakes will allow us to better constrain various physical and chemical parameters of lakes geochemistry in relation to arsenic mobility.

Preliminary results of this program indicate arsenic concentrations in sediment porewaters range from 80 to 1,600 parts per billion, consistently peaking 2-6 centimeters below the sediment-water interface. This might indicate a trend for arsenic to remobilize and migrate upwards through the sediment column after deposition. Whether this remobilized arsenic gets released into the lake water or gets trapped into a more stable mineral phase has yet to be determined.

Understanding the sources and behaviour of arsenic in such lakes is very important in understanding contaminated site attenuation and remediation efforts, helping constrain chemical behaviour of contaminants, and associated health risks to ecosystems and Human populations.

Abstract ID: 35597

Final Number: ES12A-02

Title: The Role of Mineralogical Research in Mine Site Characterization

Presenter/First Author: Jeanne B. Percival, Geological Survey of Canada, Ottawa, ON

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Co-authors: Alexandre J. Desbarats, , , ; Katherine E. Venance, , , ; Michael B. Parsons, Geological Survey of Canada, Dartmouth, NS, Canada

Abstract Body: Over the last decade, the GSC, under the Environment and Health Programs, has conducted research into selected ore deposits as a means to: characterize mineralogical and geochemical signatures; provide public geoscience knowledge for decision makers; and promote deeper understanding of mine sites to aid technical reviews of Environmental Impact Assessments for new mine sites. To date, studies have been completed on lode Au deposits in two different geological and geographic environments (Nova Scotia and British Columbia). Currently, studies are near completion on U-REE granitic pegmatites in central (Bancroft) Ontario. U, Th and REEs have been mined in the Bancroft region since the early fifties. Demand for these commodities is increasing and there is renewed interest in re-appraising the region for exploration and development. Several old mine sites were sampled (rock core, tailings, soils, stream/lake sediments, groundwater, radon) for detailed characterization. This presentation will focus on mineralogy and hydrogeology of the Croft Mine that was explored in the early fifties and again in the early seventies. Representative core samples include pegmatite and gneisses (amphibolite, metapelite, quartzofeldspathic). Samples consist of abundant plagioclase and K-feldspar with subordinate quartz, amphibole and biotite. The metapelite contains sillimanite, garnet and allanite. Minor to trace fluor-apatite was detected in one sample and several of them contain minor to trace calcite or dolomite. A variety of oxides (magnetite, hematite, ilmenite) and sulphides (pyrite, pyrrhotite, chalcopyrite) occur in minor to trace amounts. Sediment collected from the outlet of the adit reflects the overall mineralogy of the sampled pegmatite and gneisses. Characterization of the mineralogical signature (ore, gangue, alteration) at this site helps to constrain the mass transfer of U and other species to mine drainage using geochemical inverse modelling.

Although these studies are on abandoned mines, they have provided sites and samples to develop new methods for analytical, geostatistical, hydrogeological, mineralogical and geochemical characterization. Identifying the factors that control geological processes will contribute to the development of models for environmental risk assessment.

Abstract ID: 36824

Final Number: ES12A-04

Title: A Case Study using Stable and Radiocarbon Isotope Analysis as a Tool to Assess Biodegradation of Hydrocarbon Contaminants in Permafrost, Old Crow, Yukon

Presenter/First Author: Fiona D'Arcy, University of Ottawa, Ottawa, ON

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Co-authors: Bronwyn E Benkert, Yukon College, Whitehorse, YT, Canada; Liz Van Warmerdam, , , ; Ian Douglas Clark, University of Ottawa, Ottawa, ON, Canada

Published Material: Preliminary data presented in poster format at Arctic Change 2014 conference held in Ottawa, Ontario in December 2014.

Abstract Body: Old Crow is an arctic fly-in community located in northern Yukon along the banks of the Porcupine River. The village relies heavily on the use of fuel storage tanks to supply the motorized vehicles used in town, the daily airplane, and oil used for heating. All of the storage tanks are kept on a raised gravel pad located several metres from the banks of the river. Over the years, the land surrounding this tank farm has become contaminated with hydrocarbons which have leaked into the subsurface during daily fuel transfers. The clean-up of the site poses a significant challenge considering that the contamination extends into the permafrost, and natural bioremediation must be considered as an option. Natural attenuation of hydrocarbons through biodegradation can be recognized by carbon isotopes measured in the soil CO_2 which should incorporate the ^{13}C and ^{14}C signatures of any hydrocarbon being oxidized. Similarly, substrate consumption can be accompanied by a Rayleigh-type enrichment of ^{13}C in the residual hydrocarbons. Furthermore, the CO_2 created during biodegradation would contain no ^{14}C, which should be reflected in isotopic composition of the soil CO_2. In this experiment, soil gas samples as well as both active layer and permafrost cores containing the hydrocarbons have been collected from the site in order to sample CO_2. The $\delta^{13}C$ isotopic ratios and ^{14}C concentration in the carbon dioxide have been determined and show biodegradation occurring at the site. Microbial characterization of the active communities through microcosm and PCR techniques is recommended as a next step which will support these isotope studies. This method of assessing in-situ attenuation of hydrocarbons demonstrates natural bioremediation to be a viable treatment option in permafrost regions.

Abstract ID: 33071

Final Number: ES14A-0124

Title: Potential in using Field Portable Near Infrared Spectrometer for screening of sites contaminated with complexed iron-cyanides

Presenter: Thomas A Raab, BTU Cottbus, Cottbus,

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First Author Student?: No

Co-authors: Frank Repmann, , , ; Thomas Fischer, Brandenburg University of Technology Cottbus–Senftenberg, Cottbus, Germany

Published Material: These findings were published as: M. Sut, T. Fischer, F. Repmann, T. Raab and T. Dimi- trova, "Feasibility of Field Portable Near Infrared (NIR) Spectroscopy to Determine Cyanide Concentrations in Soil," Water, Air & Soil Pollution, Vol. 223, No. 8, 2012, pp. 5495-5504. doi:10.1007/s11270-012-1298-y.

Abstract Body: Importance of the industry in the world economic development has always been based on enhancing the economic welfare of citizens and supplying the material goods they consume. However, in this industrially careless race we often forget that intensive anthropogenic activity generates large amounts of waste material or by-products, causing a potential environmental threat. In recent times, when soil remediation has become of major importance, developing rapid and non-destructive methods for detection and screening of contaminants in-situ saves time and money. We would like to present our results concerning the novel application of a Polychromix Handheld Field Portable Near-Infrared (NIR) Analyzer to assess the cyanide concentrations in soil.

Iron-cyanide complexes have been observed at many industrial sites, either as an outcome of industrial processes or as an incident product. In this study, a calibration model was developed, using multivariate calibration algorithms, in order to determine NIR spectral response to the cyanide concentration in soil samples collected at the former Manufactured Gas Plant site. As a control, the contaminant concentration was determined using conventional Flow Injection Analysis (FIA). The experiments revealed that portable near-infrared spectrometers could be a reliable device for identification of contamination 'hot spots', where cyanide concentration are higher than 2400 mg kg^{-1} in the field and >1750 mg kg^{-1} after sample preparation in the laboratory, but cannot replace traditional laboratory analyses due to high limits of detection.

Abstract ID: 34197

Final Number: ES14A-0125

Title: The Use of High Resolution Characterization to Develop and Implement Site Remediation

Presenter/First Author: Rick McGregor, InSitu Remediation Services Limited, St George Brant, ON

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Abstract Body: Remediation of impacted sites can be challenging due to numerous factors including geologic heterogeneity which can result in complicated distribution of the compounds of concern. Remedial efforts to remediate these compounds of concern are often frustrated due to a lack of understanding of the geology, hydrogeology and geochemistry. Site specific factors such as geology, hydrogeology, geochemistry, contaminant distribution, etc. play important roles in controlling the design of any successful remedial program especially in situ based programs. Very few studies have been completed in the field to look at why in situ remedial programs have had mixed success.

A comprehensive field study was carried out at a site in Southern Ontario to evaluate the effect of various injection and delivery methods for three common oxidants; persulphate, percarbonate and hydrogen peroxide. The effect of the oxidant type and delivery method on the distribution and persistence of the oxidant within the subsurface was also examined. Delivery methods examined for each oxidant included direct push using drop points and side tools along with vertical wells. The results of the study indicated that the method of injection had a significant impact on the distribution at the site tested. The persistence of the oxidants were also evaluated and a large variability in persistence was noted between the three oxidants with percarbonate existing the longest within the subsurface followed by activated persulphate and hydrogen peroxide. These results suggest that the choice of oxidant and delivery method are key design parameters for any in situ remedial program.

Abstract ID: 33735

Final Number: ES14B-0130

Title: The Magha Caldera, its Local Inhabitants, and Related Landslides in Wabane, Cameroon

Presenter/First Author: Nkeze Atemnkeng, University of Buea, Kumba,

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Abstract Body: Magha is in a caldera of volcanic origin with hot springs, and is located near the Bamboutus Mountains in West Cameroon. It is in a humid tropical area, with steep slopes, visible earth fractures and continuous human activity where tilling the soils for agriculture and housing is common. These and other events such as earthquakes, soil texture, high and long lasting rainfall contribute in triggering the repeated landslides that have characterized this area and its surroundings in the past half century. In 2003 one of the deadliest landslide disasters in the area killed 21 inhabitants, and people smelled gas characteristic of gunpowder immediately following the incident. This suggests that renewed volcanic activity may be associated with the frequent landslide activities experienced in this part of the country. If this is true, then the people of Magha and Cameroon need to brace up for a greater disaster in the making. The loss of human life and farm land due to landslides is already so high that the area has been categorized as a major social and environmental problem region for its inhabitants.

Despite the topography of the Magha area, its very fertile soils have attracted many farmers in recent years. Farming is practiced throughout the year in valleys and even on very steep slopes.

Abstract ID: 33407

Final Number: ES14B-0132

Title: Turbulence characteristics in the approach flow of Piano Key Weir (PKW)

Presenter/First Author: Harinarayan Tiwari, Indian Institute of Technology Roorkee, Haridwar,

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Co-authors: Nayan Sharma, , ,

Abstract Body: Dams whose fail could cause loss of life or enormous assets injure are painstaking to survive a probable maximum flood (PMF), but the PMF in various locations has been amplified at regular intervals, resulting in spillways that no longer convene the proposed norms. Spillway rehabilitation is required for lots of dams in India; in order to get better hydraulic competence. Catastrophe in Uttarakhand & Jammu-Kashmir (June 2013 & August 2014) necessitates the research aspect of spillway rehabilitation. In recent years, a novel idea of Labyrinth weirs has been developed by means of a new shape, called Piano Key Weir. Piano Key Weir (PKW) is an innovative alternative of non-linear (labyrinth type) weirs that has a higher discharge capacity with a relatively smaller footprint. This alternative of Labyrinth weir provides an increase in the steadiness of the structure which can be positioned on the top of most existing or new diversion or storage dam structures. The PKW has a rectangular nonlinear weir crest layout (in planform), unlike traditional labyrinth weirs, the sloped floor in the inlet and outletcycles, referred to as keys, overhangs the apexes providing a longer crest length than a rectangular labyrinth weir, and several times to the transverse weir width. The Piano Key Weir doesn't have any gates. So it will involve very little operation & maintenance and would be very much cheaper than conventional dam spillways or barrage structure. Since in mountainous river of India, use of PKW may be promoted by answering the question of sedimentation behind it. As sediment from upstream normally moves downstream by flowing water, geographical features are changed and hydro-ecological habitats are subsequently affected. To support recovery of sediment continuity in rivers, the Piano Key Weir might be used as an alternative transverse structure. It needs the elemental sediment transport study in the approach flow PKW to point out the physical hydraulic characteristics. Since the sediment transport is linked with turbulence present in flow. This paper presents the experimental observations of the first and second order velocity profiles in piano key weir approach flow. Different turbulence characteristics including turbulent kinetic energy & turbulence intensity is also discussed in the paper.

Abstract ID: 33391

Final Number: ES14B-0133

Title: Neotectonic influence on geomorphology in the Gandak megafan of the Indo-Gangetic foreland basin, India

Presenter/First Author: Rudra Mohan Pradhan, Indian Institute of Technology Roorkee, Roorkee,

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Co-authors: Pitambar Pati, Indian Institute of Technology Roorkee, Roorkee, India

Abstract Body: Geomorphic evolution of any foreland basin is mainly controlled by spatial and temporal occurrence of tectonism and sediment inflow into it. The Indo-Gangetic foreland basin, bordered by the Himalayas witnesses rapid changes in geomorphology and sedimentation processes due to frequent subsidence and upliftment of the fault bounded tectonic blocks. The fluvial geomorphology of the basin is greatly controlled by this neotectonic process.

The Gandak megafan, a witness to the neotectonism in the Indo-Gangetic foreland basin records three distinct phases of shifting of course of the Gandak River due to eastward tilting of the megafan block. Post tilting surface faulting developed four terminal fans in different times. Temporal and spatial distribution of these depositional units contributed significant geomorphological changes on the megafan surface, particularly in the Gandak depression of the Indo-Gangetic foreland basin. The Oldest exposed part of the Gandak megafan shows gentle slope with numerous SW flowing small channels. However, the overlying subsequent terminal fans show south flowing channels with greater slopes. Localized sediment accumulation as terminal fans significantly modified the geomorphology of the megafan system. Surface faulting too modified the fluvial system in the region as down-thrown blocks show high drainage density and surface ponding which are generally not observed on the up-thrown blocks. Differential upliftment and subsidence divided the whole block into two distinct geomorphic entities i.e. uplands in the north and low-lying swampy area in the south. As the terminal fans are the indicator of surface faulting in the Indo-Gangetic foreland basin, these have been dated by OSL technique to work out the temporal faulting activities and the geomorphological evolution of the region. Satellite imageries since 1985-2005 show continuous growth of the younger terminal fans and gradual cover up the older units. This study highlights the role of neotectonism in geomorphological modification in the Indo-Gangetic plain.

Abstract ID: 33817

Final Number: ES14B-0134

Title: Reshaping of a Late Pleistocene Landscape by Human Activity in Northeastern Germany

Presenter: Thomas A Raab, BTU Cottbus, Cottbus,

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Co-authors: Anna Schneider, Brandenburg Technical University Cottbus, Cottbus, Germany; Klaus-Peter Wechler, , ,

Published Material: Raab, A., Takla, M., Raab, T., Nicolay, A., Schneider, A., Rösler, H., Heußner, K.U., Bönisch, E., 2014. Pre-industrial charcoal production in Lower Lusatia (Brandenburg, Germany): Detection and evaluation of a large charcoal-burning field by combining archaeological studies, GIS-based analyses of shaded-relief maps and dendrochronological age determination. Quaternary International, doi: 10.1016/j.quaint.2014.09.041.

Abstract Body: The North European lowland has been formed by glacial and periglacial processes in the Late Pleistocene. Multiple reshaping since the Late Glacial considerably changed the landscape up to and including especially historic times. Sediment sequences and (fossilized) soils can improve our understanding of Late Quaternary landscape development, but mapping of buried soils and surfaces is often limited to single outcrops. Ongoing archaeological rescue excavations in the pre-field of the open-cast mine Cottbus-Nord (northeastern Germany) with dense excavation trenches in an about 10 ha dune and drift sand area reveal multilayered sediment sequences with fossilized soils and sediments from the Late Pleistocene to the Late Holocene. Archaeological findings ranging from Paleolithic and Mesolithic flint stones to an about 200 year old ceramics in eolian sediments covering plow horizons and wheel tracks suggest that eolian relocation of sandy material was intensive about 200 years ago. Still unpublished OSL dating underline the intense eolian activity. Recent studies showed that between the 15Th to the 19Th century an iron smelter 5 km to the west of our study site was supplied with charcoal, which was produced in a forest 5 km east to our study site. Our current findings about Late Holocene eolian activity raise the question if this eolian reshaping of the landscape is connected with the operation of the iron smelter either directly by transport or bog iron ore winning or indirectly by population pressure caused by the prospering iron smelter. Our ongoing research indicates, that already for historic land-use off-site effects causing further landscape changes have to be considered.

Abstract ID: 33902

Final Number: ES14B-0135

Title: Optical Dating and Sedimentary Characteristics of Holocene Dunes on the South Shore of the Central St. Lawrence lowlands, Quebec, Canada

Presenter/First Author: Guillaume Thiery, GEOTOP-UQAM, Montréal,

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Co-authors: Martin Roy, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Michel Lamothe, GEOTOP-UQAM, Montreal, QC, Canada; Robert-André Daigneault, UQAM-Université du Quebec à Montreal, Montreal, Canada; François Hardy, UQAM-LUX-GEOTOP-Université du Quebec à Montreal, Montreal, Canada

Abstract Body: Systematic mapping of surficial sediments of the central St. Lawrence lowlands allowed the delineation of the distribution of the main Quaternary morpho-sedimentary systems. The surficial geology maps reveal the occurrence of large (multi-km) eolian sediment systems characterized by many convex parabolic dunes towards the SW. Although these sedimentary landforms cover substantial areas, uncertainties remain regarding their origin and age, as well as their stratigraphical significance within the global framework of the last deglaciation. Here we report sedimentological and chronological data from dunes located near the locality of Villeroy, Qc (NTS map sheets 21L05 and 21L12), in order to gain insights on their depositional setting and age. The distribution of these eolian features was mapped through the analysis of aerial photographs and high-resolution (LiDAR) digital elevation models, combined with field observations. Four sites were chosen for detailed investigations. Geophysical soundings (GPR) were carried out on the dunes to gain information on their internal sedimentary structures. The dunes were sampled for grain-size analysis and mineralogical identification. Sediment facies displaying clear evidence for eolian transport were sampled for optically stimulated luminescence (OSL) dating of the K-feldspar fraction. Our results indicate that this large eolian system likely derives from the reworking of beach and deltaic sands that were deposited in postglacial Champlain Sea. The main orientation of the parabolic dune fields suggests deposition by strong NE (N35°) anticyclone winds, which probably played an important role in the formation of these dunes and the remobilization of sand-sized sediments in the lowland. GPR results tend to suggest a single period of deflation. OSL investigations show that the sand particles were well exposed to sunlight prior to burial and preliminary results yielded ages of ca. 8 ka. Utlimately, results from this study will provide constraints on the period of eolian activity that followed the retreat of the Laurentide ice sheet and Champlain Sea, in addition to refine the chronostratigraphic framework for the deglaciation of the Central St. Lawrence Lowlands.

Abstract ID: 34615

Final Number: ES14B-0136

Title: Thermo-hydro-mechanical Behavior of Granite under Cyclic Temperature Changes

Presenter/First Author: Meysam Najari, McGill University, Montreal, QC

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Co-authors: Antony P Selvadurai, McGill University, Montreal, QC, Canada

Published Material: Part of the work was presented in the Environmental Earth Sciences journal by Meysam Najari and APS Selvadurai:http://link.springer.com/article/10.1007%2Fs12665-013-2945-3

Abstract Body: This research deals with the computational and experimental investigation of thermo-hydro-mechanical processes that are induced by the boundary heating of a granite cylinder containing a cylindrical cavity. The study is of interest to geomechanics problems associated with the deep geologic disposal of heat-emitting nuclear fuel wastes, the extraction of geothermal energy, oil and gas recovery, and the geologic sequestration of carbon dioxide in supercritical form. Temperature changes can influence a saturated porous geomaterials in several ways: it can cause skeletal deformation due to thermal expansion of the rock; induce fluid flow due to the fluid pressures generated by the differential thermal expansion between the porous skeleton and pore fluid; and alter the physical characteristics of the migrating pore fluid.

A cylindrical granite sample measured 15.24 cm in diameter and 30.48 cm in height containing a sealed fluid-filled cavity with a diameter of 2.54 cm and a depth of 15.24 cm was prepared. Prior to performing the THM experiment the permeability of the sample was estimated using constant flow rate steady state technique. The sample was then subjected to a cycle of temperature changes on its outer surface and the temperature and fluid pressure changes in the fluid-filled cavity were measured. It was observed that regardless of how precisely the cavity was filled with de-aired water, air bubbles can still exist in the cavity and influence the fluid pressure changes. A novel technique was suggested for taking into account the influence of the volume of trapped air and eliminating its effect in the estimation of the fluid pressure changes in the fluid-filled cavity. The experiment was computationally modeled using the finite element code COMSOL Multiphysics™ and the experimental results were compared with the computational estimates. The computational model took into account the compressibility of the water, the porous skeleton and the solid grains.

Abstract ID: 35756

Final Number: ES14B-0137

Title: Frequency Response of a New Closed-Path Trace Gas Analyzer for Eddy-Covariance Flux Measurements

Presenter/First Author: James Somers, Campbell Scientific, Logan,

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Co-authors: Steve Sargent, , ,

Abstract Body: The TGA200A (Campbell Scientific, Inc.) is a new trace gas analyzer designed to measure nitrous oxide or methane mixing ratios, or carbon dioxide isotope ratios. It is similar to the earlier TGA200, but it uses a thermoelectrically cooled laser to avoid the need for cryogenic cooling. The TGA200A also uses a smaller sample cell to provide good frequency response for eddy covariance applications, even with a lower-power sample pump.

The frequency response of the TGA200A was measured by injecting an impulse of N2O at the inlet. This measured impulse response was then Fourier transformed and normalized to give the frequency response. This test was repeated at various flow rates that represent a range of pump capacities to demonstrate the tradeoff of frequency response vs. power required for the sample pump.

Abstract ID: 36289

Final Number: ES14B-0138

Title: Spatial-Temporal effects of Landuse changes on Land surface Temperature in Nairobi.

Presenter/First Author: JAMES MUMINA Muthoka, Regional Centre for Mapping of Resources for Development, Nyeri,

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Co-authors: Charles Ndegwa Mundia, Dedan Kimathi University of Technology, Nyeri, Kenya

Published Material: The findings were published in a Proceedings of the 2014 International Annual Conference on Sustainable Research and Innovation at Jomo Kenyatta University of Agriculture and Technology.

Abstract Body: Land Surface Temperature (LST) forms an important climate variable which is related to climate change and forms a good indicator of the energy balance at the surface because it is one of the key parameters in the physics of land-surface processes. The main objectives of this study is to examine the spatial temporal effects of land use land cover changes on surface temperature, through the analysis of the temperature differences between the land covers and Normalized Differential vegetation Index using Landsat TM and ETM+ data for a period of 24 years. The effectiveness of remote sensing technology methodson surface temperature at local and regional levels is examined too.

The multispectral bands of Landsat TM and ETM+ of the dry season were used in generating the land surface temperature, NDVI and LULC. The data was checked against ground data information and measurements and statistically normalized for correlation with vegetation vigour and land cover types such as vegetated areas, barren land, water, shrubs/grasslands and built up areas.

The finding indicate a strong relationship between the land surface temperature and the land use/ covers with a negative correlation with the vegetation The relationship between land surface temperature and the land use validates the suitability of the techniques used in analysing land surface temperature for micro-climates assessment. Remote sensing data provides an efficient and relatively cheaper method for carrying out micro-climate studies thus effective in local and regional analysis. The research recommendsmitigation techniques that facilitate the reintegration of natural elements into the built environment hence reversing the climate change effect.

Key Words; Land Surface Temperature, Land Use, Land Cover, Normalized Difference Vegetation Index, remote sensing

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Abstract ID: 36509

Final Number: ES14B-0140

Title: Voxelization approach to model soil reinforcement by root systems: application for landslides risk assessment of forested hillslopes

Presenter/First Author: Nomessi Kokutse, University of Lome, Lome,

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Co-authors: André Guy Tranquille Temgoua, University of Douala, Douala, Cameroon

Abstract Body: Root reinforcement is considered as an increase of soil shear strength and this help in reducing slope failures. To investigate effects of tree root systems on slope stability, field experiments can be conducted. Such tests are difficult to perform. Numerical model appears as an alternative approach to investigate root reinforcement and risk assessment of forested slopes without taking explicitly into account roots elements in soil.

This paper presents a new and an integrated model of soil reinforcement. The model is based on voxelization technique which consists in converting 3D geometric objects from continuous geometric representation into a set of voxels that best approximates each element of a root system. Based on this technique, a root system located in a block of soil can be divided into a set of voxels or volume elements. In each voxel, roots parameters such as root area ratio, tensile resistance and roots mean orientation can be extracted for the purpose of local soil additional cohesion computation. Root cohesion in different voxels can therefore be assigned to a similar domain meshed into 3D finite elements for the field of strain computation. The process enables to search finite elements at the same spatial position as the considered voxel prior to root cohesion assignment. With this model, simulations of forested slope failure and direct shear tests of rooted-soil were performed in a finite elements environment. Results of the simulations are found to be in good accordance with similar experimental tests found in the literature. This help to investigate slope reinforcement with different types of root systems and plantation patterns. The investigations showed that, among the three main families of roots architectures (tap, heart and plate root systems), the tap root system is found to be the best in terms of soil reinforcement. Staggered in rows forest pattern was found to increase slope stability much better than all other patterns investigated.

Abstract ID: 34495

Final Number: ES21A-01

Title: Physically Accurate Soil Freeze-Thaw Processes in a Global Land Surface Scheme

Presenter/First Author: Vanessa Elizabeth Haverd, CSIRO Canberra, Canberra, ACT

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Co-authors: Matthias Cuntz, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany

Published Material: Preliminary Results were Presented at AGU Fall Meeting 2013

Abstract Body: Transfer of energy and moisture in frozen soil, and hence the active layer depth, are strongly influenced by the soil freezing curve which specifies liquid moisture content as a function of temperature. However, the curve is typically not represented in global land surface models, with less physically-based approximations being used instead. In this work, we develop a physically accurate model of soil freeze-thaw processes, suitable for use in a global land surface scheme.

We incorporated soil freeze-thaw processes into an existing detailed model for the transfer of heat, liquid water and water vapor in soils, including isotope diagnostics – Soil-Litter-Iso (SLI, Haverd & Cuntz 2010), successfully used for water and carbon balances of the Australian continent (Haverd et al. 2013). A unique feature of SLI is that fluxes of energy and moisture are coupled using a single system of linear equations, a feature preserved in the extension to include freeze-thaw processes. The extended model is evaluated extensively in stand-alone mode (against theoretical predictions, lab experiments and field data) and as part of the CABLE global land surface scheme.

SLI accurately solves the classical Stefan problem of a homogeneous medium undergoing a phase change, and accurately reproduces observations of the freezing front from laboratory experiments (Hansson *et al.* 2004). Tests against observations at a permafrost site in Tibet (Weismüller et al. 2011) reproduce seasonal thawing and freezing of the active layer to within 3 K of the observed soil temperature (fig 1) and to within 10% of the observed volumetric liquid soil moisture. Tests in the presence of snow show good agreement with observed snow-water equivalents and soil temperatures, although refreezing of melted snow water is highly sensitive to the number of model snow layers, which influence density and temperature gradients in the snow-pack.

SLI was run globally on 1ºx1º grid as the soil part of the land surface scheme CABLE. We could therefore demonstrate that this detailed and physically-realistic formulation is fast enough to be a feasible alternative to the much simpler default soil-scheme in CABLE. Modeled northern hemisphere permafrost extent and depth are shown to be sensitive to incorporation of the soil freezing curve in the model.

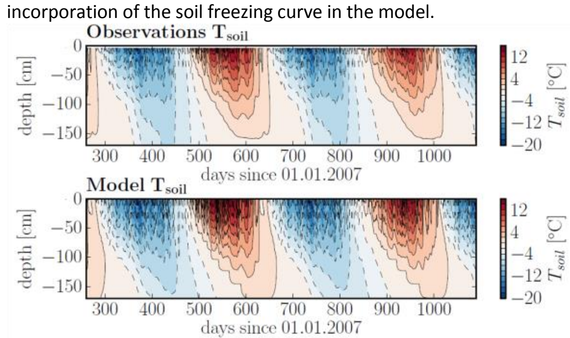

Figure 1: Observed and modelled soil temperature at a barren site in Tibet

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Abstract ID: 35818

Final Number: ES21A-02

Title: Mass Movement by solifluction and Syngenetic Dynamic of Permafrost in the High Arctic, Ward Hunt Island, Canadian High Arctic

Presenter/First Author: Manuel Verpaelst, Université de Montréal, Montréal, QC

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Co-authors: Daniel Fortier, University of Montreal, Montreal, QC, Canada; Michel Paquette, University of Montreal, Montreal, QC, Canada

Published Material: These findings were partly presented as a poster in ArcticChange 2014. These findings are not under review or accepted by a scientific journal.

Abstract Body: According to recent climatic scenarios, climates changes will affect the Arctic more than any other region of the planet. The high Arctic, which is essentially bare of vegetation, will have a strong response to climates changes and will be characterized by an acceleration of periglacial processes associated with permafrost thawing. Mass movements on slopes will be favored by the deepening of the active layer increasing the creep and continuous sliding of the material over the ice-rich permafrost table.

Our project focused on the influence of solifluction lobes movements on permafrost dynamics at Ward Hunt Island, Nunavut (Canada). On the island, many solifluction lobes deform and entrain sediments downslope. Considering the recent deepening of the active layer, the increase of material downslope may modify permafrost dynamics, a question that is not currently considered by permafrost model scenarios.

We used 3D laser scanning techniques and total station surveys to reconstruct the microtopography and volume of solifluction lobes. Permafrost coring and ground penetrating radar surveys were used to characterize solifluction lobes cryostratigraphy. Permafrost cores were then analyzed using micro-computed tomography to quantify the different components of permafrost (sediments, ice, organic matter and gas) which were also measured in laboratory.

Our study demonstrated that the movement of solifluction lobes leads to the accumulation of coarse material (gravel) with high hydraulic conductivity on the peripheral ridges of the lobe which strongly modifies slope hydrology. In the center of the lobes, the recurrent and substantial accumulation of finer-grained material downslope modifies permafrost dynamics and promotes the aggradation of ground ice. These findings suggest that the occurrence of these ice-rich zones may contribute to slow down the degradation of permafrost, due to the important effect of latent heat represented by this new volume of ground ice.

Abstract ID: 35058

Final Number: ES21A-04

Title: Black Spruce (*Picea mariana*) Water Use Response to Moisture Deficits on a Permafrost Peat Plateau

Presenter/First Author: Rebecca Kathleen Warren, University of Guelph, Guelph, ON

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Co-authors: Aaron A Berg, University of Guelph, Guelph, ON, Canada; William L Quinton, Wilfrid Laurier University, Waterloo, ON, Canada; Jennifer Lynn Baltzer, Wilfrid Laurier University, Waterloo, ON, Canada

Published Material: Preliminary data and trends were presented on a poster at the ArcticNet conference in December 2014. Since then further data analysis has occured.

Abstract Body: Large-scale permafrost degradation is occurring rapidly over the discontinuous permafrost regions of the Canadian subarctic. Within this region, peatlands are particularly vulnerable as permafrost controls the hydrology, carbon cycling, and the health and distribution of vegetation. This study examines the degree to which *P. Mariana* responds to water stress in relation to changing frost and water table depth, soil tension, and soil moisture. These findings will aid in advancing our understanding of the processes governing forest browning and the hydrological modeling of cold regions. Three *P. Mariana* were instrumented with 5 Heat Ratio Method sap flow sensors (SFS) on a peat plateau at Scotty Creek, NWT in the summer of 2014. Tensiometers were placed at a depth of 15 cm and at distances of 20 and 100 cm from the focal tree along SFS monitored roots. Volumetric soil moisture over the top 5 and 20 cm was measured every 10 cm along four transects that intersected the instrumented roots. Frost table depth was also measured along these transects. Two water table wells were installed near the bog and in the plateau interior. Diurnal patterns of soil tension, sap flow, and water table depth were observed within an overall drying trend throughout the summer. A correlation existed between soil water tension and sap flow velocity. Complex feedback processes were observed between tension, frost table depth and sap flow. Increasing frost table depth resulted in decreased water table height, as well as decreased surface soil moisture, causing drought stress in *P. Mariana* and reducing transpiration. Large precipitation events and proximity to bogs or fens may also temporally induce waterlogging. A conceptual model of *P. Mariana* response to water deficits was developed and compared to the predicted response.

Abstract ID: 35068

Final Number: ES21A-05

Title: Spatial and Temporal Patterns of Net Carbon Exchange in the Polar Semi-Desert Vegetation Community on Melville Island, NU

Presenter/First Author: Emma Buckley, Queen's University, Kingston,

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Co-authors: Neal A Scott, Queen's University, Kingston, ON, Canada; Paul Treitz, Queen's University, Kingston, ON, Canada

Published Material: Preliminary results presented as a poster at the 2014 Arctic Change conference.

Abstract Body: While studies across latitudinal gradients in mesic tundra have shown decreasing levels of net ecosystem exchange (NEE) of carbon dioxide at more northern sites, little work has explored the factors regulating NEE in the polar semi desert, a vegetation community which is widely distributed across the High Arctic.

In 2013, we deployed eight ADC Automated Carbon Exchange (ACE) systems to quantify the contribution of the polar semi-desert plant community to the landscape-scale NEE. As polar semi-desert plant cover varies at relatively small spatial scales, the chambers were distributed between vegetated areas (18-51% cover) and bare soil. Measurements were made every 30 minutes from late May to late July. Air temperature, soil temperature, and soil moisture measurements were collected in conjunction with NEE readings. In July 2013, Normalized Difference Vegetation Index (NDVI) data were collected to quantify variability in vegetation cover within the polar semi-desert. NDVI varied from -0.12 to 0.31, with the highest values occurring at vegetated sites and low values occurring on bare soil. Percent vegetation cover and NDVI correlated well at peak biomass ($R^2 = 0.96$).

NEE is driven by variability in several biophysical factors, and the factor that best predicts NEE varies throughout the season. In the early season, respiration drives NEE, and air temperature is the strongest predictor (R^2 = 0.23 to 0.55). During the warmer part of the season, photosynthesis is the dominant component of NEE, and photosynthetically active radiation (PAR) becomes the best predictor. Our results suggest a threshold temperature above which photosynthesis dominates NEE in polar semi-desert plant communities. Longer growing seasons, if associated with higher temperatures, would enhance NEE. NEE correlated positively with vegetation cover ($R^2 = 0.96$) later in the season. These relationships may be useful for quantifying NEE in polar semi-deserts using remotely-sensed data.

Abstract ID: 35174

Final Number: ES21A-06

Title: Dissolved Organic Matter Quality from a Discontinuous Permafrost Area and its Susceptibility to Photolytic and Microbial Degradation

Presenter/First Author: Pieter Aukes, University of Waterloo, Waterloo, ON

Presenter/First Author Email: paukes@uwaterloo.ca

Co-authors: Sherry L Schiff, University of Waterloo, Waterloo, ON, Canada; Michael English, Wilfrid Laurier University, Waterloo, ON, Canada

Published Material: Some of this data was presented at ArcticNet 2014 (Ottawa), but I'll be focusing on a different component (not the same presentation!)

Abstract Body: Northern environments are some of the most susceptible to a warming climate, experiencing increased active-layer thickness and permafrost degradation. Such changes can influence subsurface carbon cycling. Particularly, previously-frozen carbon can become mobilized into the hydrosphere as dissolved organic matter (DOM) and make its way into surrounding surface waters. Dissolved organic matter plays a number of important environmental roles including absorbing harmful ultra-violet radiation in surface waters, affecting the pH, and acting as an important nutrient source for microbes. Furthermore, DOM can influence water quality by binding and transporting heavy metals, as well as potentially forming carcinogenic disinfection by-products during the chlorination of drinking water. Reactivity of DOM is dependent upon its quality, which can vary depending on source, amount of degradation, and season. In northern environments, it is uncertain how degrading permafrost will influence DOM quantity and quality and the subsequent effect upon drinking water and aquatic health, especially in ice-poor permafrost areas. Our research used a variety of DOM characterization methods and geochemical techniques to quantify DOM quality from four different sources (subsurface peat porewater, ponds, streams, and rivers) in an area with degrading permafrost near Yellowknife, NWT. In addition, we conducted microbial and photolytic degradation experiments to determine whether the lability of DOM differs with source, how DOM quality changes with environmental processing, and how this ultimately influences parameters linked with drinking water quality and aquatic health.

Abstract ID: 35911

Final Number: ES21A-07

Title: Impact of temperature increase on methane emission from arctic soils

Presenter/First Author: Juyoung Seo, Yonsei University, Seoul,

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Abstract Body: Arctic tundra is one of the largest carbon stocks, of which amount is estimated up to 1,600 Pg. Global climate change models predict the greatest surface temperature rise in Arctic regions, which may result in faster decomposition of organic carbon and consequent releases of greenhouse gases such as CO_2 and CH_4. In particular, CH_4 is a significant GHG and can contribute to positive feedback on climate change; however, dynamics of CH_4 emission from arctic tundra under warming is yet to be fully understood. In this study, we conducted temperature manipulation experiments for arctic soils at field and laboratory scales and monitored CH_4 fluxes along with related microbial abundances (methanogen and methanotroph). Open-top chambers were installed in Cambridge Bay, Canada and intact soil cores collected along a melting gradient in Nome, Alaska were incubated under increasing temperature (from -20 to 20 ℃) for 60 days. At a field scale, *ca.* 1 ℃ increase in soil temperature for one growing season induced a slight increase in CH_4 emission while abundances of methanogen and methanotroph did not show any shift. . At a laboratory scale, CH_4 emission from a wetland soil was higher than that from dry soils and appeared to increase at thawing temperature (0.5 ± 1 ℃). However, a little oxidation of CH_4 was observed in dry soils at thawing temperature.

Overall results of this study suggest that CH_4 flux from arctic soils under warmer conditions is constrained not only by temperature but also by water availability.

Abstract ID: 34421

Final Number: ES21A-08

Title: Measurement of Permafrost Greenhouse Gas Emissions through a New Closed Chamber Automated System

Presenter/First Author: Samuel Gagnon, Centre d'études nordiques, Québec, QC

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Co-authors: Michel Allard, Laval University, Quebec City, QC, Canada; Esther Lévesque, Université du Québec à Trois-Rivières, Trois-Rivières, QC, Canada

Published Material: The methodology was first presented orally at the ArcticNet Annual Scientific Meeting in Halifax, December 2013. In December 2014, a poster was presented at the Arctic Change convention in Ottawa.

Abstract Body: Over the past 30 years, the Arctic has experienced a rapid increase in surface temperatures, which has led to important consequences such as the beginning of permafrost thaw. Permafrost thaw is expected to contribute to increased emissions of greenhouse gases (GHG). Such emissions have been quantified indirectly through mathematical models and from sporadic field measurements using portable gas chambers. However, modeling still holds a lot of uncertainty and direct measurements with chambers are both labour-intensive and time-consuming.

The main objective of this project was to measure permafrost CO_2 and CH_4 emissions in a polygonal peatland located in Salluit, Nunavik. In order to assess the future impact of warming on arctic carbon fluxes, GHG emissions were measured under the current climatic conditions and inside an open-top chamber (OTC), which can reproduce the climatic conditions expected in about 50 years. In addition, the spatial variations of GHG emissions in the polygonal peatland, from dry tundra polygon centers to wet troughs where permafrost is decaying, were studied in order to determine the effects of soil water saturation on GHG emissions and composition.

This project also aimed to test a new instrumentation: a closed chamber automated system. The new system was designed and built to take precise measurements over long periods of time with low-cost gas sensors instead of using conventional ways to measure carbon concentrations, which are often expensive. In addition, the system was designed to operate autonomously and maintain the integrity of the studied sites.

Four automated closed chambers were used for the project: one chamber in natural conditions (C_n), on chamber in an OTC (C_{OTC}), one chamber measuring emissions on a site without vegetation (C_{soil}) and one chamber between two polygons where the soil is permanently water-saturated (C_{sat}). Two chambers were operated every day, alternating chambers each day. The chambers were closing for 30 minutes three times a day (7h30, 13h30, 19h30).

Preliminary results show that the new automated system underestimates CO_2 fluxes, but that the trends of carbon emissions are similar to a commercial system. The greatest CO_2 emissions came from C_{sat}, followed by C_{OTC}, C_n and C_{soil}. Emissions were most influenced by air temperature and water table depth.

Abstract ID: 34405

Final Number: ES22A-01

Title: Detached Eddy Simulation (DES) of Turbulent Flow in Isolated Pool-Riffle Bedforms

Presenter/First Author: Hamed Dashtpeyma, University of Waterloo, Waterloo,

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Co-authors: Bruce MacVicar, University of Waterloo, Waterloo, ON, Canada

Abstract Body: One of the most common topographical elements of rivers is pools and riffles. The deeper parts of undulations in the bed are called pools, whereas the shallower parts are riffles. Pool-riffle sequences can be shaped naturally, but are also made artificially to control the stream energy, improve fish habitats, or control the sediment transport rate. Many researchers have focused on the hydraulic characteristics of pool-riffle sequences by numerical analyses, experimental investigations, and field work processes. However, in contrast with other types of investigations, a transient numerical analysis is particularly suited to illustrate the complex mechanisms of flow such as vortex creation and dissipation, turbulence structures, and instantaneous bed shear stress. In this research, detached eddy simulation (DES) of turbulent flow in isolated pool-riffle with different width is presented. The numerical results are verified with experimental data. The simulations show a series of vortex generation near the wall at the downstream end of riffles. Based on the width of the channel, it is illustrated that these vortices can attach to each other and form a tube of vortices or they can break into smaller scale vortices and be dissipated at the downstream by energy cascading. It is illustrated that the narrower channels generate stronger vortices; therefore, these vortices need larger pool length for dissipation. The wall and bed shear stress show more critical conditions for narrower channels. The results of this research can help designers to choose a proper geometry and location for pool-riffle sequences, and give them an insight about the mechanism of natural undulation shaping, and the sediment sorting by size of natural bedforms. In addition, a rational design of pool length can let the flow to be restored and decreases the unwanted erosion at the downstream.

Abstract ID: 35505

Final Number: ES22A-03

Title: Pattern Observation during Bed-Form Development Due to Turbulence around Obstacles in river

Presenter/First Author: Haradhan Maity, Indian Statistical Institute, Kolkata,

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Abstract Body: The objective of this study is to better understanding the mechanism of formation of different kinds of bedform structures due to obstacles immersed on the plane sediment beds in unidirectional fluid flow. Experiments have shown how local scour develops around obstacles of different shapes in non-cohesive sediments. The study shows that obstacle is the dominant cause of the initiations of scour pattern. Obstacle and the stagnation eddy together onset the scour hole at the bottom of the sediment bed, when the critical pressure gradient associated with the initiation of scour is reached. The pressure drop between the stagnation pressure upstream and wake pressure downstream of the obstacle induces this hydraulic gradient. This study explores the temporal development of scour around obstacles resting on flat bed composed of uniform, cohesionless sediment.

This study will show the statistical modeling of various turbulent parameters like velocities and Reynolds stresses; and predict the natural phenomena, like trends of coherent structure over equilibrium scour holes induced by obstacles of different shapes on the river bottom. The turbulent flow field within the equilibrium scour mark was measured in a laboratory flume using 3-D Micro acoustic Doppler velocimeter (ADV). The scours marks may be named as current-crescent preserved in geological record are traditionally used as indicators of palaeo-current direction. Using quadrant threshold technique for coherent motion, it has been shown that over the smooth surface ejections and sweeps are the largest contribution near bed region and outward and inward interactions are the largest contribution near the water surface, but within the scouring region that is not true. Also note that the qualitative and quantitative behaviors of bursting events fit well with experimental data on the smooth surface. But within the scour-hole qualitative behavior of bursting events fits well with experimental data. It is interesting to note that the *yz* and *xy*- planes are much more important in the scouring regions, but reverse are true for the smooth surface.

Moreover, this is important for interpretation of turbulence and flow structures across the scour marks available at the ancient sedimentary structures in the light of modern analog- *present is the key to the past*.

Abstract ID: 35586

Final Number: ES22A-04

Title: Stream instability risk assessment in an urban area as a management tool

Presenter/First Author: Genevieve A Marquis, Organization Not Listed, Washington, DC

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Co-authors: Hugues Lachance, J.F. Sabourin and Associates inc., Gatineau, QC, Canada

Abstract Body: Stream stability in urbanized watersheds is an increasingly critical issue for planners and managers. Unfortunately, due to lenient legislation and a lack of awareness of the impact of changes in land use, urban development in the province of Quebec has heavily impacted streams and rivers. It has also resulted in the construction of roads and houses within the migration channel of these water courses.

The St-Regis creek drains a 93 km^2 watershed located in the Saint-Lawrence lowlands, an area known for its fertile soils. Only 3 km^2 of forest cover remains in the watershed which is now predominantly occupied (82 %) by the culture of major crops. The remaining area (15 %) is relatively dense and continuous suburban development located in the downstream area of the St-Regis watershed. Many of the watercourse's meanders have been straightened during the urban development and subsequent and extensive bank stabilization was added to protect roads and houses. Yet, the channel continues to migrate. A problematic section of approximately 3.5 km is the focus of this study. A risk assessment approach has been proposed to the city managers to advise the planning of stream interventions. The risk assessment approach is seen as a compromise between the need for stable banks and allowing for the natural stream functions of flooding and migration.

Future channel trajectories can be predicted by considering stream history and hydraulics, in combination with RVR meander software output, to classify the fluvial plain according to the risk of channel migration on a

short, mid and long term basis. Based on these data and long term land use plans, stream interventions are devised focusing on minimal impact to the stream and cost-efficient methods. The integration of geomorphological concepts and the consideration of stream history and trajectory, is a new approach in Quebec and a potential sustainable replacement to the usual interventionist approach.

Abstract ID: 36825

Final Number: ES22A-05

Title: Habitat Suitability and Hydraulic Signatures of Geomorphological Units in a Restored Channel

Presenter/First Author: Paul Villard, GEO Morphix Ltd., Milton, ON

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Co-authors: Jaclyn Cockburn, University of Guelph, Guelph, ON, Canada; Cara Hutton, , ,

Abstract Body: Channel reaches consist of a series of geomorphological units. In many 'restored' channels these geomorphological units are a sequence of riffles and pools designed to mitigate flow velocity and provide suitable aquatic habitat. Geomorphological units such as pools and riffles should display morphological, sedimentological and hydraulic signatures. If we can use a hydraulic signature to differentiate between these units we can evaluate the proportion of a given geomorphological unit within a reach. Similarly, a given fish species will require specific hydraulic conditions for different activities. We can use the hydraulic signatures to evaluate suitability of reaches and geomorphological units for target fish species. Therefore, we should be able to assess 'restored' and natural channels in relation to the proportion of different geomorphological units and in the area within the channel that is suitable for a given target fish species. 650 m of creek and valley was realigned in Brampton, Ontario to facilitate development and was an opportunity to restore a degraded system. The channel studied consisted of riffle-pool sequence within a larger channel realignment and floodplain design. Velocity, water depth and substrate were measured at numerous cross-sections through a variety of flow conditions between May and September 2013. This study uses these measurements to evaluate the hydraulic signature of each geomorphological unit and the habitat suitability based on velocity and depth for a range of target species. The assessment illustrated that the approach provides quantitative methodology to examine geomorphological units within natural channels. The approach also provides a quantitative method to examine habitat suitability of target species through variable flow conditions.

Abstract ID: 34147

Final Number: ES22A-06

Title: Determining residence time of a pocket wetland and evaluating urban runoff quality through a pocket wetland in Brampton, Ontario.

Presenter/First Author: Jason Krompart, University of Guelph, Dundas,

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Co-authors: Jaclyn Cockburn, University of Guelph, Guelph, ON, Canada; Paul Villard, GEO Morphix Ltd., Milton, ON, Canada

Abstract Body: Stormwater treatment trains improve urban runoff quantity and quality by remediating water quality and mitigating peak flow. A pocket wetland (PW) at the outlet of a stormwater pond is designed to increase runoff detention, while increased residence time within the PW provides, a 'polishing' step with respect to water quality. A PW in Brampton, ON was monitored to assess effluent discharge and water quality. Discharge, temperature and electrical conductivity (EC) were monitored upstream, downstream and at the inlet of the PW from May – Oct 2014, while Suspended sediment concentrations (SSC) were determined through discrete and automated pump samples. The changes between up and downstream monitoring points were used to monitor PW effluent discharge and quality. The PW attenuated event flows on average for 2 ± 0.8 h during rainfall events. The maximum change in discharge between up and downstream was 0.55 mm due to 31 mm rainfall suggests a slow release of stormwater from the PW. A change in storage capacity after an intense rainfall (17.5 mm/hr) event in early August resulted in poor correlation between influent and effluent PW discharge ($R^2 = 0.2$). A difference of means t-test suggested there was no change in water quality due to the PW, but in-depth event analyses suggest a minor change in EC and SSC at 'first flush'. The PW remediated water quality well through rainfall events, but incised channels downstream of the monitoring area would continuously flow from the PW. Small volumes of warm surface water with an increase in EC and SSC resulted in increased temperatures (0.1 - 0.5°C), EC and SSC. Water quality parameters remained within the provincial water quality levels. The PW provided flow attenuation while increased residence time ensured good water quality. Further improvements in residence time may improve water quality and further justify the use of stormwater treatment trains for best management practice in urban stormwater management systems.

Abstract ID: 35956

Final Number: ES22A-07

Title: Human Modifications and Watershed Hydrologic Processes in a Postglacial Landscape

Presenter/First Author: Brett Gerard, University of Maine, Bangor, ME

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Co-authors: Sean MC Smith, University of Maine, Orono, ME; Alexander Sivitskis, , , ; Andrew S Reeve, Sen. George J. Mitchell Center, Orono, ME; Brian Mathys Van Dam, University of Maine, Orono, ME

Published Material: Some of this work (the hydrologic modeling component) was part of a poster presentation for the 2013 AGU conference in San Fransisco. However, that work was in an earlier stage and additional work (the geomorphic assessment) has been added to this abstract.

Abstract Body: The rates and magnitudes of watershed hydrologic processes in northern New England are influenced by the post-glacial terrain and landscape modifications made by humans following European colonization of the area in the early 1600s. The extent to which glaciation and human activities control the surface hydrologic conditions and geomorphology of the region is the focus of this research. We examine: 1) How channel geomorphic conditions vary relative to watershed characteristics; and 2) How human modifications influence stream flow regimes in the region. This research is conducted in the Sebago Lake watershed of southern Maine. Despite extensive human interventions in the watershed over the past three centuries, the region remains predominantly rural and forested. However, projections indicate a change to more extensive development in future decades, which could have hydrologic, geomorphic, and water quality implications for Sebago Lake and its tributary network.

The geomorphic assessment component of our investigation examines fluvial conditions in our study area relative to sub-basin attributes and calculated hydrologic estimates using statistical techniques. Changes to surface flows influencing stream conditions are evaluated based on simulations with a distributed watershed hydrology model using predicted scenarios for land cover, hydraulic controls, and drainage network

expansion in a sub-basin of the Sebago Lake watershed. These scenarios represent a range of watershed and drainage network modifications commonly associated with human development in the region. All scenarios result in alterations to flow conditions and the sub-basin water budget. Future work seeks to link surface flow regimes derived from varied climate and land cover scenarios with stream bed dynamics and the hydraulic conditions of the hyporheic zone.

Abstract ID: 35868

Final Number: ES23A-01

Title: Coastal Response to Physical Setting and Variable Forcing Across the Canadian Arctic

Presenter/First Author: Donald L Forbes, Natural Resources Canada Dartmouth, Dartmouth, NS

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Co-authors: Nicole J Couture, Geological Survey of Canada -, Halifax, NS, Canada; Trevor Bell, Memorial University of Newfoundland, St. John's, NL, Canada; Thomas S James, Geological Survey Canada, Sidney, BC, Canada; Dustin Whalen, , , ; Gavin K Manson, , , ; Benjamin A Bagnall, Memorial University of Newfoundland, St. John's, NL, Canada

Published Material: This is an invited overview paper that draws on many years of experience across the Canadian Arctic and inevitably some of the ideas have been previously reported in contributions such as Forbes, D.L. and Hansom, J.D. 2012. Polar coasts. In: Treatise on Estuarine and Coastal Science, vol. 3, 245-283, Academic Press, Waltham. In addition, the results related to RSL change in northern Canada are drawn from a recently published Geological Survey of Canada Open File, cited in the abstract. The presentation in this form as a synthesis of coastal sensitivity to climate change and other forcing across the Canadian Arctic, incorporating the latest RSL projections and unpublished field results, is original and not under review or accepted elsewhere.

Abstract Body: Canada's northern coasts comprise over 180 000 km of shoreline extending across 80° of longitude (Beaufort Sea to Labrador Sea) and >30° of latitude (James Bay to Lincoln Sea). Large environmental gradients in temperature, ground ice, sea ice, sea-level trend, storm climate and other factors across this vast area interact with a complex mosaic of geology and geography to produce a wide range of coastal features and sensitivity to environmental change, an understanding of which is needed to minimize negative impacts and challenges to sustainability. Relative sea-level (RSL) trends and projections, available for 22 sites across northern Canada (1), range from rapidly falling to rapidly rising RSL. Trends and projections are affected by global mean sea-level rise, glacial isostatic adjustment (GIA), gravitational fingerprinting, and dynamic oceanography. GIA dominates regional variability of RSL in northern Canada. Some areas such as the transgressive breached-lake and ice-rich permafrost shores of the Beaufort Sea already exhibit rapid change. Rising temperatures, promoting thermal abrasion, and expanding open-water, enabling more energetic waves, promote rapid and locally accelerated coastal retreat in this region. Where sediment supply is high, shoreline progradation can counteract the effects of rising sea level. Elsewhere, stable or falling sea levels against resistant rock shorelines limit rates of coastal change, except where rapid emergence (forced regression) is ongoing. Even in such areas, expanding open water and increased wave activity can promote unexpectedly rapid coastal realignment, as at Arviat and Hall Beach, Nunavut. Ice-locked, low-relief, coasts on unlithified formations in the Sverdrup Basin are primed for rapid wave reworking should open water become more extensive, but this area may be among the last to see a reduction in sea ice.

[1]James et al., 2014,
http://ftp2.cits.rncan.gc.ca/pub/geott/ess_pubs/295/295574/of_7737.pdf

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Abstract ID: 36451

Final Number: ES23A-02

Title: Consequences of climate change on soft cliff erosion on the North Shore of St.Lawrence, Québec

Presenter/First Author: Geneviève Boucher-Brossard, University of Quebec at Rimouski UQAR, Rimouski,

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Co-authors: Pascal Bernatchez, Université du Québec à Rimouski (UQAR), Rimouski, QC, Canada; Maude Corriveau, , , ; Yvon Jolivet, , ,

Abstract Body: Cliffs composed of fine sediments along the North Shore of the St.Lawrence are eroding rapidly due to cryogenic, hydrogeologic and hydrodynamic processes. Six monitoring cameras were installed along the cliff of Rivière-St-Jean between 2008 and 2012 to identify mechanisms responsible for cliff retreat. Data analysis reveals a strong seasonal behavior with activity peaks during winter and spring, which account for two-thirds of total erosional events. Small magnitude processes but frequently occurring, such as thermo-erosion, micro-gelifraction, solifluction and mudflows, induced rapid cliff retreat. Historical and seasonal monitoring using field markers, coupled with photo-interpretation and historical archive analysis, indicates an average annual erosion rate of 2 meters per year since 1948. An acceleration in retreat occured during the last 70 years, leading to a maximum between 1997 and 2005 (3,60m/yr). Lithostratigraphy exerts an important control on erosion rates which are described by three modes of retreat (hydrogeological, cryogenical or hydrodynamical). We are able to describe individual erosional events in an environmental and climatic context due to the use of high resolution data collection. Critical conditions promoting high erosion rates include the absence of an icefoot in winter, the absence of snow cover on cliff face allowing unrestricted solar radiation and the repetition of winter warm spells events.

Abstract ID: 35474

Final Number: ES23A-04

Title: A Comparison of Sable Island Dune Morphology using 1988 and 2009 Profile and Digital Data

Presenter/First Author: Mary-Louise Byrne, Wilfrid Laurier University, Waterloo,

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Published Material: These results were published in a report to Parks Canada as part of an environmental Impact statement for Sable Island Natioanal Park Reserve. The results were also published in a popular science style collection.

Abstract Body: The dunes of Sable Island can be categorized into four physiographic regions: the west spit, the main body, the wide flat beaches on the south part of the island including the plain of former Wallace Lake, and the east spit. Five profiles were measured using a theodolite and stadia rod in 1987 and 1988 across the island to define its basic morphology and dimensions. Using 2009 digital images and data similar profiles were digitized to determine changes that have occurred in the dune geomorphology over the twenty-year period. A summary of the results is outlined in this paper. In addition the dune morphology and a classification of the dunes, based on physiographic processes, vegetation cover, and morphology is presented.

The morphology of the dunes is variable, with elevation increasing toward the east, and width of the dune belt changing along the length of the island according to variations of width of the beaches and the Sandy Plain. In some areas the twenty plus years have resulted in remarkably little change in the profile of the dunes across the island. In other areas, there has been significant erosion and redistribution of sediment resulting in an overall decrease of the dune elevations. The unvegetated dunes can be classified as primary (dunes that develop as a result of wind action and the movement of sand over a uniform surface) or secondary (dunes that involve the deposition of sand on or behind pre-existing obstacles that slow wind speed in its lee). Vegetated dunes may be primary, secondary, or tertiary, depending upon the type of vegetation, the rate of change, and stability of the formation.

Abstract ID: 35510

Final Number: ES23A-06

Title: Assessment of the Approach Used to Design a Salt Marsh Restoration on the Bay of Fundy, NB, Canada and of Overall Project Success from a Geomorphic Perspective

Presenter/First Author: Jeff Ollerhead, Mount Allison University, Sackville,

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Published Material: Early results from this work were presented at the 2013 Binghamton Geomorphology meeting and the 2014 ACCESS meeting.

Abstract Body: With rising relative sea level and climate change, restoring a salt marsh as part of a dyke abandonment plan may be desirable in Atlantic Canada in coming years. As a pilot project, a salt marsh restoration on the Bay of Fundy was designed in 2009-2010 and implemented in 2010. Three openings (breaches) were cut in an old dyke to allow the adjacent areas to flood with salt water at high tide. Restoration has been monitored since 2010 and key environmental variables measured. One aspect of the monitoring was to take collected data for sediment deposition, site topography, and water flows through the breaches and in the restoration area, and use them to both improve the implementation of the hydrodynamic model used to design the breaches and to assess the relative success of the design used. Using measured water levels, breach geometry, and site topography, the type of model used to design the breaches was rerun for tide cycles for which flow data were recorded using an acoustic Doppler velocimeter (ADV) and/or an acoustic Doppler current profiler (ADCP). Overall, the results obtained are very promising. The model predicts flows in the restored area reasonably well, especially when a high drag coefficient is used. Correlation coefficients between modeled and measured flow values are generally high. For sediment deposition, the modeled results generally agree with measured results. The model is effective for showing where sediment is likely to accumulate to the greatest degree (i.e., relative deposition). The study confirms that the design approaches taken were sound, effective, and could certainly be used to design a future salt marsh restoration project on the Bay of Fundy.

Abstract ID: 37504

Final Number: ES23A-07

Title: The impact of climate change on Arctic coastal erosion

Presenter/First Author: Nicole J Couture, Geological Survey of Canada -, Halifax, NS

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Abstract Body: The Arctic Coastal Dynamics (ACD) project is an effort sponsored by the International Arctic Science Committee (IASC) to better understand coastal processes in the circum-Arctic by focussing on the physical properties of the coast and some of the major environmental forcings that affect it. The presence of ice along Arctic coasts -- both in the form of sea ice and of ground ice within permafrost -- results in conditions and processes that differ greatly from what is found in more temperate regions. ACD's primary goal was to assess the sensitivity and erosion potential of over 100,000 km of Arctic coastline. Two other initiatives sponsored by the Geological Survey of Canada (GSC) both fed into and were inspired by the ACD project. These focus on characterization and mapping of northern coasts at a Canada-wide scale (CanCoast) and a regional level (GSC Coastal Information System). All three provide a basis for classification and mapping of shore-zone topography, geomorphology, composition and exposure in relation to relative sea-level trends, atmospheric and oceanographic forcing, sea-ice conditions, and other aspects of the physical setting. Here, we present the methodology used for classification at the various scales and some of the insights emerging from these efforts. These include the regional variability of erosion rates and carbon input to the Arctic Ocean on a circumpolar basis (Lantuit et al. 2012) and the geographic variability in coastal sensitivity to climate change across the Canadian Arctic.

Abstract ID: 33796

Final Number: ES24A-0141

Title: Ice Wall Growth and Decay: Meteorological Analysis and Modelling

Presenter/First Author: Francis Gauthier, University of Quebec at Rimouski UQAR, Rimouski,

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Co-authors: Michel Allard, Laval University, Quebec City, QC, Canada; Bernard Hétu, , ,

Published Material: Recently accepted by a scientific journal (Permafrost and Periglacial Processes)

Abstract Body: The growth and decay of three ice walls was surveyed and analyzed during the winter of 2010-2011. Ice walls form on a cliff face due to the freezing of seeping ground water: two of the studied ice walls are on north-facing rock faces and one over a south-facing cliff. Ice walls growth and decay models were developed using meteorological data collected in their immediate surroundings and checked against growth and decay rates measured by volume changes from terrestrial LiDAR images. A complete energy balance model is first proposed and compared with two other simplified models. The first one is a temperature index or freezing degree-hours model (FDHm), and the second one is a model that combines the FDHm and the radiation heat budget (Q_{rad}). Both models reveal that heat loss from air convection from the seeping water to the atmosphere is the dominant heat transfer flux responsible for the north-facing ice walls growth and decay. Solar radiation also plays a major role for the melting of these ice walls. The overall evolution of the south-facing ice wall is more dependent of the daily variation of Q_{rad}. When the air temperature is cold, the ice forms mostly during the night while solar radiation favours its melting during the day.

Abstract ID: 35503

Final Number: ES24A-0142

Title: Quantifying Heat Advection by Groundwater Flow in the Active Layer: Laboratory Simulations

Presenter/First Author: Sabine Veuille, University of Montreal, Montréal,

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Co-authors: Manuel Verpaelst, Université de Montréal, Montréal, QC, Canada; Simon Charbonneau, , , ; Katerine Grandmont, University of Montreal, Montreal, Canada; Daniel Fortier, University of Montreal, Montreal, QC, Canada

Abstract Body: Rising temperatures due to climate change affect permafrost thermal regime through convective heat transfer at the air-soil interface. Surface run-off and groundwater flow also impact the ground thermal regime by convective heat transfer processes and must be taken into account to obtain an accurate global thermal balance. The magnitude of surface run-off and subsurface water flow is strongly related to topography, and both processes contribute to the thawing in the active layer. This phenomenon is even more pronounced where the active layer is ice-rich. Although the influence of heat advection has already been demonstrated, the efficiency of thawing by convection compared to thawing by conduction has been poorly quantified so far. This knowledge gap has been in part created by the impossibility to control all parameters in natural settings. The Peclet number is an indicator that can be used to determine which of the two phenomena is predominant. However latent heat is not included in the equation which limits the analysis, especially with very low flow.

To overcome field variability, experiments were carried out in a controlled environment to link field conditions with laboratory tests. To replicate physical permafrost models and compare the efficiency of thawing by convection versus thawing by conduction, eight cells were designed and filled with different saturated soils. The cells were submitted to two different air thawing conditions: 15 and 5°C. Four cells were thawed by conductive heat transfer whereas four others were submitted to sub-surface flow. Slope and water temperatures, 15 and 5°C, varied with the experimentations. Results show that the efficiency rate of thawing by convection in comparison to thawing by conduction is proportionally correlated with temperatures, water flow and slope. Convection is 2 orders of magnitude more efficient when temperatures are different (warmer water temperature) than when they are equal.

Abstract ID: 36692

Final Number: ES24A-0143

Title: Dynamics of sporadic mountain permafrost – case study of Mont Jacques-Cartier (1977-2014), Chic-Chocs Range, South-eastern Canada

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Abstract Body: In southern Quebec, mountain permafrost is restricted to the highest bare ground flat summits of the Chic-Chocs Mountains (Northern Appalachians, Gaspé Peninsula). The existence of a contemporary permafrost body was reported on Mt Jacques-Cartier – the highest point in southern Quebec (1273 m a.s.l.) – in 1977 by way of a thermistors cable installed in a 29 m deep borehole. With a 36-year long record of ground temperature, this summit is one of the longest permafrost-monitoring sites in North America and is therefore of great interest to study the impact of climate change on sporadic mountain permafrost.

The rounded summit of Mt Jacques-Cartier is mantled by a 3m-thick regolith cover reworked into periglacial landforms. The soils on the plateau support an alpine tundra vegetation and isolated krummholz patches. To determine the factors controlling ground surface temperature (GST) on the summit, 20 sensors have been installed in the near-surface (-5 cm) in sites with different terrain parameters (e.g. bare ground surface, krummholz, snow bed).

The results showed that the spatio-temporal variability of the GST over the summit is mainly correlated with the snowpack distribution which is controlled by the interaction between the prevailing NW wind and the summit topography and the surface roughness resulting from periglacial landforms and krummholz patches. On the wind-exposed plateau, the snow is systematically blown away as surface roughness is low. The mean snowpack depth is about 35 cm which corresponds to the maximum snow-retaining capacity created by the microtopography of blockfields and sorted-polygons. The mean annual GST was on average about -1°C in 2013 over the summit area. In the krummholz patches and in the topographic depression on the leeward slope, drifted snow accumulation is significant (> 2 m thick) and the mean annual GST was thus warmer (3°C in 2013) than on the wind-exposed plateau.

From 1978 to present, the air temperature increased about 1°C at the summit. The resulting ground temperature warming was +0.4°C at 14 m through this period. From 2008 to 2013, the warming trend was more pronounced with rapid warm-side deviation of the temperature profile (e.g. +0.08°C/year at 14 m). The active layer depth increased by +0.5 m/year over the same period.

Abstract ID: 35517

Final Number: ES24A-0144

Title: Impact of Land Cover Disturbances on Permafrost Landscapes in Yukon, Case Studies

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Published Material: Some of the case studies were presented at the ArcticChange (ArcticNet) Conference in Ottawa last December.

Abstract Body: The impacts of rising temperatures in permafrost regions are already being observed in many communities. Environmental changes can be exacerbated by human intervention and most of the time these operations (e.g. road installation, logging) can impact on the environment at a faster pace than those induced by climatic changes. When combined, climatic and anthropogenic changes can result in important hazards for community planning. From a project managed by the Northern Climate ExChange, case studies from Yukon were selected to illustrate the impacts of land cover changes on permafrost landscapes.

Under a FireSmart zone where trees are still present, the stability of the permafrost has been maintained with an active layer depth of 0.65 m. Illustrating how surface disturbance can impact the ground thermal regime, an adjacent cleared area has developed a near-surface talik (unfrozen zone over the permafrost) that reaches 8 m in depth.

To access gold bearing material, placer mining operations strip the first meters of soil and vegetation. A land plot shows early signs of permafrost degradation in a stripped area. By removing the insulating organic cover, the active layer has thickened to a depth greater than 1.6 m in just under 10 years. In comparison, an adjacent forested zone is showing a 52 cm thick active layer, underlain by ice-rich permafrost.

Removing vegetation and stripping the ground can also lead to the accelerated degradation of ice wedges, such as occurred at a residential area where a forest was cleared in the 90's for agricultural purposes. In a little over 20 years, degradation of ice wedges created linear subsidence and water ponding where the terrain was previously flat and polygonal network of ice wedges progressively appeared and are now clearly visible.

Our results indicate that land-use changes, especially those affecting the vegetation cover, can impact permafrost geosystems much more rapidly than changes induced by atmospheric warming only.

Abstract ID: 35012

Final Number: ES24A-0145

Title: Implications of Galling Herbivory on Ground Thaw Through Shrub-Soil Heat Transfers in Canada's Northern Boreal Forest

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Abstract Body: The significant climate warming faced by Canada's northern boreal forest has the potential to affect forest dynamics by altering the dispersion and abundance of resident natural enemies. Warmer air temperatures can impact the distribution and overwinter survival rate of these arthropods. Thus, the impacts of arthropod pests on their host plants require better understanding. Gall-inducing mites are a resident natural enemy in high latitude forests and have been shown to drive dramatic reductions in photosynthetic carbon uptake and transpiration rates of infested plants with the potential to alter shrub-energy balance. In this study we examine the impacts the gall-inducing eriophyoid mite, *Vasates oldfieldi*, has on *Betula* shrub energy inputs to the underlying ground surface. Two hypotheses will be tested: 1) a positive feedback to permafrost thaw through a reduction in evaporative cooling on the leaf surface increasing the canopy temperature of the *Betula* shrubs. The increase in the incident longwave radiation to the ground surface leads to an increase in the active layer thickness. 2) a negative feedback on permafrost thaw through a compensatory response in the shrub leading to an increase in leaf area index (LAI) to offset the loss of photosynthetic function. This reduces the amount of incident solar radiation at the ground surface resulting in a shallower active layer. To test these hypotheses, we measured soil moisture and surface temperature, leaf temperature, active layer thickness, shortwave radiation, transpiration and LAI. Our initial findings have shown an increase in active layer thickness and soil temperature under ungalled shrubs compared to galled shrubs of similar size for both the 2013 and 2014 field seasons. The results from this experiment are of great significance as the potential for a positive feedback of warming at a very local scale can potentially influence ground thaw in the northern boreal forest.

Abstract ID: 35077

Final Number: ES24A-0146

Title: Seasonal Dynamics of Ecosystem Carbon Exchange for a Wet Sedge Vegetation Community, Melville Island, NU

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Published Material: Preliminary results were presented at Arctic Change 2014 conference December 8-12 (poster presentation).

Abstract Body: Wet sedge meadows are the most productive communities in the High Arctic. Preliminary research suggests that this plant community is a net carbon sink, yet the controls – and the scale at which those controls act – are not well understood. If climate change enhances wet sedge growth, we may observe increases in the percentage of land area occupied by these meadows, altering the carbon balance of high arctic landscapes.

We examined seasonal carbon exchange processes in three wet sedge meadows at the Cape Bounty Arctic Watershed Observatory (CBAWO). Automated and static CO_2 exchange systems recorded CO_2 exchange from June to August, 2014. In conjunction with these measurements, time-series NDVI images were collected to quantify the phenological stage of the community through the growing season. Simultaneous measurements of soil temperature, air temperature, PAR, soil moisture, and active layer depth were also made.

Net ecosystem exchange (NEE) measurements indicate carbon uptake through photosynthesis, and NEE rates differed in spectrally separable 'wet' and 'dry' sedge areas (-0.33 and 0.01 μmol m^{-2} s^{-1} means respectively; $p<0.001$). NDVI measurements captured spring greening and peak summer biomass, and will likely be a critical variable for modelling CO_2 exchange. Abiotic factors such as soil and air temperature may also influence CO_2 exchange, though this system is driven strongly by soil moisture.

Predictive models of ecosystem carbon fluxes will be created using NDVI and environmental measurements as predictors of carbon flux. This will allow us to evaluate the drivers of CO_2 exchange in these communities – spatially and temporally – and facilitate predictions of NEE based on NDVI and/or biophysical variables. We will also evaluate the scale (largely temporal) dependency of these controls to improve predictions of annual carbon fluxes at the landscape scale.

Abstract ID: 35428

Final Number: ES24B-0147

Title: Iron Isotopes for Characterizing Iron Cycling in the Amazon River Basin

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Published Material: These were published in EPSL, Chemical Geology and GCA in 2014 and 2015

Abstract Body: With the global climate change and increasing anthropic pressure on nature, it is important to find new indicators of the response of complex systems like the Amazon River Basin. In particular, new isotopic tracers like those of iron may tell us much on processes such as the chemical exchanges between rivers, soils and the biosphere.

Accordingly, early studies revealed that for some river waters, large $\delta^{57}Fe$ fractionations are observed between the suspended and dissolved load, and isotopic variations were also recognized on the suspended matter along the hydrological cycle. Besides, soil studies from various locations have shown that $\delta^{57}Fe$ signatures depend mostly on the weathering regime.

We therefore conducted Fe isotope surveys through multidisciplinary field missions on rivers from the Amazon Basin. It was confirmed that acidic, organic-rich black waters show strong Fe isotope fractionation between particulate and dissolved loads. Furthermore, this isotopic fractionation varies along the hydrological cycle, like previously uncovered in boreal waters suspended matter. In contrast, unfiltered waters show very little variation with time.

It was also found that Fe isotopes remain a conservative tracer even in the case of massive iron loss during the mixing of chemically contrasted waters such as the Negro and Solimões tributaries of the Amazon River. Given that >95% of the Fe from the Amazon River is carried as detrital materials, our results lead to the conclusion that the Fe isotope signature delivered to the Atlantic Ocean is undistinguishable from the continental crust value, in contrast to previous inferences.

The results indicate that Fe isotopes in rivers represent a promising indicator of the interaction between organic matter and iron in rivers, and ultimately the nature of their source in soils. As such, they may become a powerful tracer of changes occurring on the continents in response to both weathering context and human activities.

Abstract ID: 34761

Final Number: ES24B-0148

Title: Multiple Isotopes as Tracers of Human Impacts on Geochemistry of Elements in River Systems

Presenter/First Author: Jiubin Chen, Institute of Geochemistry, Guiyang,

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Published Material: GCA,2014, 128, 128-143

Abstract Body: Zinc, Iron and Copper are anthropophile elements and are essential for biogeochemical and physiological functioning of terrestrial and oceanic organisms. Changes in the supply of these metals in continental rivers may affect their global bio-geochemical cycles and even the related metamorphic activities of aquatic organisms. It is thus essential to precisely determine the sources of these metals in river systems and the variations of fluxes of these metals input by human activities and to the ocean in modern environment. The recently developed isotope methods may be used for tracing the sources of these metals and characterizing their geochemical behaviors and fluxes in rivers. Multi isotopes may provide more complete picture of anthropogenic impact on geochemistry and the fluxes of these elements in rivers.

We report multiple isotopic compositions in both dissolved and suspended loads of the anthropogenically-impacted Seine River (France). The Seine basin displays two important characteristics: a relatively simple carbonated-dominated lithology and an increasing anthropogenic impact from the headland towards the estuary. In this study, the concentrations and isotope compositions of these metals, together with major and trace element concentrations, were measured for a wide sample sets including a geographic transect from headwater to estuary, a temporal series of samples collected in Paris and an anthropogenic sample series. Our data show that the concentrations of these metals in SPM clearly increase downstream, while their isotope compositions show a decrease. Calculation of enrichment factor relative to natural background points to an important anthropogenic input of these metals. This input could be traced by combining multiple isotopic data with the geochemistry of other major and trace elements. Taken as a whole, though Zn, Fe and Cu concentrations correlate very well, Cu displays different isotopic trends compared to those of Zn and Fe. Our study demonstrated the importance of multi-isotopes in studying the anthropogenic contribution and characterizing the geochemical behaviors of heavy metals in river systems.

Abstract ID: 35908

Final Number: ES24B-0149

Title: Bioindicators as Atmospheric Pollution Tracers: a Multi-Isotope Approach

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Co-authors: Florence Gagnon, , , ; Andre Poirier, University of Quebec at Montreal UQAM, Montreal, QC, Canada; David Widory, GEOTOP-UQAM, Montreal, QC, Canada

Abstract Body: Air quality has become in recent years a focus of attention worldwide because of its direct impact on human health. However, even if the monitoring of contaminant concentrations gives a first idea on air quality, it lacks the capacity to give indication about the source(s) and processes controlling the budget of the contaminants. Recent studies[1, 2] have suggested that an isotope approach can help alleviate this difficulty. Lately, bioindicators (including moss and lichens) have shown their added value as passive samplers for monitoring atmospheric contaminants due to their ombrotrophic nature and their lack of protective membrane that allow them to concentrate elements to levels exceeding their physiological needs.

Our study is set in the mining region of the Abitibi-Temiscamingue in eastern Ontario and seeks to differentiate the atmospheric metal contribution from two smelters (nickel and copper) in the area using the concentration and isotope ratios of lead (Pb), strontium (Sr) and osmium (Os). We collected lichen samples from a 500 km transect from the city of Sudbury, Ontario to Rouyn-Noranda, Québec. The Sudbury region is home to Vale's and Glencore's nickel smelters. Osmium is a trace metal commonly found as a –significant- impurity in nickel and platinum ores. In the city of Rouyn-Noranda, 300 km from Sudbury, Glencore operates a copper smelter.

We previously conducted a similar study in two different environments: Hawaii, USA and Rigaud, Québec. The first is a recent basaltic island sourced from a mantle plume while the second is an old granitic intrusion (564 Ma[3]) within the sedimentary basin of the St. Lawrence Lowlands. The strontium and lead isotope ratios of the bioindicators differentiate between two natural sources (local basaltic rocks and the oceanic input) in Hawaii, and between natural and anthropogenic sources in Rigaud. The osmium isotope analyses will be conducted by the time we meet in Montreal.

References:

1) Lahd Geagea et al. (2007) Environmental Science and Technology

2) Rodushkin et al. (2007) Science of the Total Environment

3) Malka et al. (2000) The Journal of Geology

Abstract ID: 34802

Final Number: ES24B-0150

Title: Isotopic analyses of *Hypogymnia physodes* (C, N, S, Pb) as a tool for assessing anthropopressure in the Świętokrzyski National Park (Poland)

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Abstract Body: Bioindicators eg. lichens are one of the most popular and useful tools for assessing an anthropogenic impact on air quality. The main goals of the present study are: (i) to compare air quality under different levels of human impact: low (Świętokrzyski National Park - ŚPN) and high (cities and industry in the vicinity of the ŚPN) and thus (ii) to assess the anthropogenic pressure on the environment using quantitative (atmospheric pollutant concentration) and qualitative (isotope compositions of carbon, nitrogen, sulfur and lead isotope ratios).

Samples were collected during heating season between the 1st and 3rd February 2013. Samples of *Hypogymnia physodes* were collected in 20 locations within the ŚNP (n=18) and in its nearest vicinity (n=2). Lichens were taken from bark and branches of *Abies alba* trees.

Concentrations of SO_2 and NO_2 in the surrounding air were analyzed by the Amay-Krochmal method using passive samplers. CO_2 concentrations and corresponding $\delta^{13}C$ were measured using Gasbench II-CF-IRMS. Isotope compositions of C and N from bioindicators were determined by EA-CF-IRMS and S isotope compositions by DI-IRMS and Pb ratios by MC-ICP-MS.

Preliminary conclusions of this work are as follows: (i) S, C, N and Pb point at distinct origins and different bio-physico-chemical pathways; (ii) $\delta^{13}C$ results shows an altitude effect but no relationship with the corresponding C concentrations; (iii) $\delta^{15}N$ shows a slightly positive relationship with altitude as well as with N concentration that could reflect inputs from fossil fuels combustion; (iv) $\delta^{34}S$ are currently analyzed and results will be presented during conference; (v) Pb isotope results indentify an industrial origin; (vi) the highest NO_2 concentrations are located near main roads; (vii) the maximum SO_2 concentrations are observed at the highest altitude and open locations indicating long-distance deposition of regional pollutants; (viii) anthropogenic air pollutants are reflection of industry derived by local dominant (S and SW) wind direction.

Abstract ID: 35170

Final Number: ES31A-01

Title: Morphology and Sediment Transport in Semi-alluvial Channels

Presenter/First Author: Peter Ashmore, University of Western Ontario, London, ON

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Abstract Body: Definitions of semi-alluvial channels differ in detail but the term has been applied to describe those channels in which alluvial deposits are either thin or discontinuous but the underlying non-alluvial (usually cohesive) material in the bed, and /or exposed in the banks, is readily eroded by prevailing flows. The consequence is that river morphology and channel adjustment, e.g. cross-section dimensions and in-channel bars, may be very similar to that of alluvial channels with similar flows. Neither the geographical occurrence nor the controlling conditions of these types of channels are well known, but they appear to be common in glaciated regions with extensive and thick deposits into which rivers are eroded. In the Great Lakes region examples range from small headwater streams, through main-stem rivers and include some of the Great Lakes connecting channels. In some cases the primary depositional cover over the non-alluvial material is gravel-cobble. While these channel types may have some morphological and process characteristics of partially-alluvial bedrock channels, the extent to which concepts of erosion, cover formation-loss, and bedload transport developed for bedrock channels are applicable to semi-alluvial channels is an open question. It is also likely that process analyses such as bedload-transport formulations for fully-alluvial rivers are not directly transferrable to semi-alluvial cases. A systematic program of research is needed to expand knowledge of semi-alluvial river morphology and processes.

Abstract ID: 34443

Final Number: ES31A-02

Title: Longitudinal variations in channel morphology in postglacial watersheds of the northeastern United States

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Published Material: Some aspects of the work were included in Snyder et al. (GSA Bulletin, 2013).

Abstract Body: Landscapes formerly occupied by continental ice sheets are characterized by exposed bedrock, till and localized thicker glacial deposits. Rivers in Maine, USA have alternating gravel-bedded steep (gradient > 0.002) and finer gradual (gradient < 0.0005) reaches imposed by the glacial geomorphic and geodynamic history of the region. The low-gradient reaches often include mainstem lakes that are infilling with sediment. These stair-stepped longitudinal profiles lead to discontinuities in sediment flux through the channel network, creating a series of downstream-fining sedimentary links (Rice and Church, 1998). In this presentation, I will review the development and testing of a model to predict bed grain size from a high-resolution (lidar) digital elevation model, based on assumptions of threshold single-thread channels with supply-limited conditions. The field area is a set of three watersheds in Maine, USA, where field ground-truth data were collected. My purpose is to explore how the success or failure of the model is influenced by longitudinal controls on bed shear stress or stream power (via slope and drainage area) and sediment supply (via tributary inputs and eroding glacial deposits). The model is most successful sediment-starved steep reaches, such as those downstream of mainstem lakes. The model is least successful in low-gradient, relatively fine-grained (median grain size < 16 mm) reaches. These variations in model success, which are connected to the glacial geology of the region, have implications for fish habitat, stream restoration, and geomorphic response to climate and land-use changes in the region.

Abstract ID: 35084

Final Number: ES31A-03

Title: Three Quarters Alluvial: Constraining the Semi-Alluvial River Condition in the Glacial Landscape of Southern Ontario

Presenter/First Author: Roger TJ Phillips, University of Toronto, Milton,

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Co-authors: Joseph R Desloges, University of Toronto, Toronto, ON, Canada

Published Material: Abstract is based on new set of classifications applied to semi-alluvial rivers. Mapping of field sites and original classifications are based on data in two recently published papers below. Phillips, R.T.J. and Desloges, J.R. (2014). Glacially conditioned specific stream powers in low-relief river catchments of the southern Laurentian Great Lakes. *Geomorphology*, 206: 271-287.Phillips, R.T.J. and Desloges, J.R. (2014). Alluvial floodplain classification by multivariate clustering and discriminant analysis for low-relief glacially conditioned river catchments. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.3681

Abstract Body: Rivers and streams of southern Ontario are carved into a diverse landscape of glacial landforms and deposits of varying thickness. Semi-alluvial channels are incised into non-alluvial boundary materials of glacial clay or exposed bedrock, with varying amounts of alluvial cover. In this paper, we question the degree to which semi-alluvial conditions are a "natural" state for fluvial systems in the low-relief glacial landscape of southern Ontario, and the degree to which intermittent contact with glacial materials modifies alluvial channel processes. To examine these questions, we consider the frequency and extent of semi-alluvial channels in the region, and the potential effects of post-settlement deforestation and urban land use history on their distribution.

An exploration of hundreds of field sites across peninsular southern Ontario provides evidence that reaches with extensive non-alluvial boundaries occupy only a small proportion of drainage networks in the region. For this study, field observations of semi-alluvial and alluvial reaches are organized within a recently published classification framework for alluvial floodplain types. Many river reaches have thick alluvial cover, with very little evidence of exposed glacial materials (or bedrock). Where alluvial channels intermittently come into contact with glacial materials, these glacial beds and bluffs are important sources of sediment, but they only impose local controls on channel behaviour. The morphodynamics of channels in intermittent contact with glacial boundaries are likely to be very similar to that of alluvial channels. Channels with thin alluvial cover and extensive glacial materials exposed on the bed and banks are often located on oversteepened tributary reaches and/or in watersheds impacted by urban development. The implications for channel morphodynamics and floodplain accretion processes in these glacial boundary reaches are still poorly understood.

Abstract ID: 34288

Final Number: ES31A-04

Title: Development of sand-bedded rivers in glaciated, Southern Ontario

Presenter/First Author: Anna Marie Megens, University of Toronto, Etobicoke,

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Co-authors: Joseph R Desloges, University of Toronto, Toronto, ON, Canada

Abstract Body: Many studies of river and floodplain sedimentology demonstrate their complexity and the need to simplify observations in the form of standard models. A standardized description, classification, and interpretation of fluvial deposits or facies models were revised by Miall (2010) to represent the behavior of meandering rivers. A field investigation was undertaken to test the applicability of the accepted meandering sand-bedded river facies model to sand-bed rivers in Southern Ontario. A challenge in this environment is the influence of non-alluvial channel boundary materials such as glacial outwash sands, till, and glaciolacustirne clay. The presence of these materials in some channel beds and banks, and entrenchment as these rivers approach the Lake Erie base level, suggest that these rivers are not in equilibrium and that recognized "models" may not be appropriate at predicting channel behaviour. A multi-faceted approach (sedimentology, channel surveys, geophysics, etc.) is used to characterize the mechanisms and formation of fluvial sedimentary structures and the processes controlling the lateral and vertical mobility of these active channels. It appears these sand-bedded rivers are resistant to change, and that laterally accreting surfaces may represent middle-late Holocene migration patterns. This is demonstrated by limited bank migration rates, anonymously tall (5 m+) meander bends with low width to depth ratios, and sediment profiles characterized by basal hardpan clays occasionally overlain by coarse gravel lag deposits. A C14 age of 8670 ± 30 years BP at river bed level also suggests that these channels, and associated floodplains, may be less dynamic over the long term when compared to the standard model of meandering, sand-bedded rivers.

Abstract ID: 33991

Final Number: ES31A-05

Title: The Dynamics of Glacial Till Erosion: Hydraulic Flume Tests on Samples from Medway Creek, London, ON

Presenter/First Author: Leila Anne Pike, McGill University, Portland,

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Co-authors: Peter Ashmore, University of Western Ontario, London, ON, Canada; Susan J Gaskin, McGill University, Montreal, QC, Canada

Abstract Body: The erosion of till material from the river bank of Medway Creek in London, Ontario was studied to determine the erosion mechanisms and critical shear stress of the till, and to understand how the alluvial cover, particularly the gravel particles, impacts the erosion process. Samples were collected from Medway Creek and were tested under a unidirectional current in a hydraulic flume at McGill University under a unidirectional current. Samples were tested under three separate sets of conditions: samples at their natural moisture content in clear flow conditions, air-dried samples in clear flow conditions, and samples at their natural moisture content with large gravel particles present in the flume. The two latter tests were performed to determine any effects that weathering and the presence of alluvial material may have in the erosion process. The results show that mass erosion was the dominant form of erosion, occurring around natural planes of weakness and irregularities, such as gravel particles, within the material. The critical shear stress was observed to be approximately 8 Pa. The effect of drying on the erosion process was extreme – the critical shear stress dropped to below 1 Pa and the structure of the cohesive material disintegrated. The presence of gravel particles led to increased surface erosion due to impacts and a more rapid progression of the erosion. In summary, the till erodes around planes of weakness and irregularities, till exposed to a wetting-drying is most at-risk of erosion, and the presence of gravel does not provide a protective layer over the till and instead lowers the critical shear stress.

Abstract ID: 35685

Final Number: ES31A-06

Title: Urbanization, Channel Adjustment, and Restoration of a Suburban Semi-Alluvial Creek: the Case Study of Wilket Creek in Toronto

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Co-authors: Margot Chapuis, , , ; Vernon Bevan, , , ; Emma Buckrell, , , ; Andre Roy, University of Waterloo, Waterloo, ON, Canada; John Parish, , , ; Ryan Ness, , , ; William Snodgrass, , ,

Abstract Body: Land use changes related to urbanization are known to have a profound impact on stream hydrology, sediment transport, ecology, and aesthetic value. Wilket Creek in Toronto is an excellent example of urban development in the 1960's and 70's because it is largely suburban, stormwater conveyance was massively increased, and a portion of the creek was preserved as a part of linear park. It is also semi-alluvial, which means that classic models of channel evolution may not be applicable. The objectives of the current study were to 1) assess the character and degree of channel change that has occurred since development, 2) determine whether channel enlargement is still ongoing, and 3) assess the likelihood of success for recent in-stream restoration efforts. Historic analysis was completed using aerial photographs, measurements from a relic channel, and a 15 year monitoring program of channel dimensions. Assessment of in-stream restoration efforts was completed using channel surveys, water-level gauges, and sediment tracking using RFID tracers. Results show that the stream network has been effectively 'pruned' as a result of development and channel enlargement is widespread. Flood hydrology is extremely flashy, with water level increases of over 1 m in less than an hour during floods. Nevertheless, a coarse layer of glacial till continues to exert an important influence on the channel gradient. Downstream of the incision of the channel through this layer, the channel is steeper and has enlarged approximately 3x from its historic dimensions, which is close to what is predicted from an analysis of the cumulative imperviousness. Continued instability has been found over the last 15 years as the channel adjusts its planform and develops a new wandering-type morphology. RFID tracking results show that the constructed pool-riffle morphology may succeed in reducing particle mobility despite the extreme hydrology.

Abstract ID: 34450

Final Number: ES31A-07

Title: Influence of Surficial Alluvium on Habitat Utilization by Fish in a Semi-Alluvial Clay-Bed Creek

Presenter/First Author: Parna ParsapourMoghaddam, University of Tehran, Tehran,

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Abstract Body: Morphodynamic processes play an essential role for the ecological integrity of river habitats. Fluvial dynamic processes and morphological changes in rivers can directly impact aquatic organisms; at different stages of their life-cycle they can be sensitive to sediment characteristics. Change in channel morphology can also influence habitat availability. Over the past few decades, efforts have been made to predict the influence of morphological change on aquatic habitat. Nevertheless, there are still large uncertainties in the degree to which erosion/deposition processes can impact the available habitat. The primary aim of the present study is to investigate relations between channel erodibility and habitat availability in a meandering semi-alluvial creek. The main focus of this paper is to examine whether channel erosion can affect the fish community, as the most commonly used indicator species, in two different meandering clay-bed reaches of Watts Creek in the City of Ottawa, Canada. These reaches have similar discharge and bed substrate, which consists of consolidated clay overlain discontinuously with surficial alluvium. However, one of these reaches has been destabilized due to meander confinement. In order to associate fish abundances with particular habitat features in the reach, habitat utilization by resident fish populations was evaluated in each reach. Finally, using a 3D morphodynamic model developed for the reach, along with the observed fish abundances, the effect of the channel instability and surficial alluvial material on habitat utilization is discussed.

Abstract ID: 34237

Final Number: ES31A-08

Title: A Noval Wave Estimator Based On The Central-upwind Scheme For Simulating Rapid Bed Erosion under Shallow Water Flows

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Co-authors: Julio Ángel Infante Sedano, , , ; Abdolmajid Mohammadian, Associate professor, Ottawa, ON, Canada

Published Material: The corresponding results are written in a paper submitted to the Journal of Hydraulic Research on 14 Jun 2014, and this paper is currently under review.

Abstract Body: A coupled numerical model with a novel wave estimator is developed to simulate the rapid bed-erosion under fast varying flows. To solve the hyperbolic governing bed-load sediment transport equation using a Godunov type Central-upwind scheme, a novel scheme estimating the numerical fluxes of bed-load terms using a different pair of bonding waves from hydrodynamic system is proposed. The two-dimensional shallow water equations are adopted to solve the hydrodynamic parameters. The morphology is updated by an Exner-based equation containing bed-load sediment transport as numerical flux terms. A general form of a bed-load transport formula with a complex definition of the bed-load coefficient is applied to calculate a universal solution of the eigenvalues of the Jacobian Matrix. The linear reconstruction of variables with a multi-dimensional slope limiter and the second-order Runge-Kutta scheme are employed to achieve higher accuracy in space and time. The proposed coupled model with novel wave estimator shows better stability and accuracy than the conventional decoupled models, which are verified by several numerical tests.

Abstract ID: 34163

Final Number: ES32A-01

Title: The Geomorphology of Ice Stream Beds: Recent Progress and Future Challenges

Presenter/First Author: Chris Stokes, University of Durham, Durham,

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Co-authors: Martin Margold, University of Durham, Durham, United Kingdom

Published Material: This is a review of the topic (previous work and future challenges). It obviously contains previously publihsed material, but also new unpublished material. The review itself is original and is being prepared for publication.

Abstract Body: Ice sheets primarily lose mass by melting and discharge via rapidly-flowing ice streams. Surface and basal melting (e.g. of ice shelves) are closely linked to atmospheric and oceanic conditions, but the mechanisms that drive changes in ice stream discharge are more complex, and influenced by conditions at their bed, which may act to sustain, enhance or inhibit their motion. Although explicit comparisons are rare, the ice-bed interface is similar to the 'boundary layer' in fluvial and aeolian environments, where shear stresses (both basal and lateral in the case of ice streams) oppose the flow of the overlying medium. The analogy extends further because processes within the boundary layer create a distinctive geomorphology that is often characterised by subglacial bedforms that resemble features in fluvial and aeolian environments. Their creation results from erosion, transport and deposition of sediment which, in turn, is intimately linked to the mechanisms of ice stream flow. The study of ice stream geomorphology is, therefore, critical to our understanding of their dynamics. Despite difficulty observing the subglacial environment, our understanding of ice stream geomorphology has grown rapidly in the last three decades, from almost complete ignorance to a reasonably detailed knowledge of their geomorphological imprint. This has been brought about by two main approaches: (i) geophysical investigation of modern (active) ice streams, and (ii) sedimentological and geomorphological investigation of well-preserved palaeo-ice stream beds. The aim of this paper is to review progress in these two main areas; highlight the key questions that remain; and discuss the key opportunities that are likely to arise that will enable them to be addressed. It becomes clear that whilst each of these two main approaches have led to important advances, they have often been viewed as separate sub-disciplines, with minimal cross-pollination of ideas and concepts, particularly with respect to how landforms can be securely linked to process. However, it is argued that future surveys of modern-ice stream beds are likely to offer unprecedented opportunities to study ice stream geomorphology that will require the convergence of ideas from each of these two main approaches, together with a third approach – numerical modelling.

Abstract ID: 33886

Final Number: ES32A-02

Title: Streamlined Landforms in Sweden: Core Types, Log-Normal Distributions and the Geomorphological Continuum

Presenter/First Author: Thomas Dowling, Lund University, Lund,

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Co-authors: Matteo Spagnolo, University of Aberdeen, Aberdeen, United Kingdom; Per Moller, Lund University, Lund, Sweden

Published Material: Inital findings where presented at AGU2014. The analysis of this is now complete and a paper stemming from this work is currently under-review for the journal 'Geomorphology'.

Abstract Body: The newly available Swedish National Height Model is a 2.0 m horizontal, and 0.01 m vertical, resolution digital elevation model (DEM) that is free at the point of use for researchers based at Swedish institutions. With coverage currently at ~90% of the country and due to be completed by 2015 this spatially extensive, high resolution, dataset has opened up new avenues of research for Quaternary geology in the country. The work presented here utilises the new DEM to map and evaluate more than 10,000 glacially streamlined landforms. The extracted morphological variables of length, width and height are then used to test recent conclusions drawn from the glacially streamlined landscape of Great Britain and North America/Canada, to assess the impact of different core types on the morphological expression of said features.

It is found that in common with drumlins found in the British Isles their characteristics can be described by a log-normal distribution, however the long tail of the features characteristic distributions a cause problems for statistical methods of evaluation. Furthermore a re-appraisal of some conclusions drawn by previous works as to the presence of a fundamental scaling law in streamlined feature elongation is necessary. Additionally; based on a limited sample size it has been found that it is not possible to differentiate a streamlined landform's core type based on their morphological characteristics taken as whole. However the length metric does show differences between core types, and therefore may bear further investigation.

Abstract ID: 35836

Final Number: ES32A-03

Title: Bed Deformation beneath the Baltic Ice Stream, Southern Sweden: Implications for the evolution of the subglacial system beneath short-lived, episodic ice streams

Presenter/First Author: Nathan R Hopkins, Lehigh University, Bethlehem, PA

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Co-authors: Edward B Evenson, Lehigh University, Bethlehem, PA; Johan Kleman, , , ; Kenneth P Kodama, Lehigh University, Riegelsville, PA

Published Material: Preliminary results of the local ice flow history near Dalby, Sweden, were presented by myself at the 2014 Geological Society of America Annual Meeting (October 19-22) in Vancouver, Canada. Implications for the evolution of the subglacial system were not included at this meeting.

Abstract Body: Temporal variability of the subglacial system is of critical importance for the dynamics of ice sheets, particularly in the case of ice streams. Herein, we explore the dynamics of the Baltic Ice Stream (BIS) through the application of Anisotropy of Magnetic Susceptibility (AMS) till fabric analysis. AMS provides a precise, unbiased, and robust assessment of the preferred orientations of silt-sized and smaller magnetic grains within the till matrix. AMS faithfully records shear strength and direction in laboratory and field situations where shear direction or ice flow is known (i.e., drumlins and flutes). In this study systematic AMS fabric analysis within an 8-meter section exposed in a quarry near Dalby, Skåne County, Sweden, reveals the dynamic nature of the BIS. This section contains over 6 meters of a dark grey, silt-clay BIS till overlain by a 1.5 m of the regional surface till – a weakly compacted, sand-rich diamicton likely deposited by the Scandinavian Ice Sheet (SIS) immediately prior to deglaciation. AMS fabric orientations in the BIS till display an apparent rotation of ice flow from northeasterly to the southwesterly, beginning approximately 0.5 m below and terminating coincident with a boulder line and discontinuous sand lenses located 3 meters from the base of the section. Above the boulder line, ice flow is from the SW. Additionally, systematic, non-linear trends in fabric strength (S_1 eigenvalue) and magnitude of anisotropy (P') punctuated by excursions coincident with the boulder line illustrate the temporal variability of bed deformation beneath the BIS during the late-stage Weichselian Young Baltic Advance (19-17ka). Each of these parameters display marked changes across the boulder line, indicating a pronounced change in the dynamics of the subglacial system during and following its formation. The surface till displays relatively high P' and susceptibilities; however, the five sample sites possessed weak fabrics (mean S_1 = 0.612) consistent with observations (e.g., lack of striated clasts) at the exposure indicating small amounts of shear. Fabric orientations from this unit indicate ice flow from the NNE indicating a SIS origin. These results have implications for the nature and evolution of bed deformation during the advance and retreat of short-lived ice streams.

Abstract ID: 36064

Final Number: ES32A-05

Title: Using sediment provenance to study ice streams in the Weddell Sea embayment of Antarctica

Presenter/First Author: Trevor Williams, Lamont Doherty Earth Obs, Palisades, NY

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Bremerhaven, Bremerhaven, Germany; Tina van de Flierdt, Imperial College London, London, SW7, United Kingdom; Stefanie A Brachfeld, Montclair State Univ, Upper Montclair, NJ; Adi Torfstein, Hebrew University of Jerusalem, Jerusalem, Israel; James Smith, British Antarctic Survey, Cambridge, United Kingdom; Claus-Dieter Hillenbrand, British Antarctic Survey, Cambridge, United Kingdom; Michael Flowerdew, , , ; Peter Braddock, , ,

Abstract Body: The geochemical and geochronological fingerprint of rock debris eroded and carried by ice streams may be used to identify the provenance of iceberg-rafted debris (IRD) in the marine sediment record. During deglacial times it has been shown that there is an increase in IRD accumulation in marine sediments underlying the western limb of the Weddell Gyre. We seek to find the provenance of this IRD, identify the ice streams contributing to the IRD load, and interpret the sequence of ice sheet retreat in the Weddell Sea embayment for the last three deglaciations.

In December 2014 we conducted fieldwork to collect samples of rock and sediment debris carried by three of the major ice streams draining the Weddell Sea embayment: the Foundation Ice Stream, the Academy Glacier, and the Recovery Glacier. We sampled both modern moraines at the edges of the ice streams and older till on hillsides next to the ice streams. In addition to rocks representing the geology of local outcrops, we found that each of the three ice streams carries a characteristic set of erratic lithologies from further upstream. The erratics also give clues to the geology hidden under the ice sheet. Over the next year we will characterize the mineralogy, $^{40}Ar/^{39}Ar$ thermochronology, U-Pb geochronology, Nd isotopic signatures, and Fe-Ti oxide compositions of these tills and erratics. The same measurements will be made on subglacial till and proximal glaciomarine sediment from core sites located at the edge of the Filchner and Ronne Ice Shelves along ice flow lines extending from the ice streams, collected on past expeditions of the RV Polarstern.

We will present initial results from this study in the context of our previous work on IRD and sediment provenance offshore of Antarctica, and discuss the possibilities for using provenance to understand ice stream dynamics over the course of glacial cycles.

Abstract ID: 34120

Final Number: ES32A-06

Title: Bedrock Streamlining in Palaeo-ice streams: a Review of Bedrock Properties, Formation Mechanisms and Glaciological Implications

Presenter/First Author: Maarten Krabbendam, British Geological Survey Edinburgh, Edinburgh,

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Co-authors: Nicholas Eyles, University of Toronto, Claremont, ON, Canada; Niko Putkinen, Geological Survey of Finland, Kokkola, Finland; Tom Bradwell, British Geological Survey, Edinburgh, United Kingdom

Abstract Body: Highly elongate bedrock landforms, including bedrock megagrooves, are increasingly recognised at the beds of former ice sheets. In contrast to soft-bedded elongate bedforms they i) are entirely formed by subglacial erosion, ii) may be formed over several glaciations; iii) are strongly influenced by bedrock geology. However, both soft-bedded and hard-bedded elongate bedforms require sustained unidirectional ice flow at the beds of (palaeo-) ice streams. Bedrock megagrooves occur in palaeo-ice streams where topographic steering is strong (Nass River, BC); weak (Ullapool, Tyne Gap, UK) or near-absent (Ontario, Quebec).

Bedrock control and formation mechanisms can be grouped:

1) Megagrooves on dipslopes/bedding planes (Sudbury, South Baymouth, ON; Assynt, UK); or gneiss (Georgian Bay, ON); often small-amplitude and wavelength, with round cross-profile and probably formed by abrasion focussed by debris concentrations;

2) Megagrooves parallel to bedrock strike. Low-angle dips often result in strongly asymmetric, angular cross-sections (Tyne Gap, Ullapool, UK; Isle Royale, Lake Superior); steeper dips give more symmetric grooves (Knapdale/Jura, UK). Lateral plucking is important for their formation, but in heterogeneous strata differential abrasion may also be significant.

3) Megagrooves at high angles to bedrock strike. Where strata dip with ice flow, 'bullet-shaped' mega-rock drumlins may develop (Niagara Escarpment, ON; Anticosti island, QC), with focussed erosion possibly guided by fractures and pre-glacial stream valleys.

The glaciological significance of megagrooves is that most grooved terrain is smooth parallel to ice flow: there are few bedrock obstacles, and no need for Weertman/Schoof type sliding. Instead, basal drag is controlled by a simple friction law, with (low) friction coefficients dependent on debris content. It is this smoothing that, once established, means that grooved terrain will steer and enhance fast ice flow during successive glaciations.

Abstract ID: 34376

Final Number: ES32A-07

Title: Erosional Origin for Drumlins by Subglacial Erodent Layers: A Tribological Model

Presenter/First Author: Nicholas Eyles, University of Toronto, Claremont, ON

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Co-authors: Shane Sookhan, University of Toronto, Pickering, Canada; Niko Putkinen, Geological Survey of Finland, Kokkola, Finland

Abstract Body: We explore the hypothesis that drumlins and megaflutes (regardless of their cores) are residual immobile landforms formed by erosion of pre-existing sediment (or rock) below a mobile abrasive carpet of deforming subglacial debris; we draw on the industrial science of tribology where comparable remnant ridges and grooves ('wear tracks') are formed by abrasion below an 'erodent layer' at the interface of surfaces in relative motion to each other. Lineated surfaces are not unique to glacial environments and are produced by erodent layers at the base of gravity-driven mass flow deposits such as rock avalanches, landslides and debris flows, and are also very common along fault traces. Correspondingly, mega-scale glacially lineated surfaces are identified as wear tracks cut by a thin erodent layer consisting of deforming subglacial diamictic debris with erodents in the form of clast-rich debris or stiffer (frozen?) rafts entrained from the underlying substrate. Swales and megagrooves are cut into older pre-existing till sheets, sediment or rock leaving remnant high-standing drumlins and megaflute ridges with autochthonous cores of till, other sediment or rock. The common erosional origin of rock drumlins and 'sediment' drumlins explains their close juxtaposition in many drumlin fields. Many drumlins have till cores: the model predicts widespread deposition of thick subglacial till earlier in the glacial cycle followed by erosion and drumlinization accompanying the onset of ice streaming late in the glacial cycle. This implies widespread transient storage of till below ice sheets.

Abstract ID: 33260

Final Number: ES33A-01

Title: Integrative Application of Traditional and Cutting-edge Techniques to Reconstruct Holocene Earth Surface Processes and Landscape Dynamics – A Case Study from the North German Lowland

Presenter/First Author: Thomas A Raab, BTU Cottbus, Cottbus,

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Co-authors: Alexandra Raab, Brandenburg University of Technology, Cottbus, Germany; Melanie Takla, Brandenburg University of Technology Cottbus–Senftenberg, Cottbus, Germany; Alexander Nicolay, Brandenburg Technical University Cottbus, Cottbus, Germany; Florian Hirsch, BTU Cottbus, Cottbus, Germany; Anna Schneider, Brandenburg Technical University Cottbus, Cottbus, Germany; Horst Rösler, Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum, Zossen, Germany

Published Material: Some findings were recently accepted for publication inArchaeological and Anthropological SciencesRaab, T. et al.: Opencast mines in South Brandenburg (Germany) - Archives for Late Quaternary landscape development and human-induced land use changes We will highlight important results from this publication and use these highligths to show the integrative application of our techniques. Moreover the most recent findings will be presented (oral presentation is preferred)

Abstract Body: This study outlines the opportunities to reconstruct Holocene landscape dynamics in active opencast lignite mines in southern Brandenburg (Germany). Studies on extensive outcrops that address geomorphology, pedology and archaeology provide unique insights into human-induced environmental changes. Our approach uses a variety of traditional and cutting-edge techniques to characterize small-scale landforms (high-resolution DEMs by micro-drone and LiDAR), to analyze soils and substrate properties in the field (GPR, ERT, geomagnetics, Field Portable XRF and XRD) and to provide chronological information (OSL, 14C, tree-ring dating). This approach is combined with a GIS for data integration. We present the most recent results and review important findings from the last several years. Studies conducted in the opencast mines focus on soil development and Late Quaternary geomorphodynamics and as well as past land use and the legacy of agriculture and woodland use.

Our results regarding the human-induced geomorphodynamics are similar to those in other regions in Central Europe, but we also observe regional differences caused by the local setting, e.g., intensification of soil erosion coinciding with the expansion of farming of cultivated lands in the Slavic Middle Ages. By analyzing LiDAR data the largest area of historical charcoal production in the Northern European Lowland (NEL) has been revealed.

We are clearly only beginning to understand the massive dimensions of charcoal production in the region and the impact on late Holocene geomorphodynamics. The usage of new high-resolution imagery is essential to identify small-scale anthropogenic landforms hidden in the landscape. Future work will consist of developing and improving our integrative approach. However, comprehensive ground truth data provided by the archaeological prospections in the open-cast mines are an excellent basis for GIS-based analyses of high-resolution ALS data and geomorphological research.

Abstract ID: 34161

Final Number: ES33A-02

Title: Tectono-geomorphology of the Timiskaming Graben, Western Quebec Seismic Zone

Presenter/First Author: Katherine E Wallace, University of Toronto, Toronto, ON

Presenter/First Author Email: kwallace@utsc.utoronto.ca

Co-authors: Nicholas Eyles, University of Toronto, Claremont, ON, Canada; Michael Doughty, University of Toronto, Toronto, ON, Canada

Abstract Body: The Western Quebec Seismic Zone (WQSZ) is one of the most seismically active areas of the 'stable' North American craton where intraplate earthquakes pose a risk to older infrastructure built on soft glacial marine clays in the heavily populated cities of Ottawa and Montreal. Evidence suggests that these earthquakes are not a function of a short-lived phase of postglacial rebound but reflect ongoing crustal stresses and intraplate deformation. Within the WQSZ the Timiskaming Graben (TG) is an extension of the Ottawa-Bonnechere Graben and forms a prominent 50 km-wide fault-bounded morphotectonic depression along the Ontario/Quebec border. Lakes Timiskaming and Kipewa lie along the graben and their bottom sediments are extensively deformed by ongoing neotectonic activity in the form of slumps, debris flows and faults. This paper describes the results of on land investigation of the floor of TG surrounding these lakes mapping neotectonic fault scarps, landslides and liquefaction structures ('sand blows') using satellite imagery, land-based seismic and ground penetrating radar.

Abstract ID: 34785

Final Number: ES33A-03

Title: Spatial extent of intermediate-time scale vertical tectonic motions across the eastern Zagros, Iran

Presenter/First Author: Behnam - Oveisi, Geological Survey of Iran, Tehran,

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Co-authors: Peter Van Der Beek, University Joseph Fourier Grenoble, Grenboble, France; Julien Carcaillet, University Joseph Fourier Grenoble, Grenboble, France

Abstract Body: The Zagros fold belt of Iran marks the present southern front of the broad Arabia-Eurasia collision zone. GPS and seismicity show the Zagros absorbs an important part of the overall convergence. Our study area covers south-eastern Zagros, where the continental collision (the Zagros) switches to the oceanic subduction (the Makran wedge). We have mapped deformed fluvial terraces along the Kol River using kinematic GPS and high-resolution imagery in order to unravel the spatial extent of vertical displacements and to analyze active deformation and its implications for seismicity. The Kol River intersects a few active folds and faults, as well as Mountain Front Fault (MFF) and High Zagros Fault (HZF). The long profile of the river shows two different spatial extent of vertical incision, 1) short-wavelength incision (d_s), controlled by structural reactivation of pre-existing structures and lateral folds propagation (plunge panel growth), and 2) long-wavelength incision (d_n) toward the entire course of the river (toward the HZF). We attribute both distribution patterns of vertical incision to reflect differential rock uplift along the river. The d_s and d_n are respectively consistent and inconsistent with the GPS strain distribution and the seismicity pattern. We suggest a young scenario of geologic strain accommodation over the active ramp of the MFF. On the other side, we estimate limited slip for the HZF, consistence with the current hypothesis about uplift propagation across the Zagros belt and through time toward the foreland. Cosmogenic nuclide exposure ages of the Kol River strath terraces (in process) improve understanding of recent crustal deformation rates and its variations through time and space across and eastern Zagros. Such information helps to provides more reliable estimates of seismic hazard for the Zagros, amongst the world's most seismically active mountain ranges.

Abstract ID: 36145

Final Number: ES33A-04

Title: Examining Interactions Between Large Woody Debris, Beach-dune Morphodynamics and Shoreline Positions Using Remotely Sensed Data

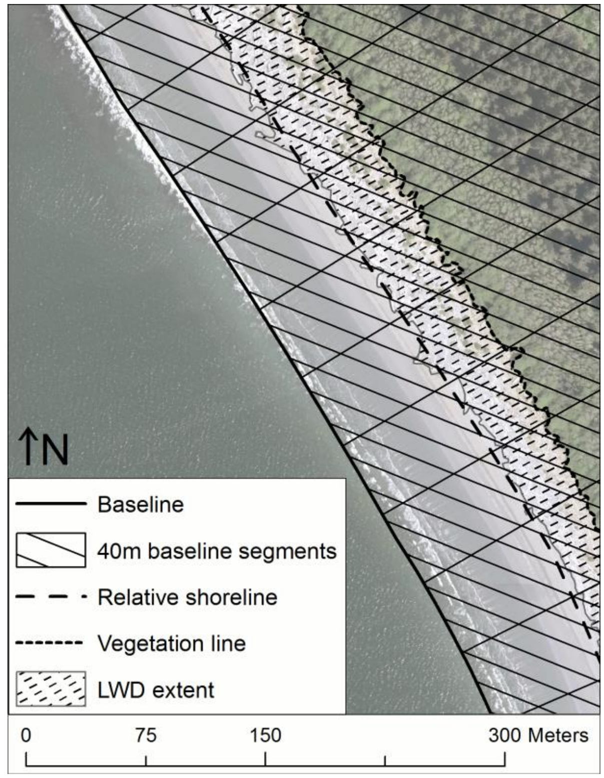
Presenter/First Author: Ian James Walker, Department of Geography University of Victoria, Victoria, BC

Presenter/First Author Email: ijwalker@uvic.ca

Co-authors: Michael J Grilliot, , , ; Jordan BR Eamer, , ,

Published Material: A portion of the talk reports on an analytical method using LiDAR and related results from a 2010 study i published in Geomorphology 118: 33-47.

Abstract Body: Large woody debris (LWD) is widespread on beaches in British Columbia and consists mostly of historic logging material. In some areas, LWD traps significant amounts of sediment and can modify coastal sediment budgets, alter beach-dune morphodynamics and affect shoreline positions and vegetation stabilization rates. This paper presents research that examines relations between LWD, sediment storage, and beach-dune geomorphology using remotely sensed data. One method uses aerial LiDAR and orthophography to quantify aeolian sand deposition in LWD on Haida Gwaii. Sand storage ranged from 9.19×10^4 to 1.39×10^5 kg m^{-1} beach width with a further storage capacity of 1.04 to 1.70×10^4 kg m^{-1}. The capacity for deposition in LWD modulates landward sand transfer and affects foredune sediment budgets and morphodynamics. The additional store of sediment in LWD can enhance incipient dune development and can increase the buffering capacity of beaches against wave erosion and storm surges. Another method uses the USGS Digital Shoreline Analysis System and a supervised classification to analyze changes in LWD coverage, shoreline position and vegetation colonization from historical aerial photography at Pacheedaht Beach near Port Renfrew, BC. LWD coverage declined between 1968 and 2013 by 38%, which is consistent with other findings in the region. Despite these declines, the shoreline prograded 71.6 m and vegetation colonized seaward 48.6 m atop former dune and LWD deposits. These trends are interspersed, however, with intervals of shoreline retreat and pronounced LWD decline. Trends in shoreline position and LWD coverage are generally synchronous suggesting a direct, positive relationship between LWD and shoreline change. This is hypothesized to result from increased sediment storage in LWD and enhanced beach-dune development. Provided that key sources of error are quantified and incorporated, these methods provide simple, systematic and statistically robust means to quantify the geomorphic and sediment budget impacts of LWD on beaches.



Abstract ID: 36305

Final Number: ES33A-05

Title: Morphodynamics of the Liwa Megabarchans as a Titan Analog : Reworking of Giant Linear Dunes by Unidirectional Winds

Presenter/First Author: Ralph D Lorenz, Applied Physics Laboratory Johns Hopkins, Laurel, MD

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Co-authors: Jani Radebaugh, Brigham Young University, Provo, UT

Published Material: paper is under review at GeoResJ

Abstract Body: We document the sand dynamics at the unusual megabarchans that begin abruptly at the Liwa Oasis in the northeastern Rub' Al Khali desert in the United Arab Emirates (U.A.E.). Their close, regular arrangement is not consistent with a conventional barchan corridor, and we propose that the dunes must have grown to their great (>100m) height as linear dunes, which are presently still more evident to the south and east of Liwa, but are now exposed to a unidirectional wind regime that forms a consistent slip face orientation and is eroding the linears into discrete but ephemeral barchan forms. We estimate present-day sand fluxes of ~4 m^3/yr/m from the ~0.1 m/yr advance of megabarchan slip faces and from combined field and satellite observations of the migration of small barchans across the interdune areas. These suggest a ~20kyr timescale to evolve into the present disequilibrium configuration, consistent with estimates of paleowind changes in Arabia. We note recent flume experiments demonstrating hooked barchans and a linear-barchan transition in mixed winds, and that similar linear-megabarchan transitions are seen on Saturn's moon Titan.

Abstract ID: 34169

Final Number: ES34A-0095

Title: 'Traction ribs' on the palaeo-ice stream tracks of the Interior Plains, North America

Presenter/First Author: Chris Stokes, University of Durham, Durham,

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Co-authors: Martin Margold, University of Durham, Durham, United Kingdom

Abstract Body: Spatially distinct pattern of basal shear stress beneath a number of Antarctic and Greenlandic ice streams has recently been discovered by inverse methods using high resolution data of ice velocity, elevation and thickness (Sergienko and Hindmarsh, 2013: *Science*). Surrounded by regions of near-zero basal shear stress, these areas of high basal shear stress have been termed 'traction ribs' and hold important implications for the force balance of ice streams. The cause of the traction ribs is unknown (i.e. whether they have a topographic expression), but their horizontal dimensions and pattern lie somewhere between typical ribbed (Rogen) moraines and recently described mega-scale ribbed moraines identified on palaeo-ice sheet beds. However, whilst both of these landform types form with their long axis transverse to the ice flow direction, the traction ribs are most commonly oriented oblique to the ice flow at angles of 30-60 degrees. Here, we report new findings from the beds of palaeo-ice streams on the Interior Plains in Alberta and Saskatchewan where landform assemblages, similar to traction ribs, occur at several sites. Individual landforms at the mapped sites have typical lengths (transverse to flow) of 5-10 km, widths of ~2 km, and their down-stream spacing is ~2-3 km. As such, they appear to represent an intermediate scale of ribbed landform that overlaps with the more extreme (larger) values of classic ribbed moraine and the smaller values of mega-ribs. Unlike mega-ribs and ribbed moraines, we also note that many of the ribbed features we mapped are aligned obliquely to ice flow direction at angles that mimic the arcuate patterns of traction ribs seen under modern ice streams. Profiles across the ridges indicate that they have amplitudes of 10-15 m, which is comparable, but slightly lower than the mean value for ribbed moraines. We therefore suggest that traction ribs have a topographic expression that sits on a continuum between ribbed moraine and mega-ribs. However, it is not clear what mechanisms lead to their formation or how widespread they are on other palaeo-ice stream beds. Future work might search for these landforms and their assemblages using higher resolution DEMs and fieldwork would allow sedimentological investigation of till properties and characteristics.

Abstract ID: 34355

Final Number: ES34A-0096

Title: LiDAR-based Volume Assessment of the Wadena Drumlin Field and End Moraines, Minnesota, USA: Evaluating an Erosional Origin for Mega-scale Glacially Lineated Terrains

Presenter: Shane Sookhan, University of Toronto, Pickering,

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First Author Student?: No

Co-authors: Niko Putkinen, Geological Survey of Finland, Kokkola, Finland

Abstract Body: Mega-scale glacially lineated terrains (MSGL) are widely recognised as the geomorphic footprint of fast-flowing paleo ice streams within otherwise slowly moving ice sheets. MSGL is common in Minnesota, USA, reflecting the convergence of several ice streams within the southern sector of the Laurentide Ice Sheet. The Wadena drumlin field of west central Minnesota consists of an estimated 2000 streamlined subglacial bedforms over an area of about 7500 km2. The field lies within a complex upland interlobate area surrounded by prominent end moraines with the Alexandria Moraine on its southern and western margins possibly marking the outer extent of the southwesterly-flowing Wadena Ice Stream at the time of drumlin formation. Light Detection and Ranging (LiDAR) data are revealing much new detail of the morphology of drumlins. This presentation posits that they are primarily residual landforms formed by erosion of a pre-existing sediment bed by a thin mobile 'erodent layer' of deforming diamictic debris that delivered subglacial debris to build morainal landforms at the outer margin of the drumlin field. We evaluate the erosional hypothesis by using a newly developed quantitative methodology based on relief curvature analysis of LiDAR imagery to evaluate subglacial debris fluxes below the Wadena Lobe.

Abstract ID: 35287

Final Number: ES34A-0097

Title: Streamlined and Lobate Landforms, Relating to Successive Ice Flows in the Smallwood Reservoir, Northern Labrador

Presenter/First Author: Roger C. Paulen, Geological Survey of Canada, Ottawa, ON

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Co-authors: Jessey M. Rice, University of Waterloo, Waterloo, ON, Canada; Beth McClenaghan, Geological Survey of Canada, Ottawa, ON, Canada

Abstract Body: Reconstruction of past ice-flow trajectories, their associated landforms and glacial landsystems are fundamental for successful application of drift prospecting as it provides information on dispersal characteristics of former Pleistocene ice sheets. The sequence of striation trends provides a complete chronology of ice-flow events, which is inscribed on many outcrops of the Smallwood Reservoir in Labrador, including the oldest documented ice flow to the northeast which originated in the Quebec Highlands. Local glacial landforms, however, do not reflect this oldest ice flow event. Lobate or reoriented landforms, with two principal axes parallel to later phase ice movements, occur within the Smallwood Reservoir. These lobate landforms have a multi-phase origin. The first and major landform-forming ice-flow phase was southeastward from ice flowing radially from the Hudson Ice Centre in northern Quebec. Nucleation of drumlin and other streamlined landform formation may have been pre-existing glacial sediments or bedrock outcrops. A subsequent eastward ice-flow remobilized the previously deposited tills and created elongated landforms with high length to width ratios, possibly indicative of fast flowing ice that surged to the Labrador coast. Esker systems in the region are also trend with this late eastward flow. Studies are ongoing to correlate the glacial record with till provenance, as part of the Geological

Survey of Canada’s GEM2 Hudson-Ungava Project.

Abstract ID: 35750

Final Number: ES34A-0098

Title: Ice stream catchments and till production records in core regions of the Laurentide Ice Sheet

Presenter/First Author: Martin Ross, University of Waterloo, Waterloo, ON

Presenter/First Author Email: maross@uwaterloo.ca

Co-authors: Tyler J Hodder, , ,

Published Material: Some of the material that will be presented has been shown at the GSA meeting in Vancouver. The majority is new and not yet submitted to a journal.

Abstract Body: Evidence of crosscutting flowsets in core regions of the Laurentide Ice Sheet (LIS) has lead to the idea that ice divide migration is one important factor of landscape evolution and till production in these areas, with deglacial records being possibly over-represented. Here we report on evidence suggesting that ice stream catchments extending far inside ice sheets is another important mechanism to consider for certain flowsets and to explain thick till successions in core regions of the LIS. In ‘ice divide’ areas, such as central mainland Nunavut on the Canadian Shield, geophysics, drillcores, and river sections show that till successions 10s of meters thick occur in places and appear to extend laterally across the till plain. In most cases, the thickest till sheet has a lithological provenance and fabric signature consistent with the orientation of a prominent landform imprint that is partially overprinted by the deglacial record. These well-preserved, but overprinted flowsets fit the criteria for paleo-ice streams such as landform elongation, converging patterns, and overall dimension/geometry. When pieced together they appear to form large systems that can be associated to an ice flow phase also responsible for widespread till production. Hence, these preserved sediments and landforms are interpreted as the record of a large and thick LIS. The partially overprinting sediment-landsystems are confidently assigned to the deglaciation. In one study area in central Nunavut, the associated surficial retreat phase till is thin (0-5 m) relative to the underlying till, which reaches up to 12 m. Ice stream catchments extending far inside an ice sheet may thus contribute in a major way to the evolution of glacial landscapes and to the stratigraphy of core regions of ice sheets. Ice stream dynamics at times of ice sheet maxima is not yet well understood and represent one important knowledge gap towards understanding ice sheets.

Abstract ID: 33126

Final Number: ES34B-0101

Title: Projecting Landslide Susceptibility Maps for Generating Future Scenarios: A Case Study of Cox’s Bazar Municipality, Bangladesh.

Presenter/First Author: Bayes Ahmed, University College London, Dhaka,

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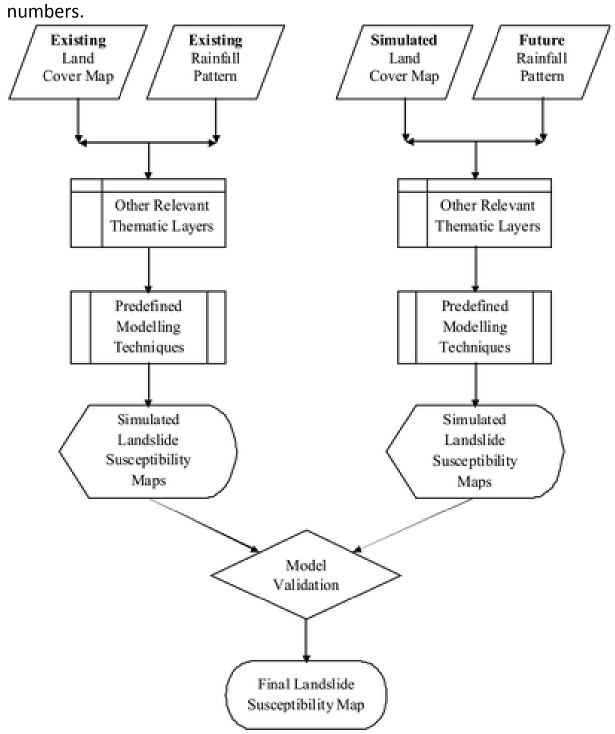
Abstract Body: Rainfall induced landslides are a common problem in the highly urbanized hilly areas of Cox’s Bazar Municipality (CBM) in Bangladesh. During monsoon it causes human casualties, property damage and economic loss. Therefore, it is important to identify the future landslide susceptible areas in advance so that it can redeem the severity of possible landslide disasters. Generating the existing Landslide Susceptibility Maps (LSM), using relevant factor maps, is a common practice among the scientists. But this paper is going to propose an innovative technique to project the future LSM. The basic concept of this new technique is to project the future scenario of the dynamic variables. Then using the projected dynamic variables and the existing static variables, it is possible to generate the future LSM of CBM (see attached figure). In this case, the dynamic variables are – the land cover and precipitation maps; and the static variables are – the slope, distance to road, distance to drain, distance to lineaments, geology and other relevant soil maps. The existing LSM is validated using the relative operating characteristic curves with an inventory map of 122 landslides in CBM. The land cover map is projected using the artificial neural network technique in IDRISI Taiga, and the parameters for rainfall projection are generated using the ‘RClimdex’ statistical package in R. The projected LSM using the new concept gives high accuracy (>85%) and is applicable for any landslide-prone area. The decision makers can incorporate this new concept in the country’s disaster management plan and help reduce human casualties in significant numbers.



Abstract ID: 34075

Final Number: ES34B-0102

Title: GIS-aided Statistical Landslide Susceptibility Modeling And Mapping Of Antipolo Rizal (Philippines)

Presenter/First Author: Jaime Angelo Sanvictores Victor, University of the Philippines, Quezon City,

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Abstract Body: Slope instability associated with heavy rainfall or earthquake is a familiar geotechnical problem in the Philippines. The main objective of this study is to perform a detailed landslide susceptibility assessment of Antipolo City. The statistical method of assessment used was logistic regression. Landslide inventory was done through interpretation of aerial photographs and satellite images with corresponding field verification. In this study, morphologic and non-morphologic factors contributing to landslide occurrence and their corresponding spatial relationships were considered. The analysis of landslide susceptibility was implemented in a Geographic Information System (GIS). The 17320 randomly selected datasets were divided into training and test data sets. K- cross fold validation is done with k= 5. The subsamples is then fitted five times with k-1 training data set and the remaining fold as the validation data set. The AUROC of each model is validated using each corresponding data set. The AUROC of the five models are; 0.978, 0.977, 0.977, 0.974, and 0.979 respectively, implying that the models are effective in correctly predicting the occurrence and non-occurrence of landslide activity. Field verification was also done.The landslide susceptibility map was then generated from the model. It is classified into four categories; low, moderate, high and very high susceptibility. The study also shows that almost 40% of Antipolo City have been assessed to be potentially dangerous areas in terms of landslide occurrence.

Abstract ID: 35757

Final Number: ES41A-01

Title: Physical and Chemical Predictors of Human Perceptions of Water Quality in Southwestern Ozark Rivers

Presenter/First Author: Amie West, University of Arkansas, Fayetteville, AR

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Co-authors: Justin Nolan, , , ; J. Thad Scott, University of Arkansas, Fayetteville, AR

Abstract Body: The rivers of Arkansas' southwestern Ozarks are ecologically, culturally, and economically significant. They support rich biodiversity and high endemism, and are popular public recreation destinations. The capacity to communicate effectively between human groups with vested interest in these rivers hinges on understanding the nature of water resource perceptions and the extent to which they vary intra-culturally. Ozark rivers are revered in the region and hold special designations by the Arkansas Department of Environmental Quality for their ecologic and scenic value. To investigate perceptions of water quality we deployed surveys and conducted interviews with water quality experts and non-experts. A pile-sort task was administered using images of the five rivers, for which we also collected chemical and physical data. Preliminary results indicate (1) cultural consensus in perceptions of water quality exists among all respondents and (2) water quality perceptions can be predicted by total suspended solids concentrations, chlorophyll-a concentrations, color, and horizontal visibility. The consensus suggests that human evaluation of water quality is guided by culturally-constructed criteria, regardless of respondent expertise. These results also imply that measured physical and chemical parameters may be communicated meaningfully across groups in terms of how they relate to visible attributes. A defined range of measured parameters may also be linked to favorable or unfavorable user perception that can inform resource management.

Abstract ID: 34921

Final Number: ES41A-02

Title: *River reach classification at high spatial resolution to support the assessment of environmental flow requirements in Canada*

Presenter/First Author: Camille Ouellet Dallaire, McGill University, Montreal, QC

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Co-authors: Bernhard Lehner, McGill University, Montreal, QC, Canada

Abstract Body: More than three million kilometers of rivers flow through the Canadian landscape and provide a wide spectrum of vital services and goods to the Canadian society. In the light of future environmental and climate changes and competing interests putting high pressure on river ecosystems, we need to develop sustainable management practices so that our communities are prepared and resilient to cope with potential alterations.

Environmental flow requirements (EFR) can be defined as the water regime provided within a river to maintain ecosystems and their benefits. Most approaches to assess EFR rely on hydrological indices at the daily time step to identify critical components of river regimes that maintain a specific ecological status. However, daily discharge data is not available for all Canadian rivers.

River classifications are used in EFR assessments to define groups of rivers that have similar hydrological characteristics. This study proposes a new river type classification for Canada facilitated by the HydroSHEDS database at 500m pixel resolution. HydroSHEDS (HYDROlogical SHuttle Elevation Derivatives at multiple Scales) encompasses a suite of hydrologically relevant datasets including a river network and monthly discharge data at the Canadian scale.

This project is based on the Global River Classification framework relying on the creation of multiple sub-classifications based on different disciplines; in this case, integrating hydrology, physiography, climate, and geomorphology. Records from HYDAT (National Water data archive from Environment Canada) will be used to investigate the correlation between monthly (HydroSHEDS) and daily (HYDAT) discharge indices within the derived river types. This information will then be used to develop an appropriate suite of monthly discharge indices to facilitate the definition of EFR at large scales.

Abstract ID: 34784

Final Number: ES41A-03

Title: Applications in Fluvial Geomorphology : a Multi-Scale Perspective.

Presenter/First Author: Hervé Piegay, CNRS, Paris Cedex 16,

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Abstract Body: Fluvial geomorphology is providing critical knowledge and tools for improving river management, restoration or conservation because river managers recently widened their scope in term of spatial and temporal scales, following in Europe for example the implementation of the Water Framework Directive and the wish to promote sustainable solutions. As a consequence, scientific feedbacks for improving or designing management strategies can be expected at different spatial scales according to stake-holder expectations. Top-down approaches usually promoted by regional or national decision-makers for planning and targeting actions can capitalize on conceptual development (reference, valuiing process versus form, assessing success of policies) as well as on efforts to highlight riverscape organisation and provide tools to target actions (so-called “geomorphic regionalisation”). Bottom-up approaches, promoted at a local scale on reaches of several 10th of km or smaller basins (e.g., 1000 to 2000 km2), usually performed to identify sustainable solutions in term of ecological benefits or natural hasard assessment can be nourished by geomorphic diagnosis and retrospective analysis, experiment, modelling and risk analysis allowing to set the river trajectory and identify objectives for river improvement or conservation. A few examples will be introduced to highlight the different approaches and open the debate on the implication of the discipline in practices. The geomorphologist as actor of social arenes has also to be considered, as such context influences the knowledge production and question the scientific independence and the way of doing research.

Abstract ID: 35576

Final Number: ES41A-04

Title: Riparian Forest Development Following Channelization and Dams on Large Rivers: the Role of Management History in Setting Divergent Ecological Pathways

Presenter/First Author: John C Stella, SUNY College of Environmental Science and Forestry, Syracuse, NY

Presenter/First Author Email: stella@esf.edu

Co-authors: Hervé Piegay, CNRS, Paris Cedex 16, France

Published Material: Approximately 30% of this material was presented as a poster at the 2014 AGU meeting in San Francisco.

Abstract Body: River management profoundly alters riparian forests, which respond to changes in channel mobility and disturbance regimes imposed by channel engineering, flow regulation and floodplain development. However, the specific impacts to riparian corridors (e.g., forest extent and community dynamics) can differ greatly among rivers, even ones with similar climates and development pressures, because of differences in river management history. In this study, we compared contemporary riparian forest and floodplain development along two of the most heavily modified rivers in the mediterranean-climate biome, the middle Sacramento (California, USA) and the lower Rhône (SE France). In both basins, we set out to understand how river management has affected the composition, sustainability, and restoration potential of the riparian zone at a large spatial scale. We conducted extensive forest inventories and sampled fine sediment depth in regulated, 160-km reaches within both systems, and compared pre- versus post-dam patterns of deposition and linked forest development.

On the Sacramento, where channel migration still occurs and drives new forest development, tree composition shifted across a chronosequence of 110 years. The transition from willow to cottonwood (*Populus*) occurred within 20 years, and the transition to mixed forest started after 50-60 years. On the Rhône, where the river was extensively engineered for navigation and later diverted for hydropower, the pre- versus post-dam surfaces at each site showed less of a shift in species composition, but had more subtle characteristics related to basal area growth and cover of shrubs and vines. Notably, the channelized Rhône had an almost complete absence of small stems of pioneer willows and poplars, portending a long-term dominance by post-pioneer communities in the future. Both rivers showed a strong understory presence on young floodplains by *Acer negundo* (box elder), which is non-native and invasive in Europe, suggesting similar processes of colonization and propagation in both systems. Overall, the Sacramento can serve as a predictive reference system for the Rhône, where significant restoration efforts are underway to improve riparian structure and function in diverted river reaches.

Abstract ID: 34134

Final Number: ES41A-05

Title: Climate and human forcing of Alpine fluvial processes in the Anthropocene

Presenter/First Author: Stuart N Lane, University of Lausanne, Lausanne,

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Co-authors: Maarten Bakker, , , ; Daniela Balin, , , ; Chrystelle Gabbud, , , ; Natan Micheletti, , ,

Published Material: Earlier versions of results were presented at the Riverflow 2014 conference.

Abstract Body: River flow in Alpine environments is likely to be highly sensitive to both: (a) climate change; and (b) human impacts (e.g. flow abstraction). Here we compare river flow and sediment flux of two Alpine drainage basins over the last 7 decades, one basin largely unimpacted by human activities (the Avançon), one strongly impacted by flow abstraction (the Borgne d'Arolla), so as to tease how climate forcing acts in isolation but also combines to impact upon fluvial processes.

First, reconstruction of the Avançon flow and sediment transport capacity shows that variability in temperature, through its effect upon snow accumulation and so the intra-annual distribution of runoff, significantly impacts upon sediment transport capacity. We observe a linkage between this increased river flow, river incision and terrace formation during runs of years that are snowier than average; and sediment accumulation and increases in the active width when warmer. Although changes in basin sediment delivery could also be responsible for these processes, we cannot exclude climate forcing of river flow as a plausible hypothesis for observed river morphodynamics.

Second, for the Borgne d'Arolla, abstraction of flow at intakes has very major impacts upon sediment deposition in the 20 km of studied river downstream. We show a slow-moving sediment wave linked to substantial reduction in the duration of possible sediment transport. But, this human forcing was hard to distinguish from climate forcing over the same period, and an observed increase in sediment transport capacity.

Thus, whilst both climate and human effects can have major impacts upon river flow and hence upon sediment flux and river channel morphodynamics, separating these effects is exceptionally difficult. Management systems have evolved continually both in response to climate forcing but also human forcing itself, and their effects on river dynamics. We need to understand climate and human forcing of Alpine rivers as co-evolving.

Abstract ID: 35130

Final Number: ES41A-06

Title: Improving Salmon Management with Automated Habitat Characterization and Functional Habitat Connectivity

Presenter/First Author: Mathieu L Roy, University of Montreal, Montreal, QC

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Co-authors: Céline Le Pichon, Irstea, Antony, France; Normand Bergeron, INRS, Quebec, QC, Canada; Marc Mingelbier, ministère des Forêts de la Faune et des Parcs, Quebec, Canada; Jean-Nicolas Bujold, ministère des Forêts de la Faune et des Parcs, Quebec, Canada

Abstract Body: Currently, Atlantic salmon conservation requirements and management targets established by the Quebec Wildlife Service rely on a model linking a physical habitat quality index and the number of migrating smolts monitored for several rivers. The production capacity of other rivers is then extrapolated using estimates of habitat quality based on channel width, substrate and morphohydraulic reach types (pools, riffles, meanders, channels, rapids, lakes). However, accumulating evidence suggest that besides habitat quality, the spatial arrangement of functional habitats patches (i.e. specific to life stages (fry, parr, adult) or function (feeding, shelter, spawning)) affects river production capacity.

Characterizing river habitat and keeping data up to date over decades represent a considerable challenge for provincial wildlife managers, considering the large extent to cover, including thousands of river kilometers remote areas in the North. In this context, increasingly available high resolution areal remote sensing imagery appears as a cost effective opportunity providing continuous data over large extents.

In this study, we developed an automated method to delineate reach types and functional habitat patches using hyperspectral areal remote sensing imagery and digital elevation model analyses. The classification of homogeneous reaches was based on channel width, slope, radius of curvature and relative depth classes. Then, we modeled the connectivity between functional habitats using a least cost approach integrating life-stage specific fish mobility. Our results present quantitative estimates of habitat probability of use based on river habitat spatial arrangement and illustrate the management functionality of the method in improving the estimation of river production capacity.

Abstract ID: 34002

Final Number: ES41A-07

Title: Impacts of bank stabilization on fish habitat in two contrasted environments

Presenter/First Author: William Massey, Concordia University, Montreal,

Presenter/First Author Email: wmassey0319@gmail.com

Co-authors: Pascale Biron, Concordia University, Montreal, QC, Canada

Published Material: An earlier iteration of these finding were presented at the American Fisheries Society (AFS) annual symposium at Québec city on August 15. Finding will soon be under review. Submission is planned to Earth Surface Processes and Landforms in the month of February.

Abstract Body: Riprap is a form of riverbank stabilization that has a standardized design based on local hydraulic conditions and is commonly used for protecting and repairing road and bridge structures. However, little is known about how streams adjust to such perturbation or how this can affect fish habitat in different fluvial environments. The objective of this study is to assess impacts of riprap on fish habitat quantity and quality through a pairwise comparison of stabilized and non-stabilized stream reaches in two physiographic regions, the St. Lawrence Lowlands and the Appalachian highlands of Montérégie-Est (Quebec). For each stream reach high-resolution measurements of depth and velocity were taken to determine zones of fast, slow, shallow and deep flow, as well as to calculate a hydro-morphological index of diversity (HMID). The reach area proportions of in-stream cover (woody debris, overhanging vegetation, undercut banks, aquatic macrophytes) and habitat units (pools, riffles, runs, glides) were also documented, longitudinally. Fish habitat quality was also assessed holistically, using a Qualitative Habitat Evaluation Index (QHEI). Results demonstrated a significant ($p<0.05$) decrease in the median proportion of woody debris and overhanging vegetation at stabilized reaches in both Lowland and Appalachian environments. Riprapped reaches in the Lowlands also showed significantly lower proportions of pool/glide habitats and higher proportions of riffle/run habitat as well as higher HMID scores. QHEI scores were found to be significantly lower at stabilized reaches for Appalachian streams and higher quality Lowland streams, while stabilized reaches for extremely degraded (straightened) Lowland streams showed higher scores. These results indicate that riprap can significantly alter fish habitat in ways that reduce fish habitat quality and the availability of specific habitat types but also improve habitat quality and diversity in streams which were already degraded.

Abstract ID: 34843

Final Number: ES42A-01

Title: Bedload sediment transport in gravel-bed rivers: Intermittence and continuum

Presenter/First Author: Andre Roy, University of Waterloo, Waterloo, ON

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Abstract Body:

Understanding bedload sediment transport in gravel-bed rivers remains a challenge for river scientists. Bedload sediment transport is often sporadic and intermittent at various temporal and spatial scales and transport rates do not necessarily increase with increasing hydraulic stresses. Bedload sediment transport occurs mostly during flood events when unsteady flow makes it difficult to obtain simultaneous and continuous records of flow and bedload transport measurements. This paper examines the complex response of bedload transport to turbulent flow. First, we will review the relationships between turbulent flow characteristics and sediment transport rates as observed in a small gravel-bed river in southern Quebec. The measurements were conducted during the rising limb of two flood hydrographs of different magnitudes. Turbulent variables change systematically with discharge through hydraulic geometry relationships. Bedload sediment transport occurred as discrete events in both floods. Among the hydraulic variables, flow acceleration/deceleration at the turbulent scale explained a large proportion of the behaviour of sediment transport rates especially for the less intense flood. This result supports evidence reported in previous studies that flow acceleration/deceleration was important in the mobility of individual gravel particles. Second, this evidence at the turbulent scale will be examined at larger time scales. We have observed that turbulent flow events are clustered in a way that generates larger scale flow pulsations. We have documented such pulsations in several gravel bed rivers at different flow stages. An important question that needs to be addressed is the relationship between these large scale flow pulsations and the dynamics of bedload transport. The impact of flow pulsations on sediment transport may be related to the frequency and temporal spacing of the large magnitude turbulent events that generate high shear stress. These extreme events contribute to the flow acceleration/deceleration patterns observed in flow pulsations and to the emergence of large scale flow properties. This may provide a key to our understanding of the intermittence, intensity and duration of bedload transport events.

Abstract ID: 36631

Final Number: ES42A-02

Title: A 3-step framework to consider hydrosedimentary dynamics in river crossing management.

Presenter: Thomas K Buffin-Belanger, University of Quebec at Rimouski UQAR, Rimouski, QC

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First Author Student?: No

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Abstract Body: In rivers with high bed load transport, morphological changes result in considerable cost for managing river crossing. In Québec, managers lack the tools to anticipate river change driven by hydrosedimentary dynamics. Simple rules are hard to provide because of river complexity and of contingency in river behaviour hence the need for a framework that is adjustable to both river character and management needs. We propose three fundamental steps that can lead to a relevant diagnostic of hydrosedimentay dynamics in support of river crossing management. The first step provides geomorphological context and first-hand understanding from river styles. The second step details historical trajectories and identifies relevant controls. The third step aims at defining sediment connectivity, from sediment sources to sinks, which can be quantified through sediment budget analysis. Taken together, the three steps provide an efficient understanding of hydrosedimentary dynamics and lead to management strategies that can address sediment-related problems. The 3-step framework will be illustrated using several cases of high sediment load rivers in eastern Quebec where river crossing issues emerge from intense hydrosedimentary dynamics.

Abstract ID: 34729

Final Number: ES42A-03

Title: Evaluating the contribution of geotechnical and vegetation processes to lateral erosion in a meandering river reach using a holistic morphodynamic model

Presenter/First Author: Yannick Y Rousseau, University of Western Ontario, London,

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Co-authors: Pascale Biron, Concordia University, Montreal, QC, Canada; Marco J Van de Wiel, University of Western Ontario, London, ON, Canada

Abstract Body: Numerical models are increasingly being employed to examine the morphodynamics of meandering river channels. Although sinuous channels are typically associated with cohesive soils and vegetated floodplains, few models formally include these two elements. Furthermore, certain models reproduce the meandering planform and migration patterns observed in nature, but they require relaxed physics and rely on simplified floodplain morphology and process representation to study morphological changes at large spatiotemporal scales. As a result, they have a limited ability to quantify the relationships between key variables. The objective of this research is to evaluate the feasibility, relevance, and usefulness of including geotechnical and plant processes in a physics-based morphodynamic model. Two new modules were developed and coupled to the computational fluid dynamics model TELEMAC-2D for that purpose. A geotechnical module relies on a fully configurable universal genetic algorithm to detect unstable slopes in a fluvial valley represented by an unstructured mesh including a single- or multi-threaded channel, and to update terrain topography following planar and rotational slope failures. A vegetation module is coupled to the former to account for the mechanical effects of plant roots on slope stability. Topographic measurements from the semi-alluvial Medway Creek, London (Canada), are used to calibrate and validate the model. The model is then applied to fictive river channels to quantify the contribution of various biophysical conditions and hydrological regimes to river bank retreat rate.

Abstract ID: 34201

Final Number: ES42A-04

Title: Estimating Bedload Transport in Braided Gravel-Bed Rivers using Structure–from-Motion Photogrammetry and the Morphological Method

Presenter/First Author: Sarah Peirce, University of Western Ontario, London, ON

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Co-authors: Pauline Leduc, University of Western Ontario, London, Canada; Peter Ashmore, University of Western Ontario, London, ON, Canada

Abstract Body: Monitoring bedload transport in gravel-bed rivers, and braided rivers in particular, has been notoriously difficult due to highly dynamic sedimentary processes that result in considerable geomorphic change, both spatially and temporally. This research aims to characterize fluvial geomorphic change, and subsequently bedload transport, using high-resolution repeat surveys from a Froude-scale physical model of a gravel-bed braided river. The overall goal is to investigate the relationship between morphological dynamics and bedload transport rate and test whether reliable bedload estimates can be based primarily on planimetric morphology and dynamics. Specifically, this research is will examine the role of the morphological active width, defined by the bed area experiencing detectable morphological change, and determining its relationship with bedload transport rate and channel morphology. High-resolution DEMs (±2mm vertically) are created of the physical model surface using Structure-from-Motion photogrammetric techniques. Successive DEMs are used to create a DEM of difference from which the morphological active width and volumes of erosion and deposition are used to calculate bedload transport rate. The use of a physical model is ideal for examining these relationships experimentally over a range of river conditions with both tiltable bed (slopes of 1-2%) and adjustable discharge (0.6-3.2 ls^{-1}). The bedload transport rate will be independently monitored using a series of sediment traps at the downstream end of the physical model to verify the relationship to the morphological measurements. These preliminary results will contribute to the theory of bedload transport in braided gravel-bed rivers by characterizing the relationship between bedload transport, morphological change and sedimentary processes.

Abstract ID: 35203

Final Number: ES42A-05

Title: Deposit geometry and grain sorting in gravel braided rivers

Presenter/First Author: Pauline Leduc, University of Western Ontario, London,

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Co-authors: Peter Ashmore, University of Western Ontario, London, ON, Canada

Abstract Body: Braided river dynamics and sedimentary processes involve complex sequences and patterns of erosion/deposition and channel migration. The different grain size, shape or thickness of the deposition layers developed during these processes create a vertical structure within the bed which vary with the river dynamics and influence the bedload transport processes. Quantitative analysis of these interrelations between sedimentary characteristics, river morpho-dynamics and bedload transport need further development. Field measurements can be used to document vertical structure on the river bed and point out layers boundaries, but the time scale and deposition dynamics is not available. We investigated the dynamic formation of the vertical bed structure using a small-scale physical

model of a braided channel. The braided channel was developed at a slope of 1.5% and discharge of 2.1 l/s. The grain size distribution in the model is an approximately 1:30 scaled distribution of medium fluvial gravel with median size 1.3mm (D10 0.3 mm, D90 4mm). Vertical stereo images (with pixel resolution of approximately 1mm) of the dry bed were taken at one hour intervals over 40 hours of flume running time during which a large area of the river was re-worked. DEMs were derived photogrammetrically with mean elevation error of about 4mm. Surface grain size was mapped using calibrated relationship with picture texture value and sieved grain size. Over the 40 hour period the range of elevation and grain size variations over the river bed can be used to analyse deposits dynamics, deposit structure and grain size variation within the river bed.

Abstract ID: 36207

Final Number: ES42A-06

Title: Physical controls on fine-sediment infiltration into gravel beds.

Presenter/First Author: Jan Franssen, University of Montreal, Montreal,

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Co-authors: Michel Lapointe, McGill University, Montreal, Canada; Pierre Magnan, Université du Québec à Trois-Rivières, Trois-Rivières, Canada

Published Material: Franssen, J., Lapointe, M., & Magnan, P. (2014). Geomorphic controls on fine sediment reinfiltration into salmonid spawning gravels and the implications for spawning habitat rehabilitation. *Geomorphology*, *211*, 11-21.

Abstract Body: As humans continue the widespread modification of the Earth's terrestrial surface augmented fine sediment loading to river systems is likely to remain an ongoing issue. In gravel-bed streams the impact of increased fine sediment loads on streambed habitats is determined by factors controlling fines infiltration into channel substratum. Much of what we know about the infiltration processes is derived from laboratory studies. Few, if any, field studies have simultaneously investigated the multiple physical factors thought to control infiltration. Here we present the results of a field experiment conducted in a boreal forest stream in Quebec, Canada, that was designed to investigate the influence of the following factors on substrate fines content: (i) substrate pore constriction size, (ii) hyporheic flow, and (iii) the quantity of fines transported across the bed surface (i.e., exposure dose). Our results indicated that the ingress of fines into gravel-beds was primarily a gravity driven process influenced by size thresholds between the infiltrating fine sediment and the size of the substrate interstitial spaces. Results also indicated that fines content at depth was unrelated to fines exposure and that the estimated upward seepage rates at these study sites were well below the threshold velocities that would inhibit the percolation of medium-grained sand into the gravel bed. We discuss the implication of this research for stream habitat rehabilitation and suggest directions for future research.

Abstract ID: 36515

Final Number: ES42A-07

Title: *Structural comparison of multiple rivers across Canada: the importance of scale for characterizing the river complexity*

Presenter/First Author: Fabien Hugue, McGill University, Montreal,

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Co-authors: Michel Lapointe, McGill University, Montreal, QC, Canada

Abstract Body: Ongoing developments in remote sensing and geographical information science are massively improving efficiencies in analyzing earth surface features. Various applications of these techniques are widely used to assess environmental and ecological processes. With the development of new satellite sensors and the lowered cost availability of high resolution multi spectral imagery, fluvial geomorphology is experiencing a revolution in mapping streams both at high resolution and over large spatial extents. Exploiting the power of aerial or satellite imagery is thus particularly useful in Riverscape framework. This study presents a multi-scale remote sensing method that helps describe the hydraulic structures of wetted habitats. Metrics of habitat description are calculated from i) depth maps obtained through spectral analysis on multiple satellite images and ii) complementary modelized velocity maps, in order to assess the spatial structure of the selected rivers. A principal component analysis on the set of metrics was used to cluster river reaches in regards to their "structural signature". We tested our method in a set of 10 Canadian rivers and investigated the link between the local channel morphology and the regional geomorphic contexts. Results highlight the benefits of such a method for characterizing 1) the habitat heterogeneity and 2) the natural (alluvial) versus controlled (non-alluvial) river variability. Results also demonstrate the importance of using remote sensing tools in a multi-river analysis not only for constraint saving in time and onerous field work, but also for uniformly characterize river structures across the country. Applications of this approach can include 1) specific fish habitat detection for regional management*,* 2) understanding how river habitat heterogeneity affects fish distribution and 3) guidance for river restoration site location.

Abstract ID: 34684

Final Number: ES43A-01

Title: Freshwater Processes and Feedbacks in Baffin Bay and the Labrador Sea

Presenter/First Author: Paul Glen Myers, University of Alberta, Edmonton, AB

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Co-authors: Xianmin Hu, University of Alberta, Edmonton, AB, Canada; Amber Marie Holdsworth, University of Alberta, Edmonton, AB, Canada; Laura Castro de la Guardia, , , ; Laura Gillard, , ,

Published Material: Aspects presented at ASOF and FAMOS workshops, as well as Arcticnet meeting.

Abstract Body: Enhanced transport of low salinity water from the Arctic, as well as the Greenland ice cap, is expected to have impacts on the stratification, water formation and circulation in the North Atlantic Ocean. In this presentation, pathways of freshwater in the Canadian Arctic Archipelago, Baffin Bay and the sub-polar North Atlantic Ocean will be examined. Both observational data and numerical modelling will be used. Observational analyses will focus on the Labrador Current where historical sections will be used to estimate freshwater transport, its variability and locations of offshore exchange. The modelling analysis will be based on regional configurations using the NEMO model of the Arctic Ocean, Canadian Arctic Archipelago and the sub-polar North Atlantic. The impact of freshwater input from the Greenland Ice sheet on the circulation and properties of Baffin Bay will be examined. Lagrangian float tools such as Ariane will also be used to examine the pathways for freshwater from both the Arctic as well as the Greenland Ice sheet into the sub-polar North Atlantic in high resolution simulations.

Abstract ID: 35172

Final Number: ES43A-02

Title: Modelling impacts of opening/closure of Arctic gateways during interglacial stages

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Abstract Body: The Canadian Arctic Archipelago (CAA) and the Bering Strait are two of the key gateways that connect the Arctic Ocean to the Atlantic and Pacific Oceans, respectively. Changes in the sea ice-freshwater flux through these gateways have the potential to significantly affect the sea-ice distribution in the Arctic and the salinity in North Atlantic subarctic basins. The relative size of the freshwater fluxes into the Atlantic through the CAA influences the location and intensity of dense water formation which might have important consequences on the strength of the Atlantic meridional overturning circulation. We investigate the impact of opening/closure of the Arctic gateways (due to Tectonic movements or changes in the sea-level) on the sea-ice distribution and water pathways of the Arctic and subarctic North Atlantic during interglacials. We specifically focus on the Baffin Bay and Labrador Sea. An eddy-permitting regional configuration of the NEMO coupled ocean/sea-ice model is used. The regional domain covers the Arctic Ocean and the Northern-Hemisphere Atlantic, with a horizontal resolution of 1/4 degree at the equator (ANHA4). We set-up several sensitivity experiments by closing either one or both of the CAA and Bering gateways to know the individual impacts of each gateway. Boundary conditions are obtained from the global climate models for Holocene and MIS-5. The model results are compared with the paleoclimate data from Arctic and subarctic seas to further understand the climate conditions during interglacial stages.

Abstract ID: 33695

Final Number: ES43A-03

Title: A few highlights of the late glacial and deglacial history of Baffin Bay and the Labrador Sea

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Published Material: Partly presented at the last AGU Fall meeting (the ice-sheet aspect)/Focus here on oceanographic implications

Abstract Body: Recent works, based on gravimetric data (e.g., Paulsen et al., GIJ 2007) provide new insights into the isostatic response of the northeastern American lithosphere to glacial loading and unloading. They point to a multidome Last Glacial Maximum (LGM) Laurentide Ice Sheet (LIS), with ice-divides over Keewatin, New-Quebec and the Foxe Basin-Baffin Land area, feeding large-scale ice streams (Stokes and Tarasov, GRL 2014). Similarly, recent studies of marine cores raised from Baffin Bay and the Labrador Sea led to reconstruct near steady-streaming interrupted by high amplitude, but out of phase surges along the NE LIS margin (cf. carbonate events from Hudson Strait and Baffin Bay; Simon et al., JQS 2014). These studies also point to the potential role of glacio- isostatic re-equilibrium and advection of warm, sub-surface waters in the NW North Atlantic sector, for the triggering of large ice surges, notably those off Hudson Strait. These findings might also imply a slightly lesser LIS-LGM volume than previously assumed (~ 70 m of "eustatic" sea level). However, a compilation of all available information on the isotopic composition of the LIS-ice suggests slightly less negative oxygen isotope composition than the currently assumed mean value (i.e., ~ -25‰ vs - 30‰, vs VSMOW). As a consequence, the overall ice-ocean mass transfer isotopic budgets between the LGM and the Present might require some re-examination. Nevertheless, the reconstruction of paleo-density gradients in the northern North Atlantic marginal basins since the LGM indicates a late attainment of full interglacial conditions, with a "modern-like" Atlantic Meridional Overturning inception at ~ 7.5 (Labrador Sea) and ~ 6.5 BP (western Nordic Seas), but fully emplaced since the mid-late Holocene transition only.

Abstract ID: 34350

Final Number: ES43A-04

Title: Late Quaternary Stratigraphy of the Baffin Island Slope

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Abstract Body: The Baffin Island Slope (BIS) extends more than 1000 km from Davis Strait in the south to Lancaster Sound in the north. Relatively little is known about lateral variations in the late Quaternary stratigraphy and geological history of the BIS. The adjacent Baffin Island Shelf is incised by 11 transverse troughs that point to a complicated history of sediment supply to the BIS. In this study, 17 piston cores, multibeam bathymetry and high resolution sub-bottom profiler data were used to examine regional variations in the Late Quaternary stratigraphy of the BIS. The shallow seismic stratigraphy of the BIS can be broadly divided between the slope north of Home Bay, where acoustically transparent sediment overlies more reflective sediment, and the slope south of Home Bay, where acoustic penetration is greater and acoustically stratified and chaotic reflections (representing mass transport deposits) are present. Similarly, north of Home Bay, the shallow lithostratigraphy is consistant; cores typically stop in a basal, dark diamict that is overlain by turbidites, stratified ice-rafted deposits, IRD-rich detrital carbonates and hemipelagic sediments. Synthetic seismogram analysis shows that the basal, dark diamict coincides with the regional change to more acoustically reflective deposits on sub-bottom profiler data. South of Home Bay, core samples are generally finer-grained with less diamict but ice-rafted detritus layers are still present. This distinct lateral change in the shallow stratigraphy of the BIS represents differences in the style of proglacial and glacio-marine sedimentation along the slope which may provide important insight into the late Quaternary glacial history of the region. Ongoing research is focused on acquiring age control for the various lithostratigraphic facies; large dateable shell fragments are uncommon in core samples, so analysis of forams and lithostratigraphic correlation with published magnetostratigraphy results will hopefully better constrain the timing of major stratigraphic events.

Abstract ID: 34904

Final Number: ES43A-05

Title: Magnetostratigraphy of Late Quaternary and Holocene Baffin Bay Sediments

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Published Material: Recent papers (Simon et al., G3, 2012; St-Onge and St-Onge, JQS, 2014)

Abstract Body: With the potential of recording the dynamics of the Laurentide, Innuitian and Greenland Ice Sheets during the Quaternary, Baffin Bay sediments were cored during several expeditions during the last decades. Unfortunately, the setting of robust chronostratographies in Baffin Bay proved challenging due to several factors including calcium carbonate dissolution during interglacials and the production of isotopically light brines resulting from sea-ice formation, that hampers the use of ^{18}O stratigraphies. Here, we will look into tentative chronostratigraphies of Baffin Bay late Pleistocene and Holocene sequences mostly based on magnetic paleointensity and directional records. In conjunction with radiocarbon dating, geomagnetic field model outputs and the identification of geomagnetic excursions, they provide a chronostratigraphic framework for sedimentary accumulation in Baffin Bay to document Holocene climatic changes and ice sheet dynamics along the Laurentide, Innuitian and Greenland ice sheet margins during the last ice-age.

Abstract ID: 35938

Final Number: ES43A-06

Title: Surficial geology and glaciomarine geomorphology of Baffin Bay continental shelf sites based on ROV observations, multibeam bathymetry, and acoustic sub-bottom profiles

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Co-authors: Bárbara de Moura Neves, , , ; Calvin Campbell, Natural Resources Canada, Dartmouth, NS, Canada

Published Material: Biological observations from the same ROV dives were presented at the 2013 and 2014 ArcticNet meetings. Geological results have not been previously presented in any form.

Abstract Body: The continental margins of Baffin Bay were strongly influenced by Quaternary glaciations, which left behind glaciomarine geomorphic features at continental slope depths. We surveyed surficial geology and associated geomorphology of three glacially-influenced environments on the margins of Baffin Bay using a Remote Operated Vehicle (ROV) as part of a broader program on deep-sea corals and sponges. ROV dive locations were guided by multibeam bathymetry, sub-bottom profiles, and fisheries bycatch data. An ROV dive on the Disko trough-mouth fan in 900 m depth in SE Baffin Bay found dominantly mud, at low slopes, with rare exposures of angular cobbles and boulders. Fan lobes were indistinct but recognizable in contour-parallel sub-bottom profiles, but were not readily apparent in multibeam bathymetry. On rill-and-gully morphology of the Home Bay trough-mouth fan at about 750 m depth in SW Baffin Bay, identified from multibeam bathymetry, sand and mud bottoms dominated, with commonly occurring highly angular cobble and boulders. Steeper slopes often, but not always, had greater exposure of cobbles and boulders. A bedrock massif within the Scott Inlet trough at ~600 m depth in W Baffin Bay had exposed bedrock only on the vertical cliff face. This vertical cliff may have been linked to faulting. Atop the massif, bedrock was usually covered by a veneer of sediment, including sand, gravel, and angular cobbles and boulders, but this veneer was not detected in sub-bottom profile. The sediments atop of the massif are probably derived from ice-rafted debris. Glacial megaflutes in sediments were observed in multibeam bathymetry downdrift from another massif within the trough. Hydrocarbon release associated with previously described hydrocarbon seeps at the Scott Inlet site was observed as an oil slick at the sea surface, but no direct evidence of hydrocarbon-related authigenic carbonates was observed during the ROV dive. Although subfossil calcareous deep-sea corals have been collected from the Labrador Sea and SE Baffin Bay, none were observed in western Baffin Bay. The modern benthic faunal composition differed greatly among sites, with greatest differences observed between Eastern and Western Baffin Bay. Faunal composition is probably affected by bottom currents and water mass characteristics, as well as geomorphology.

Abstract ID: 35473

Final Number: ES43A-07

Title: Neodymium isotopic composition of deep-sea corals from the Labrador Sea: implications for NW Atlantic deep-water masses circulation during the Holocene, MIS 5 and 7

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Abstract Body: The Neodymium isotopic composition (εNd) of aragonitic deep-sea corals (*Desmophyllum dianthus)* collected off Belle Isle Strait and Newfoundland, at Orphan Knoll (1740 m water depth) and Flemish Cap (1550 m water depth), was investigated to identify changes in the seawater εNd and thus changes in the Northwestern Atlantic deep-water masses circulation during the late Quaternary. These sites, located at depths corresponding approximately to the maximum convection depth of the Labrador Sea Water (LSW) just above the North East Atlantic Deep Water (NEADW) mass, are under the influence of the intermediate to deep-water masses re-circulating in the North Atlantic subpolar gyre. ^{14}C and U-Th dating performed on unaltered specimens selected on the basis of geochemical and mineralogical criterions indicate that they developed during warm periods MIS 1/Holocene, the Bølling-Allerød, MIS 5c and MIS 7a. Comparison between εNd values of 4 modern corals and of ambient seawater at both sites yields a good agreement around a value of – 13.5, indicating that these corals have the potential to reliably record changes in seawater εNd. First results obtained on subfossil corals indicate seawater εNd of around -14 during the Holocene and Bølling-Allerød, -25 during MIS 5c and -17 during MIS 7a. The strongly negative seawater εNd during MIS 5c and MIS 7a reveal an increased imprint of unradiogenic lithogenic sources of Nd derived from Greenland and the Canadian Shield via slope sediment remobilizations and/or an increased Baffin Bay overflow of relatively dense waters, through Davis Strait. Nonetheless, this implies the absence of deep-water formation in the Labrador Sea through the advection of more radiogenic north Atlantic waters during these time periods.

Abstract ID: 35465

Final Number: ES43A-08

Title: Labrador Sea Water variability over the last 3000 years

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Published Material: 20% of it was published in Moffa-Sanchez et al. 2014 Paleoceanography

Abstract Body: The Labrador Sea is a key location for the Earth's climate system, because it is a major component of the Atlantic meridional overturning circulation (AMOC). Due to intense surface air–sea heat exchange, dense ocean mixed layers are created, forming Labrador Sea Water (LSW), which ventilates the intermediate depths of the North Atlantic and beyond. Various studies have revealed considerable spatial and temporal variability, associated with the formation and meridional transport of this water mass, over the past few decades. Yet, crucially, because of the limited temporal extent of the instrumental records, its longer-term history and interactions with the climate at multidecadal to centennial time-scales remains limited.

In this study, we present new multi-proxy records including sortable silt and foraminiferal assemblage counts and stable istotopes from decadally resolved marine sediment cores recovered from the Eirik (SE Greenland) and Gardar (S. Iceland) Drifts to infer hydrographic changes in the LSW and thus better understand the role that the ocean played in the centennial climate variability over the late Holocene. Our results show coherent changes between the records and suggest a decrease in the formation of LSW with similar timing to the cold periods that have been previously recorded as glacial advances in the circum-North Atlantic at 3000-2500; 1100-1500 and 500-100 yrs BP. These findings strongly indicate that hydrographic changes in the Labrador Sea and the associated variability in LSW formation rates may have played an active role in these climate anomalies.

Abstract ID: 33681

Final Number: ES44A-0104

Title: Integrating hydrogeomorphological concepts in management approaches of lowland agricultural streams in Quebec: Perspectives, problems and prospects.

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Abstract Body: River management in agricultural settings has undergone profound changes in recent years, particularly in the Midwest. In particular, a better integration of hydrogeomorphological principles has led to novel approaches with the two-stage channel design for small agricultural streams being among the best examples of this change. The benefits of these approaches include: decrease of nitrate concentrations in water, better heterogeneity of stream habitat, reduction of field flooding and greater bank stability than the traditional trapezoidal profile typically used in straightened agricultural streams. However, the applicability of these innovative techniques in Quebec remains to be tested. We conducted detailed analyses of streams in agricultural areas located in Montérégie (Quebec) to determine the impacts of a change in the trapezoidal channel profile that would allow for some geomorphological adjustments of a small channel comprised within a larger, fixed one. A particular emphasis was put on the subsurface drainage outlets which often limit the degree of adjustment of these small streams. These impacts are analyzed by hydrodynamic modeling (HEC-RAS) and a hydraulic geometry approach. A crop yield analysis in the fluvial corridor along streams prone to frequent flooding was also conducted. Initial findings confirm the improvement of surface drainage for high magnitude floods, but also identify a potentially endemic problem for Quebec where, due to the rectangular shape of agricultural fields (an inheritance from French settlements), very deep subsurface drainage outlets are in conflict with natural floodplain generation within the straightened channels. Alternative measures to accommodate for natural fluvial adjustments while maintaining drainage efficiency were also explored. One approach would be to create small cavities along the streams that would provide increased heterogeneity and limit the need to dredge agricultural streams over long distances.

Abstract ID: 33122

Final Number: ES44A-0105

Title: Bank and bed stabilization using riprap: geomorphological impacts on embeddedness and implications for fish habitat

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Abstract Body: Bank and bed stabilization, through riprapping in most cases, is a common and necessary measure to protect infrastructures such as bridges and roads from fluvial erosion. However, banks artificialization may trigger hydrological, biological and geomorphological changes. In particular, in a lowland context, the coarsening of the substrate is a drastic modification from the pristine river state, but it can be mitigated by the embeddedness of riprap with finer sediments. The research objectives of this study are 1) to identify factors that may improve the substrate through embeddedness at riprapped reaches ; 2) to provide an insight on the relevance of artificially adding fine sediment into riprap to increase embeddedness ; 3) to better assess the role of embeddedness on low-flow water stage essential for free passage of fish . Visual estimation of the embeddedness at 42 sites which were recently stabilized with riprap was conducted in the region of Montérégie-Est, Quebec, Canada. Results from a combination of field topography measurements and Lidar data reveal that embeddedness depends on local topography. No temporal trend in embeddedness was observed, indicating that sediment infilling happens quickly under favourable conditions, or does not occur at all depending on conditions. It is consequently argued that artificially adding fine sediment to promote naturalization of the substrate is a worthless operation. In addition, observations show that riprapping is often linked with bed rising which can have a negative effect on low-flow stage, potentially impacting free passage of fish during the summer. A conceptual model is presented displaying interactions between groundwater base flow, surface water stage, artificial bed heightening and embeddedness.

Abstract ID: 34853

Final Number: ES44B-0106

Title: Comprehensive Interpretation of the Ice Sheet-Ocean Current Interaction Around the Baffin Bay

Presenter/First Author: Catalina Gebhardt, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven,

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Abstract Body: Baffin Bay is a marginal sea of the North Atlantic Ocean, bounded by Greenland to the east, Ellesmere Island to the north and Baffin Island towards west, and connected to the Arctic Ocean through Nares Strait and through the Canadian Archipelago. With its location between the Greenland, Innuitian and Laurentide ice sheets, Baffin Bay is a key location in understanding the glacial history of the Arctic region. Several studies from this area have revealed that the development of the ice sheets has been tightly coupled to the oceanic circulation in this area. Existing low-resolution bathymetric data both from the Greenland and Canadian boundaries show fjords with associated cross-trough channels. Bathymetric and sediment echosounder data from *RV Polarstern* expeditions ARK-XXIII/3 (2008) and ARK-XXV/3 (2010) through Lancester Sound and from the Greenland side of the Baffin Bay show a high variety in glaciogenic bedforms, ranging from iceberg scours to moraines, erosional discordances and mass wasting deposits. Bathymetric data from the Canadian fjords show comparable features. In the framework of ArcTrain, a series of expeditions to Baffin Bay is planned for the next couple of years to systematically map key areas, to gain information on the past ocean circulation and hence to develop a better understanding of the dynamics of the Greenland, Laurentide and Innuitian ice sheets, their similarities and differences, and leads and lags in their waxing and waning. This forms a prerequisite for modeling and predicting the future response of the Greenland ice sheet to changing climate and oceanographic conditions. The first expedition MerMet13-48 on *RV Maria S. Merian* is scheduled for summer 2015.

Abstract ID: 34823

Final Number: ES44B-0107

Title: Greenland Ice Sheet Development in the Northeast Baffin Bay Derived From Geo-Morphology Analysis

Presenter/First Author: Patricia Slabon, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven,

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Abstract Body: Understanding the advance and retreat history of the northwest Greenland Ice Sheet (nwGIS) and its interactions with the oceanic circulation is substantial to understand and predict its future development. During past climate warming events, the nwGIS underwent significant changes and its glaciers accelerated with major contribution to global sea level. Analyses of glacigenic seabed features, visible in high resolution bathymetric data, can provide information for the reconstruction of the history of ice sheets and thus can be applied to give insights into the past development of the nwGIS.

Already lower resolution bathymetry (e.g.the International Bathymetric Chart of the Arctic Ocean IBCAO), shows distinct cross-shelf troughs of glacial origin in the northeast Baffin Bay. High resolution multibeam and sub-bottom echosounder data collected during RV Polarstern cruises ARK-XXIII/3 (2008) and ARK-XXV/3 (2010) enhance the bathymetry in this areas and give a better understanding of the glacial processes on the northeast Baffin Bay shelf and slope. During the research cruise MerMet13-48 scheduled for July 2015, additional high resolution multibeam mapping surveys are planned for troughs and inter-trough areas in the Melville Bugt in northeast Baffin Bay.

First results from sub-bottom and multibeam echosounder data show stacked debris flows building up glacial trough mouth fans, stratified deep-sea sediments, iceberg scours and mega-scale glacial lineations on the respective continental rise and shelf. Geo-statistical analyses of these features indicate ice stream developments and ice sheet groundings, advances and retreats in this area. Geo-morphological assessment on various scales further help to reconstruct the glacial history of the northwest Greenland Ice Sheet in order to model its future development.

Abstract ID: 35900

Final Number: ES44B-0108

Title: Diachronous Evolution of Sea Surface Conditions from the Labrador Sea to Baffin Bay since the Last Glaciation

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Published Material: These findings are currently under review by the scientific journal *The Holocene*. A portion of these findings were presented at the *Arctic Change* 2014 meeting in December in Ottawa, ON.

Abstract Body: An increased understanding of the dynamics and variability in Labrador Sea Water (LSW) formation requires assessing past regional hydrographic responses driven by changes in climate and ocean circulation, specifically freshwater outflow through Baffin Bay. The shift from the most recent glacial to postglacial interval with deglacial meltwater influx from surrounding ice sheets provides examples of the breadth of conditions. Here, we reconstruct sea surface conditions based on dinoflagellate cyst (dinocyst) assemblages from four cores collected from Baffin Bay, Davis Strait, and the northwest Labrador Sea. All exhibit a major shift from a polar-subpolar heterotrophic species assemblage tolerating cold and extensive sea ice cover, to assemblages characterized by a higher diversity and the presence of phototrophic taxa associated with North Atlantic waters. Sea surface reconstructions using transfer functions display an abrupt shift from harsh, quasi-perennial ice cover to warmer summer sea surface temperatures and seasonal sea ice cover. This shift occurred at ca. 11.9 cal ka BP south of the Davis Strait sill under the influence of warm North Atlantic waters, while Baffin Bay remained densely sea ice covered. These warmer waters penetrated into Baffin Bay and mixed with the West Greenland Current (WGC) by ca. 7.4 cal ka BP. A major change in Labrador Sea surface conditions occurred at about the same time, when the strong stratification of surface waters weakened, due to the reduction in meltwater supplies from the Laurentide Ice Sheet. This change finally allowed winter convection and the inception of LSW formation. Therefore, these shifts were facilitated by the advection of North Atlantic water and retreat of the Greenland and Laurentide Ice Sheet margins. Since deglaciation, however, these records demonstrate large fluctuations in sea surface conditions possibly controlled by the relative strengths and shifts of the warmer WGC and colder Baffin Island Current.

Abstract ID: 34765

Final Number: ES44B-0109

Title: A High Resolution Chronology of Clastic Supply to the Central Baffin Bay during the Last Deglacial Ice Sheet Melting

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Abstract Body: The Baffin Bay is a key region for understanding the interaction between ocean circulation and the Greenland Ice Sheet (GIS). Oceanic conditions in the basin are affected by the extent of seasonal sea-ice and changes in the inflow of water from the Labrador Sea and North Atlantic. The input of freshwater from the Arctic Ocean and meltwater from both the Canadian Arctic Archipelago and the GIS also plays an important role. All of these systems have been shown to vary on millennial and centennial timescales, and their state is predicted to change in response to the ongoing Arctic warming trend. However, the complex feedbacks and phase relationships between these systems, as well as how they respond to shifts in climate in the wider region, remain unclear.

During the last deglaciation, the region experienced large magnitude environmental change. We use this interval to investigate periods of increased clastic supply from the melting of the GIS, using two sediment cores from the central Baffin Bay. A novel preparation method allowing AMS 14-C dating of ultra-small samples (0.5 mg) has been used to generate a robust deglacial chronology in both cores. Here, we present profiles of sediment physical and chemical properties for both cores which provide, to date, the highest-resolution continuous record of terrigenous input for the central Baffin Bay, spanning the entire deglaciation.

Results indicate several intervals during which the composition of the clastic fraction shifts; the older episode of detrital input coincides with the timing of Heinrich Event 1 centred around 17ka BP. However, further through the deglacial, the chronology of detrital input appears to be out of phase with Greenland temperatures. An interval of elevated deposition, enhanced clastic supply and thus enhanced meltwater input began in the Younger Dryas stadial at 12.5 ka BP, indicating a fundamentally different relationship between ice-sheet derived clastic supply and Greenland temperature during the late deglacial period.

Abstract ID: 34950

Final Number: ES44B-0110

Title: Paleaoceanographic Changes in Disko Bugt Area in Relation With Human Settlements During the Holocene

Presenter/First Author: Marie-Michèle Ouellet-Bernier, GEOTOP (UQAM), Montréal, QC

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Published Material: The results have been published : Ouellet-Bernier, M-M, de Vernal, A, Hillaire-Marcel, C et Moros, M (2014). Paleoceanographic changes in Disko Bugt area, West Greenland, during the Holocene, *The Holocene*, 24(11), p.1573-1583.And presented at the EGU meeting in 2014.

Abstract Body: Palynological and isotopic analyses of a sediment core raised off Disko Bugt (West Greenland) were undertaken in order to document Holocene paleoceanographical changes in the eastern Baffin Bay. The Modern analogue Technique (MAT) applied to dinocyst assemblages provided information on paleo sea-surface conditions (temperature, salinity, sea-ice cover and productivity) whereas isotopic analyses of benthic foraminifera aimed at documenting the "deep" water mass at the site. The paleoceanographic information we obtained is compared with archeological data from the Disko area as compiled by JF Jensen et al. (*Copenhagen University Archaeological Notes*, 1999).

From ~ 10 to ~ 7.3 ka, important discharge of ice and meltwaters from the Greenland ice sheet, mostly through the Jakobshavn Isbrae, resulted in harsh conditions with dense sea-ice cover, low temperature and low pelagic and benthic productivity. Postglacial conditions settled at about 7.3 ka as indicated by a sharp increase in dinocyst diversity and abundance, which corresponds to increase in summer temperatures. Optimal conditions were finally achieved by about 6 ka, i.e. before the first human occupancy dated at about 4.5 ka. The mid- to late Holocene dinocyst data suggest a slight cooling with increased sea ice cover at ~ 4.2-4.0 ka followed by a slight warming, which matches maximum occurrence of Saqqaq people artefacts in Disko area. Sea-surface temperature continued to increase in summer until about 1.8 ka, when a pronounced cooling was accompanied by increased seasonal sea ice cover and salinity, together with a decrease in productivity. The event marked by harsh conditions in surface waters spanned from about 1.8 to 1 ka. It is consistent with a slight increase in $\delta^{18}O$-values in benthic foraminifers at about 2.1-1.1 ka, which also indicate a cooling in subsurface waters and/or lesser meltwater fluxes. This regional event coincides with the main decline in the number of paleo-Eskimo occupation sites in the Disko area. On this basis it might be hypothesized that rough climate conditions and productivity drop contributed together to the regional decline in paleo-Eskimo population.

Abstract ID: 35010

Final Number: ES44B-0111

Title: Surface and sub-surface multi-proxy reconstruction of mid to late Holocene palaeoceanographic changes in Disko Bugt, West Greenland

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Published Material: Poster presents and discusses results of a multi-proxy study in Disko Bugt area, West Greenland. Several data sets (benthic foraminifera: Perner et al. 2011 in QSR, 2013 in The Holocene; Lloyd et al. 2011 in Geology; diatoms of core 343310: Krawczyk et al. 2013 in QSR, dinos of core 343300: Ouellet-Bernier et al. 2014 in The Holocene) are published recently and new data (diatoms, alkenones) are presented.

Abstract Body: We present new surface water proxy records of meltwater production (alkenone derived), relative sea surface temperature (diatom, alkenones) and sea ice (diatoms) changes from the Disko Bugt area in central West Greenland. We combine these new surface water reconstructions with published proxy records (benthic foraminifera -

bottom water proxy; dinocysts – surface water proxy), along with atmospheric temperature (Camp Century ice core). This multi-proxy approach allows us to reconstruct centennial scale mid to late Holocene palaeoenvironmental evolution of Disko Bugt in more detail than previously possible. Combining surface and bottom water proxies identifies the close coupling between ocean circulation (West Greenland Current conditions), the atmosphere and the Greenland Ice Sheet. Centennial to millennial scale changes in the wider North Atlantic region lead to variations in the West Greenland Current (WGC). During periods with a relatively warm WGC, the atmosphere in west Greenland warms and glaciers retreat producing significant meltwater flux to the west Greenland margin. In contrast, during periods of cold WGC the atmosphere cools and glaciers advance. This highlights the longer-term influence of ocean forcing on ice sheet behavior. We also identify links between palaeoceanographic evolution in the Disko Bugt region and the history of human occupation. Cooler oceanographic conditions at 3.5 ka BP support the view that the Saqqaq people left Disko Bugt due to deteriorating climatic conditions. The disappearance of the Dorset people is less clear, but our new data indicate that it may be linked to a significant increase in meltwater flux causing cold coastal conditions at *c.* 2 ka BP. The subsequent settlement of the Norse is clearly associated with climatic amelioration during the Medieval Climate Anomaly and their disappearance linked to harsher conditions at the beginning of the Little Ice Age.

Abstract ID: 33812

Final Number: ES44B-0112

Title: Paleoceanography of marine isotope stage 31 in the northwest North Atlantic

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Co-authors: Anne de Vernal, University of Quebec at Montreal UQAM, Montréal, QC, Canada; Claude Hillaire-Marcel, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Abstract Body: We investigated paleoceanographic conditions during Marine Isotope Stage (MIS) 31 at IODP site 1305, off southwest Greenland in the Labrador Sea, based on the analysis of dinocyst and foraminiferal assemblages, in addition to isotopic measurements in planktic foraminifers as complementary tracers of properties in mesopelagic and epipelagic water masses. The Modern Analogue Technique (MAT) has been applied to reconstruct sea surface conditions using dinocyst assemblages. Low salinity conditions (32-34.5), large seasonal temperature gradients with cool winters (3-6°C) and mild summer (10-15°C) characterized the surface water mass. In contradistinction, the application of MAT to foraminifers assemblages, which are largely dominated by the deep dwelling species *Neogloboquadrina pachyderma* left coiling, indicate very cold conditions both in winter (-2-0°C) and summer (2-4°C), a range consistent with the observed isotopic composition of planktic foraminifers. Hence, the discrepancy between dinocyst vs planktic foraminifer reconstructions suggests strongly stratified, relatively warm surface waters, overlying a cold and more saline intermediate water mass. These results lead to infer conditions unfavorable for convection and intermediate- or deep-water formation in the Labrador Sea during the interval.

Abstract ID: 34854

Final Number: ES44B-0113

Title: Alkenone paleothermometry in the NW Atlantic: A review and synthesis of surface sediment data and calibrations

Presenter: Markus Kienast, Dalhousie University, Halifax, NS

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Abstract Body: Despite its undisputed importance in the global ocean-atmosphere system, the NW Atlantic is arguably the region of the global ocean where reconstructions of past variations in sea surface temperatures (SST) are fraught with the greatest uncertainty. While alkenone paleothermometry has successfully been applied to reconstruct past SSTs in many parts of the northern Atlantic, including off Iceland and Greenland as well as off Newfoundland and Nova Scotia, previous studies have also highlighted the large scatter of alkenone unsaturation (expressed as the UK37 or UK'37 index) determined from N Atlantic surface sediments around the globally established calibrations of UK37 versus SST.

Here we present a synthesis of 94 previously published and 99 new alkenone unsaturation data from surface sediments in the northern and NW Atlantic. These data will be reviewed in the context of global calibrations of UK37' versus mean annual, SSTs and of regional calibrations that have been developed specifically in an attempt to improve the calibration between alkenone unsaturation and SSTs in the N Atlantic. Scatter around these calibrations, or residuals, will be discussed in the context of ocean frontal systems with large SST gradients, sea surface salinities, sea ice extent, the possible input of allochthonous alkenones from other areas of the Atlantic and even from land, and potential effects of melt water intrusions from the Greenland ice sheet. Neither of these factors, individually or combined, can fully explain the increased scatter around the low-temperature end of UK37' - SST calibration. The largest decrease in uncertainty, however, is obtained by considering alkenone unsaturation in terms of bloom and/or spring-summer SSTs, rather than mean annual temperatures.

Abstract ID: 35232

Final Number: ES44B-0115

Title: Evidence for Meltwater Drainage via the St. Lawrence River in Marine Cores from the Gulf of St. Lawrence, Laurentian Channel and Labrador Sea at the Time of the Younger Dryas

Presenter/First Author: Elisabeth Levac, Bishop's University, Sherbrooke, QC

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Co-authors: Michael C F Lewis, Geological Survey of Canada Atlantic, Dartmouth, NS, Canada

Published Material: Most of these findings are presently under review in a scientific journal. However, the data from Bay of Islands is not published and not part of that manuscript.

Abstract Body: The debate about the source(s) and paths of meltwater that drained into the North Atlantic Ocean at the time of the Younger Dryas (YD) is ongoing. There are still discussions about the eastern route from glacial Lake Agassiz and predecessor lakes of the Laurentian Great Lakes located along the southeastern edge of the Laurentide Ice Sheet. We

present evidence for meltwater drainage via the St. Lawrence valley from six new sediment cores from Cabot Strait, Laurentian Channel, Scotian Shelf and Labrador Shelf at the time of the YD. Palynological analyses are used to reconstruct sea surface conditions based on dinoflagellate cyst records, and pollen data are used for additional correlation. The reconstructions show distinct drops in salinity, temperature and increased sea ice cover duration within the YD period. In addition to these new records, we present a re-examination of original data and paleoceanographic interpretation of surface waters based on a new analysis of dinoflagellate cyst zonation in combination with an updated chronology supported by new radiocarbon dates and refined calibrations. The intervals corresponding to the YD are clearly defined in the cores and contain strong evidence of lowered salinity, thereby re-establishing the St. Lawrence drainage system as a significant route for inflow of YD meltwater to the North Atlantic, including the Labrador Sea. This inflow does not exclude the possibility for another source of freshwater, possibly via the Labrador Current, as suggested by geographical differences in the duration of cold, low salinity conditions west and east of Laurentian Channel associated with the YD climatic event.

GEODESY

Abstract ID: 34052

Final Number: G11A-01

Title: Least Squares Wavelet Analysis

Presenter/First Author: Ebrahim Ghaderpour, York University, Toronto,

Presenter/First Author Email: ebig2@yorku.ca

Co-authors: Spiros D Pagiatakis, York University, Toronto, ON, Canada

Published Material: This is under review by Digital Signal Processing (Elsevier)

Abstract Body: The least-squares spectral analysis (LSSA), an alternative to the classical Fourier analysis, was introduced by Vanicek in order to analyze unequally spaced and non-stationary time series in their first and second statistical moments. When a time series has low or high frequency and amplitude variation over time, however, both the LSSA and Fourier analysis are not appropriate tools for analysis. On the other hand, the classical short-time Fourier transform (STFT) and the continuous wavelet transform (CWT) do not consider the covariance matrix associated with a time series nor do they consider trends or datum shifts. Both, the STFT and the CWT are not defined for unequally spaced time series.

In this talk, we present a new method called the least-squares wavelet analysis (LSWA) that can analyze a non-stationary and unequally spaced time series with high frequency and amplitude variation over time by transforming the time series to the time-frequency domain. The LSWA is a powerful method for analyzing an unequally spaced and unequally weighted time series with associated covariance matrix superseding the well-known wavelet analysis. Several examples from artificial and real time series will be presented to demonstrate the effectiveness of the method.

Abstract ID: 34058

Final Number: G11A-02

Title: Stochastic Surfaces in the Least Squares Wavelet Analysis

Presenter/First Author: Ebrahim Ghaderpour, York University, Toronto,

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Co-authors: Spiros D Pagiatakis, York University, Toronto, ON, Canada

Published Material: This paper is under review by Digital Signal Processing (Elsevier).

Abstract Body: The stochastic significance of peaks of the least-squares spectrum was discussed by Pagiatakis (1999), which we extend to define the stochastic surfaces of the Least-Squares Wavelet Analysis (LSWA) spectrograms that follow the beta distribution. Several examples will be presented to show the stochastic surfaces for the LSWA spectrograms that define confidence levels (usually 95% or 99%) above which spectral peaks in LSWA spectrograms are statistically significant. In the examples, we also show that the spectral peaks must be stronger for higher frequencies to be statistically significant as the number of data points for the segments of a time series decreases in the LSWA.

Abstract ID: 34985

Final Number: G11A-03

Title: Principal component analysis of InSAR data

Presenter/First Author: Kristy French Tiampo, University of Western Ontario, London, ON

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Co-authors: Pablo J González, University of Leeds, Leeds, United Kingdom; Sergey V Samsonov, Canada Center for Remote Sensing, Ottawa, ON, Canada; Jose Fernandez, Complutense University of Madrid, Madrid, Spain

Published Material: Initial results were presented at Fall AGU, 2013. The final results, to be presented here, are being written up for journal submission in the next few months.

Abstract Body: Geodetic data, the spatial and temporal surface expression of complex geophysical processes in the earth, is being acquired today at unprecedented rates and accuracies. Differential Interferometric Synthetic Aperture Radar (DInSAR) is a satellite remote sensing technique that is used extensively for mapping ground deformation with a high spatial resolution and sub-centimeter precision over a large area. Spatial resolution of the modern SAR sensors ranges from 1 to 20 m over areas from 10x10 km to 200x200 km. Images produced with advanced DInSAR techniques can contain millions of data points. Previous research has demonstrated that an eigenpattern decomposition technique known as principal component analysis (PCA) can be used to identify a unique, finite set of correlated deformation patterns for a given regional network of GPS stations. Similar in nature to the empirical orthogonal functions (EOF) historically employed in the analysis of atmospheric and oceanographic phenomena, the method derives the eigenvalues and eigenstates from the diagonalization of the covariance matrix. After decomposing large data sets into their orthonormal eigenvectors and associated time series, based upon the spatiotemporal relationships that exist in the data, the decomposition can be used to study those modes most responsible for the various signals and their sources or to remove those uninteresting modes in the system. One additional benefit is that these modes are ordered naturally by the predominant spatial wavelength of the signal and can be used to identify the potential anthropogenic, volcanic and tectonic sources responsible for those signals. Here we demonstrate its application to DInSAR data from several different regions and its ability to isolate the handful of important signals in the thousands of data points in remote sensing images.

Abstract ID: 34589

Final Number: G11A-04

Title: An integral image approach to performing multi-scale topographic position analysis

Presenter/First Author: John Barrie Lindsay, The University of Guelph, Guelph, ON

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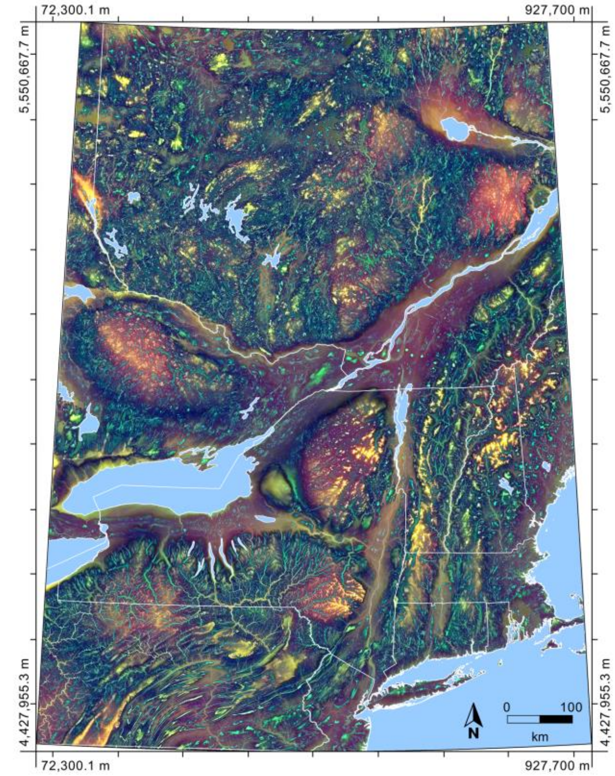
Co-authors: John C Gallant, CSIRO Land and Water, Canberra, ACT, Australia; Jaclyn Cockburn, University of Guelph, Guelph, ON, Canada; Hazen Russell, , ,

Abstract Body: Digital elevation model (DEM) derived measures of terrain ruggedness and relative topographic position are useful parameters for automated landform classification and are widely applied in soils, vegetation, and habitat mapping. These topographic attributes are inherently scale dependent because they are defined in the context of a local neighborhood. Previous studies have focused on assessing the multi-scale properties of these attributes based on varying roving window sizes, grid resolution resampling, and hierarchical object-based methods. Despite significant advantages, the computationally intensive nature of large-window DEM filtering has limited the varying window size approach from being used to study the scaling properties of topographic position in high resolution and at broad spatial scales.

This study uses integral image and integral histogram based approaches to explore two common measures of relative topographic position, deviation from mean elevation (DEV) and elevation percentile (EP). The approaches were applied to a massive DEM of an extensive, heterogeneous region in eastern North America (40°N to 50°N and 70°W to 80°W). Compared with traditional image filtering techniques, the integral image approach was extremely efficient for calculating DEV, enabling high-resolution multi-scale analysis. A technique, based on a novel multi-scale DEV, was developed for visualizing the scaling characteristics of topographic position using color composite imagery. The information density in these images, provided by the contrast in the dominant scale response of nearby pixels, was very high. The integral histogram approach was similarly highly computationally efficient, enabling EP measurement at scales that are not feasible using traditional methods. However, large memory requirements limited applicability to moderate sized DEMs of low-to-moderate relief landscapes.



Abstract ID: 35918

Final Number: G11A-05

Title: Ice Mass Loss Monitoring in the Canadian Arctic: A Study on the Filtering Methods with Release-05 GRACE Data

Presenter/First Author: Iliana Tsalis, University of Calgary, Calgary,

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Co-authors: Dimitrios Piretzidis, University of Calgary, Calgary, AB, Canada; Elena Veselinova Rangelova, Univ Calgary, Calgary, AB, Canada; Michael G Sideris, University of Calgary, Calgary, AB, Canada

Abstract Body: The biggest challenge in GRACE gravity data analysis is the signal separation of the GRACE-observed integrated geophysical signals. Due to the geometry of the twin-satellite orbit noise is produced, which is described as long, linear features generally oriented from north to south in the GRACE maps of mass variability. These 'stripes' imply a high degree of correlation in the gravity field coefficients, so spatial noise filtering is needed. As the halfwidth of the filter is increased, the level of smoothing is increased and the amplitude of the stripes decreases, until the pattern of the geophysical signals become apparent, but the magnitude of the geophysical signals is reduced.

In this study, in order to remove the 'striping' effect, a series of miscellaneous filtering methods is applied, tested and evaluated by ice mass loss estimates from previous studies in the Canadian Arctic. The data used include 139 months of GFZ and CSR Release-05 (RL05) GRACE time-variable gravity coefficients, covering the time period 01/2003-10/2014. Monthly gravity coefficients are converted to mass changes and corrected for the Glacial Isostatic Adjustment (GIA) effect.

The filtering methods that have been tested are: (1) Wiener filter (the signal and the error covariance depend only on the spherical harmonic degree), (2) post-processing decorrelation filter followed by Gaussian smoothing (convolution with an isotropic Gaussian smoothing kernel), and (3) non-isotropic smoothing (decorrelation) using the k-filtered five DDK filters RL05 GRACE solutions. We conclude that the general performance of isotropic filters is weak for ice applications.

Abstract ID: 36508

Final Number: G11A-06

Title: Wavelet spectral techniques for error mitigation of superconductive angular accelerometer output

Presenter/First Author: Elaheh Mokhtari, University of Calgary, Calgary, AB

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Co-authors: Mohamed Mamdouh Elhabiby, University of Calgary, Calgary, AB, Canada; Michael G Sideris, University of Calgary, Calgary, AB, Canada

Abstract Body: A superconductive angular accelerometer is an important sensor that often supplements a superconductive angular gradiometer on a moving platform during data acquisition operations.. The gradiometer instrument senses not only gravity gradients, but also various effects of an accelerated coordinate frame (which are introducing major errors). The superconductive angular accelerometer measurements help compensate the main error, which is entering as angular velocity squared in the gradiometer output. While the angular accelerations can be measured, angular velocity squared has to be computed by integration. However, a major difficulty arises when the angular accelerations are noisy because of translational accelerations of the platform and temporal fluctuations of the environment during the operation. These errors are a source of low and high frequency error in the accelerometer output. Therefore, filtering of angular accelerations is necessary before integrating them to produce angular velocities. We have implemented wavelet de-noising and de-trending techniques in order to mitigate these errors. Wavelet results indicate 80% improvement in reducing the RMS noise level compared to the results obtained with traditional Wiener low pass filtering.

Abstract ID: 35001

Final Number: G11A-07

Title: Multilinear Filtering of Nonstationary Array Data and Inversion

Presenter/First Author: J A Rod Blais, University of Calgary, Calgary, AB

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Published Material: The application part on seismic imaging has partially been discussed at CGU 2014 in Banff, AB.

Abstract Body: For various geoscience applications, observations and measurements provide array data that necessitate filtering and inversion for parameters of interest. Although most geophysical processes are nonlinear and nonstationary, simplifications are often implemented in practical data array computations. Starting with linear filtering and inversion of stationary array data, the mathematical convolution can often be generalized to multilinear tensor formulation for filtering and inversion of nonstationary data. Multilinear and tensor algebras can then be exploited to optimize the transformation to conventional matrix algebra and hence take advantage of linear equation solvers available in numerical libraries. These strategies and procedures will be briefly discussed using simple numerical examples with special attention to the computational aspects of Kirchhoff least-squares imaging using seismic data. Some open questions are also included for further research and development.

Abstract ID: 33493

Final Number: G11A-08

Title: MATLAB Tools for Earth's Surface Deformation Studies

Presenter/First Author: Mohammad Ali Goudarzi, Laval University, Quebec City, QC

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Published Material: Some parts of this poster were already published in GPS Solutions with DOI 10.1007/s10291-012-0296-2, and 10.1007/s10291-013-0354-4, and some parts are presented here for the first time. In this poster, however, we present them as a software suite and focus on their computational aspects rather than the mathematical background, as well as a case study for eastern Canada.

Abstract Body: We developed three software programs for research on Earth's surface deformation studies, including time series analysis, Euler pole estimation, and strain analysis. The first software named GPS Interactive Time Series Analysis (GITSA) is capable of visualizing the input time series, determining and removing jumps and outliers, data interpolation, calculating quality indicators and producing publication quality graphical outputs. Along with computing basic statistics such as mean and variance, it can accomplish the bivariate statistical analysis, residual analysis, and spectral analysis. The second application named Euler Pole Calculator (EPC), estimates the expected velocities for any points on Earth's surface given the relevant Euler pole parameters. It also allows for calculating the Euler pole parameters from observed velocities of a set of sites on the same tectonic plate. The last program named GeoStrain, calculates the crustal strain rates using the least-squares collocation method. It is able to simultaneously determine the signal and noise of the velocities at the observation points with the best possible removal of the observation errors, or any other position with no velocity observation. Furthermore, it allows for calculating strain and rotation rate tensors at any points of interest. The advantage of the software is the fact that it can optionally consider the effect of the vertical velocities on the strain rates.
Although our programs are independent, they make a software suite: the output of each program is the input of another one. While inputs of the first program are the position time series of continuous GNSS sites obtained from a GNSS data processing software, the outputs of the last one are parameters of deformation, e.g., in the form of strain tensors. We developed these programs using MATLAB programming language with a graphical user interface, and released them freely as open source software. MATLAB Parallel Computing Toolbox was used to increase the performance of computationally intensive algorithms on multi-core processors.

Abstract ID: 33205

Final Number: G12A-01

Title: Assessment of the SHAO-C Tropospheric Delay Correction Model Over Ethiopia

Presenter/First Author: Yohannes Getachew Ejigu, Retired, Wolkite,

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Co-authors: Gizaw Mengistu Tsidu, Addis Ababa University, Addis Ababa, Ethiopia

Published Material: In the AGU Chapman Conference on Longitude and Hemispheric Dependence of Space Weather at Addis Ababa, Ethiopia, 12–16 November 2012, have been presented in the poster session, but stil can not submitted to any scientific journal publisher.

Abstract Body: Tropospheric signal delay can introduce a considerable error in satellite positioning if it is not properly modeled. In the neutral atmosphere, the average GPS signal delay in the zenith direction can varies from 1.8 m to 2.5 m depending on meteorological conditions and site location. In this work, the spatial and temporal variations of the zenith tropospheric delay (ZTD) over Ethiopia, are analyzed using ECMWF (European Centre for Medium-Range Weather Forecast) pressure-level atmospheric data and compared with ZTD time series for 5-year period from 2007-2011 measured at several GPS stations from the Crustal Movement Observation Network over Great Rift Valley regions of Eastern Africa managed by UNAVCO. A new tropospheric delay correction model, SHAO-C used in China, is evaluated for its performance over Ethiopia. The ZTD along altitude, latitude and longitude is fitted with a second order polynomials at a reference height, and the mean ZTD is modeled directly by a harmonic function together with an initial value and an amplitude in each grid. The coefficients of this modified model are generated using the ECMWF ERA-Interim data at a resolution of 0.75X0.75 degree latitude-longitude grid. The altitude is obtained from high resolution digital elevation model (DEM). The agreement between GPS and model ZTD is found to be very good which reflected in overall average bias between -4.3 cm to -1 cm, and RMSE less than 4.5 cm. The model results are within the requirements of most GNSS navigation or positioning applications in terms of the tropospheric delay correction.

Index Terms— **ZTD, SHAO-C, Troposphere Delay Correction, Navigation, Positioning**

Abstract ID: 35330

Final Number: G12A-03

Title: GAPS for Atmospheric Studies (GAPS-ATM): Preliminary Results

Presenter/First Author: Marco Aurelio Moraes de Mendonca, University of New Brunswick, Fredericton,

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Co-authors: Marcelo C Santos, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: Precise Point Positioning (PPP) is a well-established method of satellite positioning data processing. Since late 1990's, several developments have been made in order to take into account the impact of atmospheric effects on the satellite signals such as the ones caused by troposphere and ionosphere. At first, these effects were modelled in order to improve the quality of the estimated coordinates. Lately, by modelling the effects, new researches moved towards correlating the positioning errors with different atmospheric activities. Nowadays, GNSS data is widely used to estimate several different "side" parameters such as water vapor in the atmosphere and electron density. In this work, we use GPS Analysis and Processing Software (GAPS), a PPP software developed and maintained at UNB, to constrain known and nuisance - in this scope - parameters as the receiver's antenna final coordinates, and estimate atmosphere activity indexes. Among many parameters of interest, one can highlight troposphere wet and dry delay components and horizontal gradients, Total Electron Content (TEC) for each satellite in view, Electronic Gradients over time and others. An online platform is under development to allow the user to submit its own GNSS data and antenna coordinates to obtain a processing reporting focusing not on position estimation, but on atmospheric parameters represented in time series, plots and maps. Our first results show that the combination of PPP and the correct constraining of coordinates is a reliable alternative to estimate the atmospheric influence over satellite signals and, hence, estimate the behavior of the atmosphere in several different ways. By developing and implementing new tools on GAPS and focusing on the specific needs of atmospheric researchers, GAPS-ATM shows itself as an innovative and pioneer initiative among the GNSS post-processing packages available commercially or not.

Abstract ID: 35611

Final Number: G12A-04

Title: An overview of the UNB Ray-Tracer for geodetic applications

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Co-authors: Felipe G Nievinski, , Presidente Prudente, SP, Brazil

Abstract Body: Ray-tracing through the neutral-atmosphere is an important task to retrieve meteorological parameters from a numerical model. There are several ways of doing it, which implies different representations of the neutral-atmosphere, as well as different ways to integrate through the path. We have developed a ray-tracer that involves alternative models for the ray-path and the atmospheric structure involved in the operation. The ray-tracer is currently in continuous use in the evaluation of zenith delay and one of the Marini coefficients of the Vienna Mapping Functions, generated daily at UNB as a service towards GGOS. This paper overviews the main characteristics of the UNB Ray-Tracer and discusses applications when dealing with integration through numerical weather models for neutral-atmospheric delay modelling. The paper also discusses other uses of ray-tracing in geodesy.

Abstract ID: 35641

Final Number: G12A-05

Title: Forecasting the radiooptical properties of the atmosphere

Presenter/First Author: Josep M Aparicio, Environment Canada, Dorval, QC

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Abstract Body: The weather forecasting community is both a user and a provider of geodetic products. Numerical weather prediction requires huge amounts of data from a vast number of sources. Most of the traditional measurements are not directly related to geodesy. However, over the last decade, certain highly accurate geodetic products such as Zenith Delay, and particularly satellite radio occultations, have become available in volume and timeliness sufficient to have a significant impact for weather forecast. This is only expected to grow to larger volumes and faster access. We will present the current state of these technologies, plans for the near-term future from the point of view of the meteorological use of these data, and the impact that they have to the accuracy of the weather forecast service.

Also, with the increasing accuracy of meteorological products, as well as with the increasing demands of the geodetic community, the traditional infrastructure and products of meteorology have become relevant for geodesy. Besides certain products that are already used in accurate positioning applications, such as fields of atmospheric pressure load, other quantities such as Zenith Delays, the vertical profile of refractivity, atmospheric horizontal gradients, and atmospheric scintillation are fields that can also be estimated or forecasted, and that can become products for use within the geodetic community. There is therefore place for a two-way relationship between the atmospheric and the geodetic communities.

Abstract ID: 36122

Final Number: G12A-06

Title: Inside Tropical Cyclones With GPS: A New Perspective on Their Morphology and Intensity Estimation

Presenter/First Author: Panagiotis Vergados, NASA Jet Propulsion Laboratory, Pasadena, CA

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Co-authors: Zhengzhao Johnny Luo, CUNY City College, New York, NY; Kerry Emanuel, Massachusetts Institute of Technology, Cambridge, MA; Anthony J Mannucci, Jet Propulsion Laboratory, Pasadena, CA

Published Material: These findings were published in the Journal of Geophysical Research - Atmosphere in January 2014, and have never been presented before to the AGU or CGU science meetings.

Abstract Body: Despite the great progress in trajectory forecasting of tropical cyclones (TCs) in the past few years, little progress has been made to their intensity forecasting. Temperature inversions layers at the outflow inside the eyewall of TCs, superimposed on the background upper troposphere, markedly affect the background thermal structure of the upper-troposphere lower-stratosphere (UTLS) region. The temperature difference between the ocean surface and the outflow region defines a TC's thermodynamic efficiency, which is a direct analog of its intensity. Global Positioning System radio occultation (GPSRO) observations offer a unique opportunity to sense the vertical thermal and moisture structure of a hurricane – from its center to the outermost closed isobar – with a vertical resolution of ~100 m. Here, we employ collocated vertical temperature and humidity profiles from the European Center for Medium-range Weather Forecasts Re-Analysis Interim (ERA-Interim) to assess the thermodynamic environment of an ensemble of hurricanes and compare them against GPSRO data sets. Combining GPSRO observations, along with ocean surface temperatures from NASA Modern Era-Retrospective Analysis for Research and Applications (MERRA), we demonstrate how to infer TC intensities using a simplified vortex TC model [*Wong and Emanuel,* 2007]. We analyzed TCs in the time period 2006–2010, and our GPSRO-based TC intensity estimates are found to be quantitatively consistent with best-track values from the Joint Typhoon Warning Center (JTWC) within 1.2–9.0%. This suggests that GPS signals can potentially augment current datasets in TC intensity forecasting, and provide accurate thermal information of a TCs' morphology and strength.

Abstract ID: 35894

Final Number: G12A-07

Title: Geophysical Parameters and Geophysical Application Development for Space-borne Polarimetric SAR (Synthetic Aperture Radar)

Presenter/First Author: Wooil M Moon, University of Manitoba, Winnipeg, MB

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Co-authors: Junjun Yin, Tsinghua University, Beijing, China; Duk-Jin Kim, Seoul National University, Seoul, South Korea

Published Material: This research is in progress and a part of the same material will also be presented at the URSI At-RASC conference in later part of May 2015 in Gran Canaria. However, none of the material to be presented was published yet.

Abstract Body: Polarimetric SAR (Synthetic Aperture Radar) is an important microwave remote sensing tool which has increasing new applications in geophysics research. In addition to all weather operation advantages without sun light, it has interferometric applications utilizing the phase information of the backscattered signals. Understanding of geophysical parameters have been particularly important in the development of new geophysics applications for polarimetric SAR. As increasing number of new remote sensing satellites are now launched into Earth's orbit, it is timely to revisit and study various geophysical parameters which are closely related to backscattered microwave signals and their interaction at the surface of Earth.

In this paper, we will first investigate geophysically applicable regions of electromagnetic spectrum and will discuss basic principles of space-borne fully polarimetric SAR (Syntehtic Aperture Radar), in regard to the observation of solid Earth processes such as earthquakes, volcanoes and mass movements at the surface of Earth. In addition, we will also discuss various geophysical parameters which play important roles in the observation of waves, currents and surface winds over Earth's hydrosphere, including oceans and rivers, with radar scattrometer, radar altimeter and polarimetric SAR on-board Earth orbiting platforms. This paper will also discuss the available multiple frequency SAR systems and their applications.

Abstract ID: 36628

Final Number: G12A-08

Title: Ionospheric Disturbances after 2010 Merapi Eruption: The Biggest Amplitude of Disturbances by Volcano Eruption

Presenter/First Author: Cahyadi Nur Nur Cahyadi, Institute of Technology, Surabaya,

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Abstract Body: Global Positioning System (GPS) satellite orbit was located on the 20,000 km above earth surface. Those satellites transmitted two kind of L band signals which were L1 (1.5 GHz) and L2 (1.2 GHz). The signals were transmitted by satellites trough ionosphere then it was received by receiver in the earth surface. Because of this transmission method, we could observe electron density in ionosphere specially F layer which was called by Total Electron Content (TEC). Variation of ionosphere was caused by seismic wave propagation from earthquake, tsunami or volcano eruption. Seismic propagation was composed from three components with different velocities, Raleigh wave (velocity about 4 km/s), Acoustic wave (1 km/s) and Gravity wave (velocity about 0.3 km/s). This research focused on the ionospheric disturbances caused by Merapi volcano eruption which seismic wave was took into account in this variation. Ionospheric disturbances research was done in several topics using GPS-TEC,a comprehensive research about near field Coseismic Ionospheric Disturbance (CID) with Indonesian GPS array (INACORS) was done by [Cahyadi and Heki,2014].

Merapi volcano erupted on the 5 November 2010 on the 19:00 UTC, this was biggest eruption during 1872. Ionospheric disturbances was detected first time on the 18:40 UTC. They were several satellites which observed the disturbances e.g satellite number 6,3, and satellite number 21. The amplitude of the disturbances was about 1.7 TECU which was the biggest amplitude of disturbances caused by volcano eruption. Ionospheric disturbances by volcano eruption was also found in Indonesia for example

2013 Kelud volcano eruption , but the disturbances was smaller than disturbances by 2010 Merapi volcano eruption.

The directivity of the disturbances was located around south-west and north-west of the volcano which was different with CID of the 2011 Sumatra earthquake which directivity of the CID followed geomagnetic field direction. The magnitude of ionospheric disturbances by 2010 Merapi volcano was positive then became normal variation, it was like CID of earthquakes. This characteristic was very different with ionospheric disturbances by Kelud volcano, the later has positive peak variation then was followed by longer oscillation.

Abstract ID: 33490

Final Number: G13A-01

Title: Contemporary 3D Velocity Field of Eastern North America based on 14 Years of Continuous GPS Observations

Presenter/First Author: Mohammad Ali Goudarzi, Laval University, Quebec City, QC

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Co-authors: Marc Cocard, Laval University, Quebec City, QC, Canada; Rock Santerre, Laval University, Quebec City, QC, Canada

Abstract Body: The Saint Lawrence Valley in eastern North America is under intraplate surface deformations and has experienced strong historical and instrumental earthquakes. This shows the probability of occurring earthquakes all along the valley which is an important issue from the seismic hazard point of view. The area is further influenced by the glacial isostatic adjustment (GIA). We study this region using observations of all the available continuous GPS (CGPS) stations in the area as well as some more CGPS stations to the west and south of the valley in order to delineate the GIA process in eastern North America. The data comprise 14 years of continuous GPS daily solutions (8 years on average) from 112 CGPS sites. We use Bernese GNSS software to process the GPS data and our GITSA software for time series analysis to obtain the contemporary three-dimensional velocity field of the eastern North America and their uncertainties. The results clearly show the counter-clockwise rotation of the North American plate with an average velocity of 16.3 mm/yr constrained to ITRF 2008. The repeatability of results is at the level of 1.2 mm/yr for horizontal and 4.7 mm/yr for vertical velocities at the best sites assuming the white noise model. The accomplished noise analysis on the post-fit residuals using both spectral and maximum likelihood estimation methods brings us to obtain more realistic uncertainties for the estimated velocities and distinguish non stable GPS stations. The results show the white plus flicker noise model is the best, and uncertainties are increased with the order of 5~30 times. We discuss limitations in the computed velocities, especially when the possible instability over time causes non-linear behavior in the time series. In this way, 13 stations (out of 112 sites) were identified as stations with non-stable monuments. We also present an ongoing uplift model in the study area using the variogram analysis. At the best sites, the vertical velocities agree with the ICE-5G (VM2) model to within 0.02 mm/yr. However, the model shows a systematic tilt of ±6 mm/yr compared to the ice model in the east-west direction with a vertical hinge line approximately located to the west of Ontario province.

Abstract ID: 34732

Final Number: G13A-02

Title: Investigations on the Quality of the GOCE Level 1b Gradiometer Data around the Magnetic Poles

Presenter/First Author: E. Sinem Ince, York University, Toronto, ON

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Co-authors: Spiros D Pagiatakis, York University, Toronto, ON, Canada

Published Material: Some amount of this presentation was presented as a poster in the 5th GOCE User Workshop in Paris, in November 2014.

Abstract Body: The latest Canadian Geoid Model was developed based on the combination of GOCE, GRACE, terrestrial and altimetry data. It is observed that the GOCE data have improved the Canadian geoid up to a few centimetres in some regions. Our preliminary investigations on the GOCE Level 1b gradiometer data have shown that GOCE data processing methodology still needs improvements. It is found that GOCE gravity gradients along the satellite track are affected by unknown external sources over Northern Canada and Greenland. These effects can disturb the gravity signal up to three times the expected noise level. In this study, we have attempted to understand the reasons behind these disturbances present in the gradients by using external and GOCE-independent space weather datasets. Solar satellites ACE (Advanced Composition Explorer) and WIND derived interplanetary magnetic and electric field data and magnetic activity data observed by the terrestrial CARISMA (Canadian Array for Real-time Investigations of Magnetic Activity) stations are used for this purpose. We found that GOCE was affected by the increasing short-term solar activity and its corresponding effects around the polar cusp regions. We have investigated both, the GOCE and magnetic activity observations in time, spectral and spatial domain and attempted to eliminate these disturbances from GOCE observations. We believe that any improvement on GOCE data processing can help scientists improve the quality of the global and regional geoid models as well as the processing of other missions' datasets.

Abstract ID: 36281

Final Number: G13A-03

Title: Microgravity Effects of Earthquakes in the Cascadia Subduction Zone

Presenter/First Author: Jeong Woo Kim, University of Calgary, Calgary, AB

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Co-authors: Juergen Neumeyer, University of Calgary, Calgary, AB, Canada; Joseph Alan Henton, Pacific Geoscience Center, Sidney, BC, Canada; Byung-Gon Chae, Korea Institute of Geoscience and Mineral Resources, Daejon, South Korea; Hojjat Kabirzadeh, University of Calgary, Calgary, AB, Canada; Michael G Sideris, University of Calgary, Calgary, AB, Canada; Ik Woo, Kunsan National University, Kunsan, South Korea; Ricky Kao, University of Calgary, Calgary, AB, Canada; Junghae Choi, KIGAM, Daejeon, South Korea

Published Material: The preliminary results were presented at the meeting as a poster, but never been published. This presentaiton contains the updated results with recent data with advanced methodologies.

Abstract Body: An iGrav superconducting gravimeter (SG) and an A10 absolute gravimeter (AG) have been deployed at Pacific Geoscience Centre (PGC) on Vancouver Island, Canada, since 2012. The PGC is situated in the forearc of the northern Cascadia Subduction Zone (CSZ). In this area, a transient surface deformation accompanied by tremor-like seismic signals has been documented with a recurrence interval of 13 to 16 months. This phenomenon, named episodic tremor and slip (ETS), has been interpreted to be associated with slow slip events (silent earthquakes) in the CSZ. To detect the ETS events, the continuous microgravity recordings from the SG were reduced for all known environmental effects including Earth and ocean tides, polar motion, atmospheric pressure and soil moisture. The residual gravity effects were then compared with the GPS-detected ETS.

The gravity effect of the Haida Gwaii earthquake was analyzed. The earthquake occurred near the plate boundary between the Pacific and North America plates on 28 October 2012 with a magnitude 7.8. A large co-seismic gravity change of -2.6 microGal was recorded at the onset of the earthquake. In addition, a significant decrease of gravity was observed for the 15 days prior to the eartquake, and the decrease lasted for 11 days after the earthquake. The distance from the SG to the earthquake center is about 780 km. Compared to the observed co-seismic gravity change of 0.58 microGal whinin a distance of 3.4^o by Imanish et al. [2004] that was confirmed by a dislocation model, it is a significant gravity change. This gravity change can be associated with both subsurface mass redistribution and surface height displacement. For further interpretation, it has to be proved with straightforward seismic and dislocation models. Another earthquake that occurred in a similar region was the southwestern Alaska earthquake (5 January 2013, m7.5), and although it triggered a tsunami warning, it did not show any sign of co-seismic gravity change in the SG recordings.

These studies have shown that identification and assessment of geohazards and geodynamics such as active fault movement, as well as mass changes in geological CO_2 storage, may be possible with continuous monitoring of microgravity with combined SG and AG when the environmental gravity effects and surface displacements are effectively reduced.

Abstract ID: 35513

Final Number: G13A-04

Title: Precise Point Positioning for Geodynamics

Presenter/First Author: Marcelo C Santos, University of New Brunswick, Fredericton, NB

Presenter/First Author Email: msantos@unb.ca

Co-authors: João Carlos Chaves, , ,

Abstract Body: Precise Point Positioning is a Global Navigation Satellite System technique that allows the determination of centimeter-level coordinates in an Earth-Centered, Earth-Fixed frame using observations collected by a unique receiver. It requires external information, namely, satellite orbit and satellite clock offsets of better quality than the ones broadcast by the navigation message. It has found tremendous use in the last 10 years, and remains a topic of great development potential. One of the applications is in geodynamic studies. This presentation overviews the principles of PPP and discusses its application for crustal deformation modelling. A full case study will be presented and results compared to geophysical and geometric models.

Abstract ID: 36568

Final Number: G13A-05

Title: Real-Time Global Navigation Satellite System Positioning along Canada's Active Coastal Margin: Efforts Directed Toward Support of Tsunami Early Warning

Presenter/First Author: Joseph Alan Henton, Pacific Geoscience Center, Sidney, BC

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Co-authors: Herb Dragert, Geological Survey of Canada Sidney, Sidney, BC, Canada; Yuan Lu, Geological Survey of Canada (Pacific), Sidney, BC, Canada

Published Material: Some material presentated at the 2014 AGU Fall Meeting (significant updates expected to be presented at the Joint Assembly).

Abstract Body: High-rate, low-latency Global Navigation Satellite System (GNSS) data are being examined for real-time applications to monitor motions related to large earthquakes in coastal British Columbia. Specific goals for real-time regional geodetic monitoring are: collection of GNSS data with adequate station density to identify the source function for regional earthquakes with M>7.3; robust, continuous real-time analyses of GNSS data with a precision of 1-2 cm and a latency of less than 10s; and display of results with attending automated alarms and estimations of earthquake parameters. Megathrust earthquakes (M>8) are the primary targets for immediate identification, since the tsunamis they generate will strike the coast within 15-20 min. However, large (6.0<M<7.5) normal or strike-slip earthquakes when occurring within the ocean plate offshore could be mistakenly identified as large tsunamigenic events and need to be discriminated from subduction thrust ruptures in order to avoid tsunami "false alarms" and unwarranted mitigation responses.

Results from commercial software packages RTD and RTnet run in-house are compared to real-time precise point positioning streams received from other organizations. Comparison of multiple real-time solutions allows a realistic evaluation of day-to-day software performance especially when faced with adverse conditions such as data gaps or poor satellite geometry. Forward models for scenario earthquakes in this region can "fingerprint" the coseismic displacements expected from various offshore events which allows an evaluation of the effectiveness of the current regional coverage. The present distribution and density of real-time sites is sufficient for aiding the timely estimation of size, location, and nature of a great (M>8) megathrust earthquake. However, current coverage is inadequate for the unambiguous identification of the same parameters for 7<M<8 earthquakes, especially those occurring offshore northern Vancouver Island.

Abstract ID: 35593

Final Number: G13A-06

Title: Land Hydrology Monitoring in North America via GRACE and Hydrology Models: A Comparison Study

Presenter/First Author: Dimitrios Piretzidis, University of Calgary, Calgary, AB

Presenter/First Author Email: dimitrios.piretzidis@ucalgary.ca

Co-authors: Elena Veselinova Rangelova, Univ Calgary, Calgary, AB, Canada; Michael G Sideris, University of Calgary, Calgary, AB, Canada

Abstract Body: Monitoring the time-varying gravity field with GRACE satellite can be used to derive information about hydrological processes on the Earth surface. In the area of North America, the GRACE signal is contaminated with the effect of glacial isostatic adjustment (GIA). A study has been done to compare hydrological signals from several global hydrology models and determine the one that is closest to the GRACE-observed hydrology signal.

The set of hydrology models investigated consisted of the available releases of the global and regional hydrology models GLDAS 1.0 and NLDAS 2.0. These models use integrated satellite and terrestrial observations along with different data assimilation methods to derive various land surface states and fluxes. The land surface models used for GLDAS 1.0 were the Noah, CLM, Mosaic and VIC, and for NLDAS 2.0 the Noah, Mosaic and VIC. The recent GRACE CSR Release 05 data were also used. Proper masks were applied to cover Greenland and other areas with strong snow growth signal.

The study was focused on the variability of equivalent water height (EWH) which was computed on 1°-grids. To ensure a fair comparison between the GRACE and hydrology EWH fields, the latter were converted to the spherical harmonic domain and filtered with the same filters that were applied to GRACE. The effect of GIA was then removed from GRACE time-series using the latest GIA models.

The computed EWH fields show good agreement with both GRACE signal and seasonality. The models closest to GRACE EWH signal are the GLDAS NOAH and VIC. In North America the GLDAS NOAH is closest to GRACE signal. On the contrary, the GLDAS CLM present the largest disagreements with GRACE signal. The results also show that the GLDAS VIC model exhibits better agreement with GRACE seasonality. Finally, the performance of NLDAS models is similar for both EWH signal and seasonality.

Abstract ID: 34795

Final Number: G13A-07

Title: High-Precision Repeat Gravity Measurements In Riyadh Using Fgl Absolute Gravimeter, Potential Applications For Saudi Arabia

Presenter/First Author: Saad Mogren AlMogren, King Saud University, Riyadh 11451,

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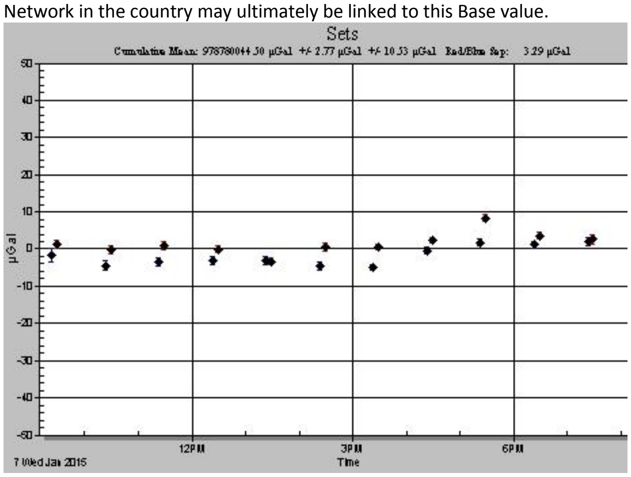
Abstract Body: High-precision repeat Absolute Gravity measurements are lacking for the Kingdom of Saudi Arabia, though there is an urgent need for such measurements considering their scientific importance, tectonic implications and also the size of the country. Presently there is no IGSN71 station within the Kingdom. Not only that; the base and baseline stations established by USGS, through network tie with IGSN stations in Africa way back in 1985, have also become extinct. Considering these aspects, we undertook repeat Absolute Gravity measurements by deploying FGL Absolute Gravimeter, for one locale on the Arabian Platform – King Saud University (KSU) Riyadh, Saudi Arabia. These measurements were continued since June 2008 through December 2014, which consists of a total of 310+ processed repeat data sets, displaying a set scatter of 1.87 – 4.52 µGal, where, the measuring precision is found to range between 0.29 – 0.52 µGal. Its best determined value at the King Saud University Absolute Gravity Base (called; KSU-AGB1) is: 978780044.50 µGal, Lat: 24.72167N, Long: 46.61722E, Elevation: 650.00 m, Set Scatter: 2.77 µGal, Measurement Precision: 0.57 µGal, , Total Uncertainty: 10.53 µGal. Plate I illustrates a typical display record for the FGL Absolute Gravimeter monitored on 7 January 2015 at KSU-AGB1. We recommend that the absolute gravity value reported here for KSU-AGB1 may be considered as the National Gravity Base for Saudi Arabia, and the Absolute Gravity Network in the country may ultimately be linked to this Base value.



Abstract ID: 34847

Final Number: G14A-0151

Title: Assessment of discontinuities of Helmert's gravity anomalies on the geoid

Presenter/First Author: Ismael Foroughi, University of New Brunswick, Fredericton,

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Co-authors: Petr Vanicek, University of New Brunswick, Fredericton, NB, Canada; Robert William Kingdon, Department of Geodesy and Geomatics Engineering, Fredericton, NB, Canada; Michael Sheng, Department of Geodesy and Geomatics Engineering, Fredericton, NB, Canada; Marcelo C Santos, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: Downward continuation of gravity anomalies has been always one of the most problematic steps in geoid computation, which in that, gravity anomalies on topography are transformed down to the geoid. The area of computation is broken down typically into 1°×1° cells, as the Poisson's formulation -the rigorous formulation of the downward continuation problem- is very demanding on computer resources and the solution is sought separately for each cell. The results in individual cells are then fused together. That can be reliably done if there are no discontinuities between the downward continued values in adjacent cells. This implies that continuity of results should be checked and topic of this contribution is one possible approach to such checking.

The proposed method is assessing differences between overlapping adjacent 1°×1° cells; instead of downward continuing gravity anomaly to a 1°×1° cell on geoid, the cell area is increased by 1' strip on each side. Such that cells on the geoid will have 1' overlap on each side, which then offer an opportunity to compare the results from adjacent 1° cells in two adjacent 1'-wide strips. Theoretically the differences should be either zero, or at least negligible if they are less than a low multiple of the standard deviation of observed data. We note that this approach can be used in a variety of problems encountered not only in geodesy but also in other experimental sciences.

Numerical assessment of the potential of this method has been done for mean Helmert gravity anomalies in Auvergne, France. The area limits to -1°<λ<7° and 43°<φ<49°, with standard deviation of about 40 µGal. Discontinuities between downward continued Helmert anomalies are between ±120 µGal. The general behavior of differences suggests that they are random in origin, but more detailed examination shows some biases which may be coming from topography, neglected far zone contributions or differences in the number of iterations in downward continuation process.

Abstract ID: 35337

Final Number: G14A-0152

Title: Progress Update on the U.S. Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project and Lessons Learned for Geoid Modelling

Presenter/First Author: Monica Youngman, National Geodetic Survey, Germantown, MD

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Co-authors: Vicki A Childers, NOAA, National Geodetic Survey, Silver Spring, MD; Simon A Holmes, SGT inc., Greenbelt, MD

Abstract Body: The U.S. National Geodetic Survey is collecting airborne gravity with the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project to produce a geoid supporting heights accurate to 2 centimeters where possible with a modernized U.S. vertical datum in 2022. This year GRAV-D will approach 50% of the country with airborne data collected to support the geoid, with over 75% of this data complete and publicly available. In this poster we provide an update on data collection status and present areas of known geoid improvement. We also discuss challenges faced when using airborne gravity to improve the geoid over a large, geographically diverse area with varying amounts of corroboratory data.

Abstract ID: 35407

Final Number: G14A-0153

Title: Continuation of Surface Anomalies to the Geoid in Regions of Negative Heights

Presenter/First Author: Robert W Kingdon, Fugro Airborne Surveys, Ottawa, ON

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Co-authors: Petr Vanicek, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The Poisson integral is a spatial solution to the Dirichlet boundary value problem for the exterior of a sphere. In the context of geoid computation, the Poisson kernel is usually applied to gravity anomalies on the geoid (approximated locally by a spherical surface), to determine gravity values on topography. Conversely, a discrete form of the Poisson integration can be inverted to determine gravity anomalies on the geoid, from gravity values on topography. Direct Poisson integration attenuates high frequencies, while the inverse operation amplifies high frequencies, in accordance with the physics of potential fields.

The Poisson integral as usually implemented, choosing the geoid as the spherical boundary and applying it to gravity anomalies harmonic only above the geoid, cannot be applied to gravity measurements within (below) the geoid. Two methods are herewith proposed to resolve this issue, in the context of continuation of Helmert gravity anomalies. In the first, the Helmert anomalies on topography are converted to a space where they are harmonic above a reference sphere corresponding to the lowest elevation in the area. They are then downward continued to the reference sphere, upward continued to the geoid, and converted back to the Helmert space. In the second, the **B** matrix representing the Poisson integral kernel in its discreet form is partitioned into sub-matrices, separating areas of negative and positive heights. The sub-matrices associated with negative heights are applied to gravity anomalies at negative heights, while the sub-matrices of $\mathbf{B}^{-1}$ associated with positive heights are applied to gravity anomalies at positive heights. Application in a test area over the Dead Sea shows agreement between geoid results from both methods of less than 1.5 cm in regions of negative height, and suggests that the second method is the more accurate.

Abstract ID: 35462

Final Number: G14A-0154

Title: Determination of the spectral weights of satellite models, and terrestrial and airborne gravity data for local geoid computations – case studies from GSVS11 and GSVS14 area

Presenter/First Author: Yan Ming Wang, NOAA, Boulder, CO

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Co-authors: Tao Jiang, Chinese Academy of Surveying and Mapping, Beijing, China

Abstract Body: For local geoid computations, the least squares collocation has been the standard method to combine several sets of gravity data. An alternative is to use the spectral combination which takes into account the error characteristics of each data represented by their error degree variances (EDV). However, the EDV of terrestrial and airborne gravity data are not known; thus limiting wide use of the method in practice. One way to estimate EDV of terrestrial and airborne gravity data is to use statistical models of red and white noise. This paper explores the feasibility of computing EDV directly from gravity data without using the statistic models. The EDV at low degrees are estimated by the aid of a satellite gravity model, while a leave-out-one error estimation technique is introduced to estimate those at the medium and high degrees directly from the local data themselves. The EDV implied spectral weights restrict the satellite models to long wavelength, the contribution of airborne gravity to the medium wavelength, and terrestrial data to the medium to short wavelengths of the gravity field. The spectral weights are applied in local geoid computations in GSVS11 and GSVS14 areas. The study shows not only the contribution of each data set to the geoid in the frequency domain, but also reveals the degree of correctness of the satellite gravity models.

Abstract ID: 35529

Final Number: G14A-0155

Title: Geoid Determination from Airborne Vector Gravimetry: An Example Using AIRGrav Data from Tanzania

Presenter/First Author: Stephen Ferguson, Sander Geophysics Ltd, Ottawa, ON

Presenter/First Author Email: stevef@sgl.com

Co-authors: Rene Forsberg, Technical University of Denmark - Space, Kongens Lyngby, Denmark

Abstract Body: Airborne gravity measurements have proven to be very useful in geoid computation, both as a sole source of data in areas where access is challenging, and as an addition to ground gravity data in other areas. Until now, measured airborne horizontal gravity components for geoid computation have not been utilized. One of the potential advantages of using horizontal gravity data for geoid determination is the relaxation of requirements for obtaining gravity data over a region larger than the area of interest, often practically impossible in coastal regions, or for countries in the developing world, where gravity data for neighboring countries are often lacking or kept secret.

In this presentation, high-resolution airborne vector gravity data over a large area of Northeastern Tanzania is used to compute new high-resolution geoid models, both with and without the use of horizontal gravity data. The geoid models are computed by remove-restore methods using least-squares collocation and Fourier methods, and these results are inter-compared, as well as compared with other recent geoid models and available GPS/levelling data.

The vector gravity data were acquired in 2012 using a Sander Geophysics AIRGrav system, as part of a large high-resolution multi-parameter survey conducted for the Tanzanian Ministry of Energy and Minerals (Fig. 1). Three large contiguous blocks are used in this study, covering an area of about 180,000 square km (Fig. 1). A larger airborne gravity survey, covering all of Tanzania, was carried out in 2012-13 by DTU Space in cooperation with the Tanzanian Department of Lands, and allows an independent comparison of the geoid results.

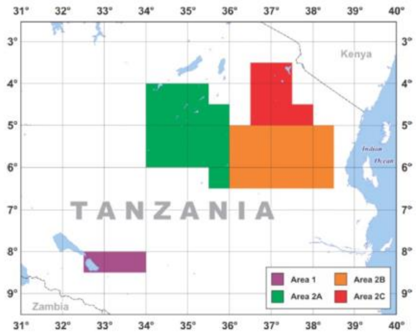

Figure 1: Survey location map showing the three contiguous areas (green, orange and red) used for geoid modelling

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Abstract ID: 33578

Final Number: G14A-0157

Title: Assessments of Recent GRACE and Release 5's GOCE Global Geopotential Models in Canada

Presenter: Marc Veronneau, Natural Resources Canada, Ottawa, ON

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First Author Student?: No

Published Material: Part of the results (less than 25%) was reported in the AGU Fall 2014 and the 5th user workshop as co-authors.

Abstract Body: The GOCE satellite by European Space Agency was launched on March 17th, 2009, and re-entered the Earth's atmosphere falling into the ocean on November 11th, 2013. Its objectives were to measure the Earth's gravity field with an accuracy of 1 mGal (one millionth of the Earth's gravity) and geoid with an accuracy of 1-2 cm at a spatial resolution of 100 km. Up to 2014, five generations of GOCE-only and GOCE-based satellite geopotential models have been released. In the meantime, satellite-only geopotential models derived from more than 10 years of observation by the ongoing GRACE mission were also released recently. While these satellite-only models only provide the long and medium wavelengths of the gravity field components, an extra-high degree model (EIGEN-6C4) complete to degree/order 2190 has been developed by combing the GRACE and GOCE models with the terrestrial and marine gravity data to improve the determination of the complete Earth's gravity field.

Assessments of the new releases of GRACE- and GOCE-based models are to understand what new and improved gravity information these new GRACE and GOCE models have brought in; what unique contribution of each mission is in term of improving the Earth's gravity field; how accurate these models are in terms of both commission and omission errors; and how the combined model EIGEN-6C4 have improved determination of the full Earth's gravity field. Answers to these questions are necessary for our ultimate goal that is to best use GRACE and GOCE information to improve the geoid model in Canada. This study attempts to address these questions through assessing the recent GRACE models and Release 5's GOCE geopotential models using GPS-Levelling, astronomical deflections of the vertical and gravity data in Canada.

Abstract ID: 34315

Final Number: G14A-0158

Title: Concerning the Roundabout Method to Downward Continuation and the Evaluation of the Far-zone

Presenter/First Author: Michael Sheng, Department of Geodesy and Geomatics Engineering, Fredericton, NB

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Co-authors: Petr Vanicek, University of New Brunswick, Fredericton, NB, Canada; Robert William Kingdon, Department of Geodesy and Geomatics Engineering, Fredericton, NB, Canada; Ismael Foroughi, University of New Brunswick, Fredericton, Canada; Juraj Janak, Slovak University of Technology, Bratislava, Slovakia; Marcelo C Santos, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The Stokes-Helmert approach to precise geoid computation is used in the SHGeo software package at the University of New Brunswick. This method uses Stokes's theorem which requires the knowledge of gravity anomalies on a boundary (the geoid); measurements on or above the surface of the Earth must therefore be downward continued to the geoid. The mathematical instability of the downward continuation is well-documented and its effect on the resulting geoid must be considered.

Helmert space differs from the real one by removing topography above the geoid and applying Helmert's second condensation method. It has a similar gravity field to the real space while satisfying the harmonicity of the gravity potential above the geoid as required. Another space that can be used is the No-Topography (NT) space, defined by the Earth after the removal of topography; this causes the field to be much smoother than the real field. The NT anomaly can be downward continued and transformed to Helmert space by accounting for the condensation layer. We call this technique of evaluating Helmert's anomalies on the geoid the 'roundabout' approach compared to continuing Helmert's anomalies directly to the geoid (the 'direct' approach). Results from the roundabout technique should be more accurate due to the smoothness of the NT anomalies.

Applying this approach in Auvergne, France ($44.5° < \varphi < 47.5°$, $1.5° < \lambda < 4.5°$), the results for the roundabout approach after downward continuation are worse than for the direct approach. After testing we found that the NT anomalies are about twice as sensitive to the far-zone contribution than the Helmert ones. By doubling the integration radius for the downward continuation of the NT anomalies, the geoid results from the roundabout approach are comparable to those obtained from the direct approach. The fit to GPS benchmarks in Auvergne is $\sigma = 0.042$m vs. 0.037m. This preliminary work shows that the NT field is worth further investigation.

Abstract ID: 34354

Final Number: G24A-0159

Title: Updating Bench Mark Coordinates for the New U.S. National Datums

Presenter/First Author: Daniel R Roman, National Geodetic Survey, Silver Spring, MD

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Abstract Body: The National Geodetic Survey (NGS) maintains the National Spatial Reference Systems (NSRS) within the United States. The NSRS currently includes the North American Datum of 1988 (NAVD 88) for orthometric heights and the North American Datum of 1983 (NAD 83) for ellipsoidal coordinates. Replacing these two datums with new geometric and geopotential datums in 2022 will require many changes in standards, technique, policy, and practices. The approach envisioned is to use GNSS observations in conjunction with online processing tools to obtain geometric coordinates, which would then be interpolated into a high accuracy gravimetric geoid (geopotential) model to determine orthometric heights.

This would mark a move away from traditionally defined bench mark coordinates that currently provide definitive positional control. The NGS Integrated Database (NGSDB) serves as the electronic repository for bench mark data on nearly 500,000 NAVD 88 leveling sites and 80,000 NAD 83 coordinate sites. The role of this bench mark data would then become secondary, serving as a backup in case of catastrophic failure of GNSS access. To be useful then, bench mark data will need to be made consistent with the new datums requiring an adjustment of the positional coordinates in the NGSIDB. These values must be consistent with what would be obtained using a GNSS receiver and the geoid model in the new datums. Backward compatibility will be maintained through knowledge of the coordinates under the older and newer datums, which will be used to produce a transformation model similar to VERTCON and NADCON software.

Abstract ID: 34833

Final Number: G24A-0160

Title: Practical and Technical Considerations for the Replacement of NAVD 88 and IGLD 85

Presenter/First Author: Dru A Smith, NOAA Natl Geodetic Survey, Silver Spring, MD

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Abstract Body: The North American Datum of 1988 (NAVD 88) was co-defined with the International Great Lakes Datum of 1985 (IGLD 85) through the determination of geopotential numbers at some 600,000 passive geodetic control bench marks. Those geopotential numbers were computed from geodetic spirit leveling and surface gravity measurements. Most of the field work was performed in the 1970's and 1980's, though some of the leveling dates from NGVD 29 and CGVD 28.

The primary method by which surveyors and other geospatial professionals access NAVD 88 and IGLD 85 is through the publication of Helmert orthometric heights (for NAVD 88) or Dynamic Heights (for IGLD 85), both derived from geopotential numbers, at passive control. NAVD 88 and IGLD 85 were significant achievements and improvements over previous height systems on the North American continent. However, they have a significant number of disadvantages, including: the general lack of vertical change monitoring; the removal of passive control during construction projects; the inconsistency between marks which move with the crust and those which are deep-driven rods and move only with underlying bedrock; the inconvenience of marks not existing in an area of interest to a surveyor; the propagation of leveling errors over thousands of kilometers and the failure to incorporate 2nd and 3rdorder effects into the original determination of geopotential numbers.

In 2008, the National Geodetic Survey (NGS) formally announced its policy to replace NAVD 88 with a geopotential reference frame implicitly linked to a new geometric reference frame (which will replace NAD 83). The geopotential reference frame will have the data and tools needed to provide to users their orthometric height, dynamic height, deflections of the vertical or acceleration of gravity at any point in the USA or its territories. The orthometric heights will be accessed from CORS stations, a time dependent gravimetric geoid model and GNSS positioning techniques. The dynamic heights will be similarly accessed, but will also rely on a time-dependent surface gravity field.

This talk will focus on the technical and practical considerations surrounding the definition of such a frame, its upkeep and its method of access by geospatial professionals. Topics will include data collection, models, tools, accuracy and sustainability.

Abstract ID: 34896

Final Number: G24A-0161

Title: Maintaining a National Geoid-Based Vertical Datum

Presenter/First Author: Marc Veronneau, Natural Resources Canada, Ottawa, ON

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Co-authors: Jianliang Huang, Natural Resources Canada, Ottawa, ON, Canada

Abstract Body: In November 2013, Canada established the Canadian Geodetic Vertical Datum of 2013 (CGVD2013). This new datum is defined by an equipotential surface (W_o =62,636,856 m^2/s^2) and realized by a geoid model (CGG2013), making it compatible with Global Navigation Satellite Systems (GNSS) for positioning. The adoption of CGVD2013 represents a major shift from the old datum CGVD28, which was defined by the mean sea level at selected tide gauges and realised by traditional levelling measurements, and a major impact for the users, who have relied on benchmarks for the last 100 years to conduct their surveys.

The presentation will not only discuss the advantages for Canada to moving to a geoid-based datum, but also discuss the challenges in maintaining such as vertical datum in an era where technology is moving rapidly and data are coming in in large numbers allowing the possibility of a quick turnaround in the release of new realisations of the geoid-based vertical datum. This is quite different as when benchmarks were re-surveyed at a 20- to 30-year cycle or sometime never revisited again, keeping heights very consistent over the years. How to satisfy users who want to live in world as static as possible, but simultaneously providing continuous improvement in the vertical datum to satisfy utmost scientific requirements.

Abstract ID: 35364

Final Number: G24A-0162

Title: Practical and Technical Considerations for the Replacement of NAD 83

Presenter/First Author: Joe G Evjen, National Geodetic Survey, NOAA, Silver Spring, MD

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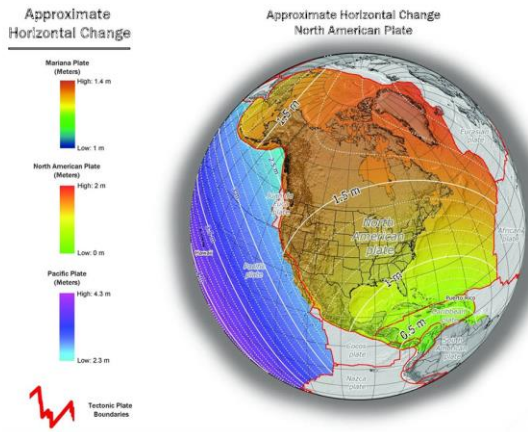
Abstract Body: The official U.S. horizontal mapping datum, the North American Datum of 1983 (NAD 83)—in both its definition, as well as the services NGS provides for its access—is in need of improvement. As defined, it is non-geocentric by over two meters and has non-zero, residual plate velocities. Since 1983, increasingly accurate International Terrestrial

Reference Frames (ITRF) have become available and have been adopted by many groups, including Mexico's INEGI and the U.S. National Geospatial-Intelligence Agency.

The U.S. National Geodetic Survey is planning a replacement of NAD 83 with a new ITRF-aligned geometric datum, to be released with a new GNSS-accessible geopotential datum to replace the North American Vertical Datum of 1988. We will discuss recent progress, expected benefits, planned products, services, models, and tools to access the new datum, legislative steps, and impacts and concerns from Federal, State, Private Sectors.



Abstract ID: 36111

Final Number: G24A-0163

Title: *New Datum CGG2013 applications for DSM-DEM-DTM preparation from earth observation satellites data*

Presenter/First Author: Jay Sagin, Saskatchewan Polytechnic, Saskatoon, SK

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Abstract Body: *The high resolution Digital Surface Model (DSM), Digital Elevation Model (DEM) and Digital Terrain Model (DTM), a topographic model of the bare earth-terrain relief (DTM=DEM of the earth surface), are valuable data for many earth studies applications. Many regions, including Canada, lack the high resolution DSM-DEM-DTM. We have compared the DEM obtained from satellite datasets, including Canadian Radarsat-2, German TanDEM-X DEM, and Japanese ASTER. The Bathymetry Model (BM) was development into a DTM compilation by subtracting the BM from the DSM. The high resolution Global Navigation Satellite System (GNSS) collection equipment GPS Pathfinder ProXRT GLONASS (the real-time receiver can achieve decimeter (10 cm) accuracy), with satellite OmniSTAR G2 satellite subscription are used for the field elevation data collection. Calibration and verifications of the DSM-DEM-DTM were done in the research area, North West Territory, by using the new Geoid stations, CGVD2013. The critical points along the road profile with the new Geoid stations and the Slave River, bare rock outcrops, including Slave River upstream, Fort Smith town, and downstream, Fort Resolution town, were used to the height reference. The new updated Geoid CGG2013 stations are used as the main DSM-DEM-DTM reference points. Ice thickness and water depth are measured along the Slave River by auger drilling. The collected field data and processed satellite data with prepared DSM-DEM-DTM are to be used for the ice jam and flood predictions along the Slave River, NWT, Canada.*

Abstract ID: 36538

Final Number: G24A-0164

Title: Toward the Computation of a Geoid Model of Ghana

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Co-authors: Petr Vanicek, University of New Brunswick, Fredericton, NB, Canada; Robert William Kingdon, Department of Geodesy and Geomatics Engineering, Fredericton, NB, Canada; Michael Sheng, Department of Geodesy and Geomatics Engineering, Fredericton, NB, Canada; Ismael Foroughi, University of New Brunswick, Fredericton, Canada; Marcelo C Santos, University of New Brunswick, Fredericton, NB, Canada; Peter John Dare, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: Use of the Global Positioning System (GPS) was introduced to Ghana in the early 1990s. The widespread use of GPS in height-related surveying and mapping activities has made the computation of a geoid model a very important task. In this research, the first gravimetric geoid for Ghana is being computed using the Stokes-Helmert method, developed by the University of New Brunswick (UNB), Canada. This method utilizes a two space solving the associated boundary value problems, including the real and Helmert's spaces. The UNB approach combines observed terrestrial gravity data with long-wavelength gravity information from a Global Gravitational Model (GGM).

All the terrestrial gravity data used in the computation was derived from the Geological Survey Department of Ghana, due to difficulties in obtaining data from BGI and GETECH. The first gravity survey was part of Ghana's contribution to the International Geophysical Year, 1957-1958, and was linked to the gravity network of the neighboring countries and to Potsdam reference system through a connection to Pendulum House, Cambridge, United Kingdom (UK). A least squares adjustment of the gravity survey network was carried out in the UK. Since this first campaign of gravity collection, more data have been added to the gravity database, which now covers between 70 and 80 percent of the country. A GGM is used to pad those areas lacking in terrestrial gravity data.

For the computation of topographic effects on the geoid, the STRM, a Digital Elevation Model (DTM) generated by NASA and the National Geospatial Intelligence Agency (NGA), is being used. Since the terrain in Ghana is relatively flat, the topographic effect, often a major problem in geoid computation, is unlikely to be significant. This first geoid model for Ghana will be computed on a 1'1' grid over the computation area bounded by latitudes 4ºN and 12ºN, and longitudes 4ºW and 2ºE. GPS/levelling heights will be used to validate the results of the computation.

Keywords: Geoid, Stokes' formula, Global Gravitational Model, Topographic effect, Digital Terrain Model

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Abstract ID: 33913

Final Number: G34A-0116

Title: Geodetic versus geologic subsidence rate along the United States east coast: Implications for global isostatic adjustment and effects of ground water extraction

Presenter/First Author: Makan A. Karegar, University of South Florida Tampa, Tampa, FL

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Abstract Body: Subsidence along the Atlantic coast of the United States is the largest amplitude collapse of a pro-glacial forebulge on Earth. High-quality geological records of Holocene relative sea level are now available for the region (Engelhart et al., 2009; Engelhart and Horton, 2012; Kemp et al., 2014). These data provide an independent constraint on Global Isostatic Adjustment (GIA), for comparison to continuous GPS measurements that directly measure net vertical motion of the crust from GIA and other processes. Long GPS time series are now available, allowing precision in the vertical component better ± 1mm/yr. Here, we present an improved vertical velocity field for the eastern seaboard of the U.S. and parts of Atlantic Canada with uncertainty estimates that incorporate time-correlated noise. We demonstrate good agreement between GPS vertical velocities and the geologic rates for most of the U.S. eastern seaboard. Exceptions are most likely related to areas of recent excessive ground water extraction, which affects the GPS vertical rate estimate.

References:

Engelhart, S.E., Horton, B.P., Douglas, B.C., Peltier, W.R., Törnqvist, T.E. (2009). Spatial variability of late Holocene and 20th century sea-level rise along the Atlantic coast of the United States. Geology, 37(12), 1115-1118.

Engelhart, S.E., Horton, B. P. (2012). Holocene sea level database for the Atlantic coast of the United States. Quaternary Science Reviews, 54, 12-25.

Kemp, A.C., et al., (2014). Late Holocene sea-and land-level change on the US southeastern Atlantic coast. Marine Geology, 357, 90-100.

Abstract ID: 34110

Final Number: G34A-0117

Title: ANALYSIS OF GEOLOGICAL-GEOTHECNICAL RISKS DUE TO GROUNDWATER EXPLOITATION USING SPACE AND TERRESTRIAL TECHNIQUES: LORCA AREA (SPAIN) TEST CASE

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Abstract Body: To provide new products and services for the analysis, management and mitigation of the geological-geotechnical risks associated with the exploitation of aquifers in urban areas and their surroundings, are the aims of AQUARISK reseach project. For this purpose multi-sensor (ERS & ENVISAT, ALOS PALSAR, Sentinel, PAZ) satellite Advanced DInSAR and GNSS data fusion will be performed at regional scale to determine the 3D deformation field of the mediterranean arc (Southeast Spain) and also at local scale for a detailed study of the areas of interest. This analysis will permit to detect the temporal evolution of subsidence in those hidrographic basins that suffer the greatest exploitation (e.g. Lorca área at Guadalentin-Segura River Basin). In this area, new in situ monitoring systems will be developped and implemented to carry out a real time monitotoring of the temporal evolution of ground water level and the aquifer deformation in depth. These terrestrial measurement data will be integrated with the remote sensing EO data to determine the 4D deformation field, and to define future climate change based scenarios of the aquifer system response. All this effort will permit to develop, calibrate and validate advanced numerical geomechanical models that will simulate the past-present-future aquifer system response, and to analyze the impact of subsidence on urban structures and infrastructures.

In this framework, AQUARISK will performs research and development on new services & products based on EO multi-sensor satellites data in conjunction with in-situ data; and will promotes the exploitation of EO and in situ data to monitor, model and predict subsidence due to aquifers exploitation in different climatic change scenarios.

A summary of the obtained scientific results and of the works to be carried out in the near future will be presented.

Abstract ID: 35143

Final Number: G34A-0118

Title: Horizontal Displacement Monitoring In Eastern Ontario

Presenter/First Author: Hadis Samadi Alinia, University of Western Ontario, London, ON

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Co-authors: Kristy French Tiampo, University of Western Ontario, London, ON, Canada

Abstract Body: Eastern Ontario is a region of moderate seismic hazard, an area of ongoing intraplate deformation in the North American plate (Tiampo et al., 2011; Calais et al., 2006). However, the continuous melting of ice sheets during deglaciation today causes horizontal and vertical deformation of the Earth surface near Hudson Bay and to the southern Great Lakes. In this work, new measurements from GPS stations installed in the Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity (SOSN/POLARIS) network, combined with permanent stations that are operated by Natural Resources Canada (NRCan), are analyzed in order to estimate the associated horizontal and vertical crustal motions with accuracies less than mm.

GPS stations of the eastern Ontario networks are distributed sparsely, with a spacing of approximately 250km or more. In this work, several sets of reference stations were processed using Bernese 5.0 and residual time series coordinate changes of each station were compared to the global solutions for crustal motions (http://geodesy.unr.edu/). Comparison of our results with others global solution techniques show an internal accuracy at the level of 0.1 mm/yr. (1 sigma) for horizontal and vertical velocities at the best sites.

The focus of this paper is to present GPS stations horizontal velocities obtained by analyzing their coordinate time series. To achieve this goal, the basic parameters such as mean and variance are estimated then jumps and outliers are detected and eliminated. Correlation coefficients of linear trend, residual analysis, interpolation of spaced data, spectral analysis and wavelength power spectrum are computed. Finally, all of the obtained horizontal velocities are corrected for the North America plate motions (Altamimi et al., 2012) and compared with the predicted glacial isotactic adjustment (GIA) model ICE3G (Tushingham and Peltier, 1991; Peltier, 2004) with different viscosity structures. The horizontal velocities are consistent with the ICE-3G postglacial rebound model with 0.1-0.2 mm/yr. uncertainties, and they provide new insights into the modeled viscosity structure.

Abstract ID: 35359

Final Number: G34A-0119

Title: CO2 reservoir joint modeling using time lapse micro gravimetry and ground deformation

Presenter/First Author: Hojjat Kabirzadeh, University of Calgary, Calgary, AB

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Co-authors: Jeong Woo Kim, University of Calgary, Calgary, AB, Canada; Michael G Sideris, University of Calgary, Calgary, AB, Canada

Abstract Body: Geodetics and gravimetric methods have been used for CO2 reservoir monitoring purposes in the past. However they have been employed as a joint process rarely. We use gravity and surface deformation forward modeling in order to show the feasibility of a numerically joint study. A reservoir is considered to be located at 1800 meters depth with 20 meters of thickness. 2.5 million tons of CO2 is injected to this reservoir. This excessive CO2 causes a negative density change in the pore content and consequently a negative gravity anomaly at the surface. On the other hand the positive volumetric changes caused by excessive pressure inside the reservoir results in uplift at the surface. For modelling procedure, subsurface is divided to rectangular portions and two different Green's functions relates the gravity and surface deformation to density and volume changes in each cell. The results show that under these assumptions we can detect -5 µGal gravity change as well as 30 mm of ground deformation just above the injection well. The obtained gravity signal target is well above the precision of Superconductive gravimeters. Superconducting gravimeter supported by absolute gravimeter can provide unique measurements with high resolution (0.05 µGal in time domain). Millimetre scale accuracy of INSAR surface deformation measurements enables the deformation detection due to CO2 injection with a very high accuracy.

Abstract ID: 36251

Final Number: G34A-0120

Title: Constraints Provided by Ground Gravity Observations on Geocentre Motions

Presenter/First Author: Yves J G Rogister, EOST École et Observatoire des Sciences de la Terre, Strasbourg,

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Co-authors: Anthony Mémin, , , ; Severine Rosat, IPGS-EOST, Strasbourg, France; Jacques Hinderer, Institut de Physique du Globe Strasbourg, Strasbourg Cedex, France; Marta Calvo, CNRS EOST, Strasbourg, CDX, France

Abstract Body: The geocentre motion is the motion of the centre of mass of the entire Earth, considered an isolated system, in a terrestrial system of reference. Up to now, geocenter motions have been derived from positioning measurements only. We propose a new approach to constrain these motions by using ground gravity measurements. We first derive a formula relating the harmonic degree-1 Lagrangian variations of the gravity, the harmonic degree-1 vertical displacements of the station and the displacements of the whole Earth's centre of mass. The relationship is independent of the nature of the Earth deformation and is valid for any source of deformation. We impose no constraint on the system of reference, except that its origin must initially coincide with the centre of mass of the spherically-symmetric Earth model. Next, we consider the geocentre motion caused by surface loading. In a system of reference whose origin is the centre of mass of the solid Earth, we obtain a specific relationship between the gravity variations at the surface, the geocentre displacement and the load Love number h'_1, which demands the Earth's structure and rheological behaviour be known. We show that an annual gravity signal of 400 nGal (100 Gal = 1 m/s^2) associated with a geocenter motion of 1 mm is above the noise level of the superconducting gravimeter (SG) in Strasbourg, France. Given that, we investigate if the present network of SGs co-located with positioning measurements can detect the annual variation of the geocenter motion.

GEOARCHEOLOGY

Abstract ID: 33368

Final Number: GA43A-01

Title: Archaeomagnetism as Geoarchaeology: Using Mineral Magnetic and Palaeomagnetic Measurements to Understand Behaviour, Palaeoenvironmental Change, Occupation Intensity and Fire Use on Palaolithic Sites from South Africa, Australia and China.

Presenter/First Author: Andy IR Herries, La Trobe University, Bindoore, VIC

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Published Material: Brown et al. 2009. Science. various media outlets. (Pinnacle Point) and various archaeological meetingsHerries and Fisher, 2010. J. Human Evolution. (PInnacle Point) and various archaeological meetingsCurnoe et al. 2012. Plos One. (Red Deer Cave).the remaining material fromSouth Africa and Australia has not been presented and is unpublished.

Abstract Body: The term Archaeomagnetism is generally synonymous with Archaeomagnetic Dating and the use of geomagnetic secular variation data for understanding the age of sites. However, in a broader sense it should be used to include the use of mineral magnetic and palaeomagnetic measurements on archaeological sites as part of the field of geoarchaeology. It should also be undertaken with a multi-disciplinary perspective in mind and in combination with other geoachaeological methods such as micromorphology and geochemistry. A number of studies have undertaken this approach but archaeomagnetism in this sense remains an underutilized method within the realms of archaeological science despite being able to inform archaeologists about a range of different processes including palaeoenvironmental change, site formation processes and human behavior through fire use and pyrotechnology. To illustrate the potential of archaeomagnetism to the Palaeolithic time period, a range of case studies will be shown that illustrate this. This will include work on the hominin bearing site of Red Deer Cave in China, the Middle Stone Age Pinnacle Point Caves and Erfkroon Later Stone Age site in South Africa and a range of site contexts in Australia. From the Pinnacle Point Caves and caves in Western Australia mineral magnetism in conjunction with micromorphology has been used to understand fire use and inferences for site occupation intensity. At other cave sites in South Africa, Australia and at the Red Deer Cave in China mineral magnetism has been used to show climatic change, including evidence for millennial scale changes during the Holocene and late Pleistocene. At Pinnacle Point archaeomagnetism has also been succesfully used to identify the oldest evidence for the heat treatment of stone by early humans to make stone tools and this work has been continued in Australia. At Erfkroon potentially early Later Stone Age hot rock technology has been identified and in conjunction with work on Australian Clay Balls this will be used to illustrate the need for experimental archaeology as a fundamental part of archaeomagnetic analysis.

Abstract ID: 35126

Final Number: GA43A-02

Title: Iron isotopes as a new tool for old metals tracing

Presenter/First Author: Jean Milot, GET Géosciences Environnement Toulouse, Toulouse,

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Co-authors: Franck Poitrasson, Universidade de Brasilia-IRD, Brasilia, Df, Brazil; Sandrine Baron, Laboratoire TRACES, Toulouse, France; Marie-Pierre Coustures, Laboratoire TRACES, Toulouse, France; Caroline Robion-Brunner, Laboratoire TRACES, Toulouse, France

Abstract Body: Geochemical and isotopic analyses are well known tools for old metal provenance studies and ancient trade networks reconstitution. For relevant archaeological interpretation, the metallurgical processes have to be taken into account and analyses must be performed on ores, slags and produced metal. Classically, trace elements analyses are used for ferrous metals provenancing (Coustures *et al*., 2003), whereas lead isotopic analyses are used for non-ferrous metals (Stos-Gale *et al*., 1997; Durali-Mueller *et al*., 2007). However, these two techniques show limitations. Indeed, trace elements analyses of ferrous artefacts are performed on slag inclusions which induces significant deterioration of archaeological pieces. Moreover, a very pure metal does not contain any slag inclusions. Concerning lead isotopes analyses, distinct mining districts may have a homogeneous isotopic composition while ores from the same mine can show a heterogeneous isotopic composition. This may induce some questionings for provenance issues (Baron *et al*., 2014). These limitations underline the need to develop new tracers as a complement to the existing ones.

For the first time, iron isotopes are used for old metals characterization and provenancing. To develop our method, we analyzed material from reduction experiments and metallic artefacts clearly constrained by archeology and by multi-elemental analyses. The isotopic ratios ^{57}Fe /^{54}Fe and ^{56}Fe/^{54}Fe were quantified using a Multi Collector Inductively Coupled Plasma Mass Spectrometer after sample dissolution and Fe purification.

Our first results show that iron isotope compositions of ores, slags and metal are homogeneous for each iron ore reduction experiments. Moreover, iron isotopes allow to distinguish iron ores from different sources which were undistinguishable using lead isotopes. It demonstrates here that whereas iron isotopes remain unaffected by the ferrous metallurgical process, they can become a powerful tool for provenance studies.

Abstract ID: 35342

Final Number: GA43A-03

Title: Interpreting the Different Scales of Ceramic Paste Compositional Datasets: Archaeological Perspectives and Scales of Analysis.

Presenter/First Author: Yves Monette, University of Montreal, Montreal, QC

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Published Material: Part of the presentation uses material from my PhD thesis also published in the Journal of Archaeological Science (2007) and one example on fire assay crucibles was published in 2013 in Applied clay Science.

Abstract Body: Over the past 20 years, ceramic paste chemical analysis has become common practice in archaeology. Chemical data obtained through a variety of analytical methods is either used to answer questions of provenance, pin-point the source of raw materials, highlight trading routes and patterns or simply to characterise a ceramic container and reveal some of its deeply buried secrets. The variety of research questions that one can tackle via a robust chemical dataset covers a large angle.

Through a selection of case studies making use of geochemical data, this paper explores the multiple scales of analysis of ceramic pastes through wide to narrow archaeological perspectives. The selected examples will present European and colonial ceramic materials dated from the 16th-19th Century time period. Form the broad observations to the very small scale study, we will look at the 16th and 17th centuries worldwide diffusion of highly refractory fire assay crucibles, at the chemical characterization of potters ceramic wastes in a regional perspective, and have a look at an early 19th Century pottery production were multiple production series can be identified.

Moving forward in the demonstration, we will highlight the interplay between the scales of analysis and the archaeological perspectives, and their mutual influence on the reality we are trying to capture.

Abstract ID: 35624

Final Number: GA43A-04

Title: Using Microfossils to Observe the Occupancy of Pre-Historic Peoples: the Value of Non-Pollen Palynomorphs

Presenter/First Author: Nicholas Riddick, Brock Univ, St Catharines, ON

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Abstract Body: Microfossils, particularly pollen grains, have been used to address archaeological questions since the early 1900's. Their use has expanded beyond their original application to date archaeological remains. A classic example is the response of various microfossil groups (diatoms, rotifers, fungal spores, dinoflagellate cysts and pollen) to several periods of human occupation around Crawford Lake, Ontario. While Euro-Canadian land clearing, farming and logging (identified by abundant ragweed pollen) added nutrients to the lake, the Iroquois occupation (identified by cultivar pollen and spores of their pathogenic fungi) had the greatest impact on the lake ecosystem. These higher abundances are observed more than once between ~A.D.1286–1486, indicating cycles of habitation of the village. Similarly, the distribution of palynomorphs (acid resistant microfossils) in small lakes on the Penetanguishene Peninsula and in Severn Sound, Ontario reveals distinct Euro-Canadian and Wendat (Huron - ~A.D.1450–1650) occupation zones, both characterized by an increase in algal microfossils (particularly eutrophic taxa) as well as non-arboreal pollen. Ongoing studies in Lake Simcoe have identified evidence of Wendat occupation in the Orillia region, where the palynological signature is supported by measurements of increased nutrient and heavy metal concentrations in pre-European sections of the core. The abundance of algal palynomorphs in our samples clearly records cultural eutrophication, but because most pollen analysts use acetolysis to "clean up their preparations", the more susceptible non-pollen palynomorphs are destroyed. Analysis of samples from Smith's Bay (Lake Simcoe) pre- and post- acetolysis treatment show a loss of most desmid species (particularly Staurastrum spp.) and small, thin-walled dinoflagellates, for instance, whereas Pediastrum appear to be unaffected. Geoarcheologists are urged to avoid acetolysis and examine the non-pollen palynomorphs in their "pollen" slides, thus getting broader insights into anthropogenic impact than by relying on the pollen alone.

Abstract ID: 36235

Final Number: GA43A-05

Title: The Geochemical Provenance of Pre-Contact Copper Artifacts from the Gaspereau Lake Area, Nova Scotia: Analytical Approaches, Challenges and Interpretation

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Co-authors: Jessica Whattam, Saint Mary's University, Halifax, NS, Canada; Catherine Cottreau-Robins, Nova Scotia Museum, Halifax, NS, Canada; Christopher RM McFarlane, University of New Brunswick, Fredericton, NB, Canada; W. Bruce Stewart, Cultural Resource Management Group Ltd., Halifax, NS, Canada; Mike Sanders, Cultural Resource Management Group Ltd., Halifax, NS, Canada

Abstract Body: In-situ microanalysis of archaeological materials by laser ablation ICP-MS is rapid and virtually non-destructive compared to bulk techniques (XRF, NAA), allowing compositional variability to be assessed at high spatial resolution. We used LA-ICPMS to compare trace element concentrations in 28 copper artifacts (worked natural “nuggets”) from the Gaspereau Lake area of Kings County, Nova Scotia to natural samples from Michigan (7 deposits) and Nova Scotia (3 deposits) providing constraints on geological provenance.

Intra- and inter-sample variations in trace element concentrations at hand sample and deposit scales are <20% (relative) whereas previous NAA and XRF data is compromised by contaminating mineral inclusions in the copper that cannot be excluded in the large sample volumes required for these methods. Comparison of patina and fresh metal show systematic enrichments in Zn, Sn, Fe, As and Au in patina and S, Sb, Co, Ni and Ge in fresh copper matrix; however, this fractionation resulting from oxidation does not impact composition sufficiently to limit the use of fresh copper or even patina in provenance studies.

Eight of the artifacts were derived from 2 principle copper sources on the Bay of Fundy coast that can be easily differentiated from one another by their contrasting Ag/Pb ratios. (Cap D’Or and Margaretsville-Victoria Beach). The remaining 20 artifacts are not from the Bay of Fundy, or any Michigan sources (enriched in As relative to Fundy) and comprise 5 distinct yet geographically unidentified provenance groupings.

Preliminary results reassert the importance of local (Fundy) copper to pre-contact period indigenous peoples of Nova Scotia and the Maritimes, and negate the Lake Superior model. The diversity of copper sources indicated has significance in the broader context of territorial procurement of copper, and trade relationships between groups of aboriginal peoples in the Atlantic Northeast.

Abstract ID: 35385

Final Number: GA43A-06

Title: Geoarchaeology of the ancient harbour bassin of Ostia, Rome, Italy

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Abstract Body: For the first time we prove, by the use of corings, the location of the basin harbour of Ostia. The study of the stratigraphic sequence of Ostia basin is based on multidisciplinary geoarchaeological approach that integrate 17 radiocarbon dates obtained on 12m of stratigraphy. Three units can be distinguished: pre-harbour, harbour and post-harbour. (i) The pre-harbour is a fluvial-marine environment dated between the 9th and 8th BC: this is the paleo-mouth of the Tiber. (ii) The base of the harbour sequence is characterized by a facies of dark grey silty clay: this is a quiet area in connection with both the river and the sea. It starts at the earliest in the middle of the 4th c. BC (360 BC) and is attested until no later than the end of the 3rd c. BC (205 BC). At that time the depth of the basin reached 6m below roman sea level. This unusual depth is very significant for the time and implies that seagoing vessels could access the basin. (iii) The summit of the harbour sequence is marked by yellow sands brought by floods of the Tiber. The protective role of the basin decreases between 165 BC and 5 AD and depth is no longer than 2.5m under the ancient marine zero. Most seagoing ships cannot access it anymore. (iv) The basin loses its function at the beginning of the imperial period because its depth was only 60 cm between 45BC and 25 AD and about 30cm between 80 and 230 AD.

Abstract ID: 33572

Final Number: GA43A-07

Title: Archaeology and Geomagnetism: Investigating the Earth's Magnetic Field in Italy during the Neolithic Period. New Data from the Portonovo Archaeological Site (Marche, Italy)

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Abstract Body: Archaeomagnetic data from ancient baked clays is a precious source of information about the past variations of the Earth's magnetic field. Thanks to archaeomagnetic records from well dated archaeological artefacts it is possible to reconstruct the geomagnetic field variations in the past and better understand its behaviour. On the other hand, once a detailed secular variation path is established for a certain area, reliable archaeomagnetic dating is possible. In order to enrich the Italian reference database and extend it back in time, we present here the results of an archaeomagnetic study carried out on three Neolithic ovens excavated at the archaeological site of Portonovo (Marche, Italy). The discovered structures are a rare example of well preserved domed ovens from the Early Neolithic period, dated based on archaeological information and radiocarbon dating. Standard thermal demagnetization procedures were used to determine the archaeomagnetic direction registered by each oven during its last firing and their archaeointensity was determined with the multi-specimen procedure (MSP-DSC). Both directional and intensity results are of high quality and they clearly show an intensity low during the Neolithic period. These new results, that are the first full geomagnetic field vector data available for this period in Italy, have been compared with other contemporaneous data from Europe and with global geomagnetic field models. Independent archaeomagnetic dating of the three ovens has been also performed using the SCHA.DIF.8k model. The obtained results are in excellent agreement with the radiocarbon dates, confirming that all ovens belong to the Neolithic period and were almost contemporaneously used. The new results importantly enrich our knowledge of the geomagnetic field during the Neolithic period that is poorly covered by data, not only in Italy but in the whole Europe and show that archaeomagnetic dating can provide accurate results even for prehistoric periods.

Abstract ID: 33219

Final Number: GA43A-08

Title: Geochemistry of Ancestral Mi'kmaw Ceramics from Southern Mainland Nova Scotia: Constraints on Pottery Pathways

Presenter/First Author: J. Victor Owen, Saint Mary's University, Halifax,

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Co-authors: John D. Greenough, University of British Columbia, Okanagan, Kelowna , BC, BC, Canada; Megan Himmelman, , , ; Stephen Powell, , ,

Published Material: full-length paper was submitted to Geoarchaeology in Oct. 2014. It is still in review.

Abstract Body: The mineralogy and bulk chemical compositions of 33 potsherds (14 shell-tempered, 19 grit-tempered) and local sediments (sand and clay, where present) from six ancestral Mi'kmaw sites across southern mainland Nova Scotia were determined, and are compared to samples from a long-used aboriginal site near Pinkey's Point at the mouth of Bear River (BdDk-1), in the Annapolis Basin. Mineralogical criteria link several of the sherds to local raw materials (e.g., grit); biotite has the same range of X_{Mg} values, and monazite similar Ce:Nd:La ratios, as the same minerals in nearby Devonian granitoid rocks, and rare garnets have morphologies and compositions consistent with those found in these granitoid rocks and their metasedimentary host rocks. The presence of biotite granodiorite clasts (and their mineralogical constituents) in the grit-tempered potsherds from the sites described here link this pottery to the Bear River/Annapolis Basin area. This inference is supported by multidimensional scaling (MDS) of the bulk compositional data for the sample suite. Shell-tempered samples, however, lack the granodiorite clasts that largely control the trace element signature of the grit-tempered samples, so they are geochemically distinct even where evaluated exclusive of shell components (Ca, Sr). Although we cannot discount an Annapolis Basin origin for them, geochemically, this linkage remains tenuous. We postulate that granodiorite-tempered pottery from the Annapolis Basin was distributed to other sites in the province via navigable waterways, including the the Mersey River corridor southeast to the Atlantic coast, and the Annapolis River to the northeast.

Abstract ID: 33662

Final Number: GA44A-0121

Title: The Challenges of Research at Varying Geological Spatial Scales for the Geoarchaeological Study of Prehistoric Stone Tool Quarry Sources

Presenter/First Author: Adrian Burke, University of Montreal, ,

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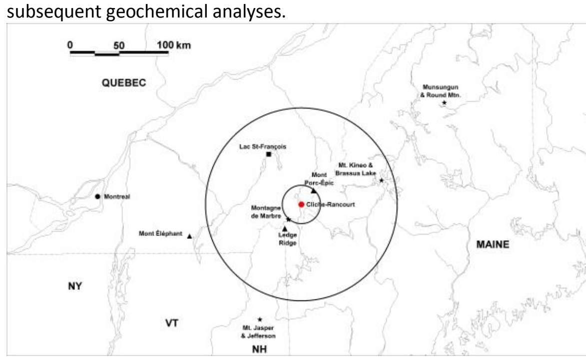
Published Material: Some archaeological and geological examples used in the presentation have been published or are in press. Other examples represent new data from other ongoing research projects. The paper is an overview of our long term research approach and program.

Abstract Body: It is commonplace for geologists to work at various spatial and time scales. The geoarchaeologist must add to this research the variable scales at which humans interact with each other and the environment. This represents an added level of complexity in the analysis, description and interpretation of geoarchaeological data. This paper focuses on the lithic raw materials that humans and their ancestors have used for more than 2 million years to manufacture cutting and scraping tools. The material to make these tools is not geologically ubiquitous, being primarily limited to highly siliceous, conchoidal rocks like cherts, flints, quartzites, rhyolites, and obsidian. Hunter-gatherers, and later settled agriculturalists, used many different geological sources both in primary bedrock and secondary surficial settings. On any given prehistoric site in North America it is common to find lithic raw materials that come from the area surrounding a site, from a regional setting (<100 km) and from further afield, sometimes over 1000 km distant. Some of these materials were obtained by going directly to a bedrock source and extracting the material at a quarry, while other materials were obtained through trade with neighboring groups. It is therefore imperative that the archaeologist know with precision where the materials come from in order to reconstruct past patterns of group movement in a territory, and also to understand the interaction between groups through trade. In this paper I present examples from aboriginal sites in northeastern North America dating from the earliest Paleoindian occupations to the time of European contact to demonstrate how the geoarchaeologist must continually adjust the scale of analysis depending on the time period, the culture studied, or simply the lithic material and its specific technological qualities. This has significant impacts on geoarchaeological fieldwork, sampling, and subsequent geochemical analyses.



Abstract ID: 35627

Final Number: GA44A-0123

Title: Geophysical signatures and sand thickness at Bestwood Farm, South Africa

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First Author Student?: No

Co-authors: Carl-Georg Bank, University of Toronto, Toronto, ON, Canada

Abstract Body: The Bestwood Valley, an archaeological complex located near the town of Kathu, South Africa, covers an area of about 700 by 1200 m and is dated to the Early Stone Age based on the type varieties of local handaxes, blades, and other lithic tools. The valley consists of ironstone hills of cobble sized clasts (many of which are the archaeological artefacts) grading into a flatter area of red siliceous sands blown in from the Kalahari desert. Our study attempts to compare different geophysical data sets, and depth from two ground-truthing excavations, collected in summer 2014. Analysis of a dozen 500 m long GPR lines across the valley give a good sense of sand thickness in the northern part of the valley; the sand becomes too thick in the southern part to produce radar reflections. Seismic refraction data were collected using 4.5 Hz vertical geophones on two crossing 100 m lines and show clear first arrivals. A magnetic walking survey shows very large (>1000 nT) variations in total field amplitude over short (10s of meters) distances near the edges of the sand fill, these variations become less pronounced towards the center of the valley. We are currently working on determining how signatures of the three different methods may relate to the sand thickness, and how the magnetic

amplitude and wavelength may be used in areas where GPR becomes ineffective.

Abstract ID: 33463

Final Number: GA44A-0124

Title: Mapping historic charcoal production fields from excavation to landscape scale

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Published Material: Parts of the presented findings were presented in other scientific meetings and were recently published in journal articles: - Methods and results of manual mapping of kiln sites are described in Raab, A., Takla, M., Raab, T., Nicolay, A., Schneider, A., Rösler, H., Heußner, K.U., Bönisch, E., 2015. Pre-industrial charcoal production in Lower Lusatia (Brandenburg, Germany): Detection and evaluation of a large charcoal-burning field by combining archaeological studies, GIS-based analyses of shaded-relief maps and dendrochronological age determination. Quaternary International, doi: 10.1016/j.quaint.2014.09.041.- The automatic mapping method is described in a (technical) paper in Schneider, A., Takla, M., Nicolay, A., Raab, A., Raab, T., in press. A template matching approach combining morphometric parameters for automated mapping of charcoal kiln sites. Archaeological Prospection. doi: 10.1002/arp.1497.In addition to this material, we will present recent and unpublished results of archaeological excavations, the application of the automated mapping routine, and of microdrone-based aerial photography.

Abstract Body: In the forefield of the open-cast mine Jänschwalde (north of Cottbus, Germany), archaeological excavations have revealed one of the largest charcoal production fields described so far. As remains of the historic charcoal kilns, small mounds of sediment rich in charcoal fragments and ash cover the soil surface. We applied a combination of methods for mapping such kiln relicts across a range of scales, in order to analyze the spatial distribution of kiln sites and to improve the understanding of historic forest use systems.

In archaeological excavations in the mine forefield, the geometry of kiln relicts could be studied in high detail. We used a microdrone to record high-resolution photographs of excavation sites for the documentation of kiln site ground plans and other traces of historic land use. Based on airborne laser scanning elevation models, kiln site mapping was extended to areas beyond the mine forefield. Manual digitization from shaded relief maps was used for mapping kiln sites in further woodland areas surrounding an historic ironwork north of Cottbus. An automated mapping approach based on template matching was developed to detect charcoal production fields on a larger scale, and was applied for an area of about 1000 km^{2}up to now.

In archaeological excavations, about 900 kiln sites have been documented on an approximately 17 km^2 large area. Excavation documentations and aerial photographs show variations in the kiln site ground plans. By manual digitization from Shaded Relief Maps, more than 5000 kiln sites with diameters up to 29 m were detected in the 32 km^2 area of the royal forest Jänschwalder Heide north of Cottbus. First results of mapping for larger areas indicate similar densities, but smaller diameters of kiln sites in other charcoal production fields; and show that charcoal production is a so far underestimated component of the land use history in many areas in the Northern European Lowlands.

Abstract ID: 35785

Final Number: GA44A-0125

Title: Constraints on the Geochemical Provenance of Refined Copper and Brass Artifacts from the Gaspereau Lake Area, King's County, Nova Scotia: Insights into the Metallurgical and Trace Element Systematics of European Contact-era Trade Alloys

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Abstract Body: During the 16th and 17th centuries, copper and copper alloys were key trade materials with considerable spiritual and functional significance to indigenous peoples. A collection of 9 copper-based archaeological artifacts from the Gaspereau Lake area of Kings County, Nova Scotia were analyzed by a variety of microanalytical methods in order to constrain the European origin of the contained metals, providing insight into the timing and nature of trade activities between the indigenous peoples of the Atlantic Northeast and European explorers/settlers, and geographic constraints on ore sources for the production of the metal alloys.

The artifacts range in composition from pure (refined) copper to gilding metal, bronze, and a variety of brass alloys. Refined copper coinage of known European provenance (Sweden, Spanish Netherlands, England, Hungary) and age (spanning a ~300 year period) were characterized by SEM-EDS to provide a reference provenance data set for the range of bulk and "speiss" inclusions (contaminant inclusions formed during smelting) expected in refined copper from the period bracketing European exploration of North America. The majority of speiss compositions ranged from single element (Pb) to complex alloy compositions (Pb-As-Sb-Fe-Sn-Ni-Ag). Similarities in speiss composition exist between Swedish and Spanish coinage (containing Cu sourced from Sweden) minted from 1560 to 1680 and three of the artifacts. Preliminary LA-ICPMS data indicate that Sb/As ratios in the artifacts may be used to differentiate Swedish from central European sources of Cu, owing to the presence or absence of specific sulfosalt minerals in the original mined ores. Preliminary Pb isotope data from the Pb-bearing speiss inclusions (by SIMS) shows that whereas ~pure Cu artifacts with minimal speiss contamination sit closer to compositional fields for the primary Swedish site of Cu production (Falun deposit, Great Copper Mountain), artifacts composed of brass alloys or heavily contaminated with Pb-rich speiss have Pb isotope compositions overlapping with the Central European sources in Poland and Germany, suggesting a non-Swedish source for Cu or Zn required for brass production, and/or Pb-bearing flux used during Cu smelting. The Pb isotope heterogeneity of the Falun deposit is also being evaluated.

Abstract ID: 33813

Final Number: GA44A-0126

Title: *From the source to the object : tracing the archaeological materials using LA-ICP-MS. The example of stone ornaments in the ancient societies.*

Presenter/First Author: Anne Baron, University of Montreal, Montreal,

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Co-authors: Bernard Gratuze, CNRS/Université d'Orléans, Orléans, France; Claude Chapdelaine, Université de Montréal, Montréal, QC, Canada

Published Material: Baron Anne 2011, title of oral communication*: Exploitation des roches noires à l'âge du Fer : vers une restitution des systèmes de production et de diffusion;* Proceedings of the International Colloquium Production-Distribution-Economy. Settlement and economic processes in the La Tène period, 28-30 oct. 2011, Nonnweiler (Saar) , *Universitätsforschungen zur prähistorischen Archäologie*, Baron Anne 2012: Provenance et circulation des objets en roches noires (« lignite ») à l'âge du Fer en Europe celtique (VIII^{ème}-I^{er} s. av. J.-C.), British Archaeological Report, Oxford, 589 p.

Abstract Body: Ancient societies used various natural resources to make many artefacts (ornaments, tools, weapons), especially lithic resources. Current research is mainly dedicated to the study of chipped stone tools such as flint or obsidian, but the study of other kinds of rocks is less developed. We focus here on the case of "soft" rocks (such as black shale, soapstone, serpentinite) used mainly to make ornaments. The study of these rocks constitutes a real scientific challenge: i) from an archaeological point of view, the geological sources and the distribution away from these sources of the artefacts is unknown, consequently this poses a difficulty in reconstructing ancient economic or cultural exchange networks; ii) from an analytical point of view, these materials are difficult to characterize due to their heterogeneity. The lack of systematic characterization studies has impeded the construction of relevant reference data and therefore to establish precise relationships between the archaeological objects and the geological resources exploited. Consequently, interdisciplinary research is essential because raw material characterization forms the basis of any provenance study. However, the destruction of archaeological objects constitutes a major limiting factor. The use of Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) which allows to carry out nearly invisible micro samplings was chosen as it presents several advantages. Its application to stone artefacts has provided promising results. Two examples of two kinds of "soft" rocks will be presented in order to show the relevance of this method and the results obtained: i) on ornaments made of black shales by the Celts of Europe (8th to 1st century B.C.) and ii) on soapstone beads made by the Iroquoians of the Saint Lawrence Valley in Quebec (15th & 16th centuries).

Abstract ID: 33418

Final Number: GA44A-0127

Title: X-ray microfluorescence, microradiography and tomodensitometry provide a broader view of the archaeological space.

Presenter/First Author: Geneviève Treyvaud, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Varennes,

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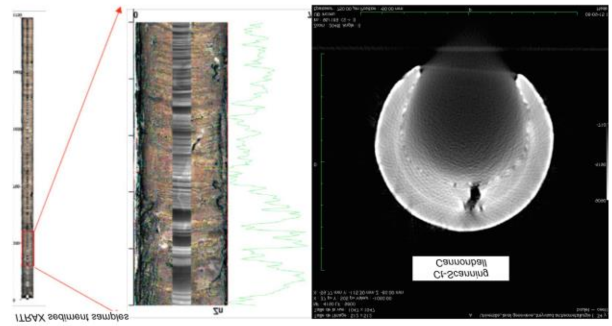
Co-authors: Pierre Francus, Inst Nat Recherche Sci, Québec, QC, Canada

Abstract Body: Archaeologist faces multiple pressing questions while being in the field. What is the composition of the different soil layers and what are their laterals extend? What modifications have been made by human occupation? Is it possible to measure, identify and characterize this space in order to evaluate the potential of the archaeological site? The Itrax core scanner allows acquiring geochemical data and high-resolution radiographs from sediment without loos or destruction of material to be analysed. This instrument rapidly and continuously conducts the analysis of sediment samples, such as half cores or u-channels, allowing to retrieve geochemical profiles variations and to visualize the presence of archaeological material. Tomodensitometry (CT-scanning) is a process which uses X-ray equipment to produce three-dimensional representations of components both externally and internally with a sub millimeter resolution. Thanks to it non-destructive nature, its high precision and its speed, medical CT-scans allows to capture in 3 D the deposits architecture of sediment bodies and archaeological artefacts. Applications of these high precision instruments are numerous and various in Archaeology: chemical and physical characterization of archaeological deposits, study of *chaînes opératoires*, characterization and identification of the archaeological collection, bio-anthropology, zooarcheology et dendrochronology.



Abstract ID: 33808

Final Number: GA44A-0128

Title: Geochemical fingerprints of paleo-environmental changes and paleo-pollution in the sedimentary archives of the Roman harbor of Ephesus (Turkey)

Presenter/First Author: Hugo Delile, Université Lumière Lyon 2, CNRS UMR 5600, 69676 Bron, France, Lyon,

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Published Material: Delile, H., Blichert-Toft, J., Goiran, J.-P., Stock, F., Arnaud-Godet, F., Bravard, J.-P., Brückner, H., & Albarède, F. (2015). Demise of a harbor: A geochemical chronicle from Ephesus. Journal of Archaeological Science, 53, 202–213.

Abstract Body: At the end of the 1st c. BC, Ephesus became the Roman capital of Asia Minor and the most important commercial, religious, and cultural center of the area. To shed light on the paleo-environmental evolution of the harbor, including potential anthropogenic fluxes, we measured major and trace element concentrations, including heavy metals, Pb isotope compositions, and ^{14}C ages of ancient harbor sediments from a 12 m long sediment core drilled in the Roman basin of Ephesus. Using these data together with sedimentological data, grain size distribution analysis, and Principal Component and Factor Analyses, we reconstituted the paleo-environment of the harbor basin.

We ascribe observed shifts in the geochemical and sedimentological parameters to the deltaic progradation of the Cayster River (Küçük Menderes) towards the west. A single major disruptive event located at 550 cm core depth (1st BC/AD) significantly affected the ventilation of the harbor water body resulting is oxygen deficit (anoxia). It appears that either passage of the river mouth to the west of the harbor basin or avulsion of the river towards the north was responsible for this abrupt environmental change.

While concentrations of metallic trace elements are well correlated with the oxygenation conditions of the harbor water body throughout the core, the Pb isotope compositions of leachates and residual fractions attest to possible anthropogenic influx in only the uppermost part of the core. The geologically and geochemically informed parameters T_{mod}-µ-κ (derived from the time-integrated measured Pb isotope compositions) are exogenous to the Eastern Mediterranean basement (Pb age-depth model >200 Ma). Searching our European and Circum-Mediterranean Pb isotope database (>6800 samples) we find that Pb ores used at Ephesus during the late Middle Ages came from Western Europe (France, Germany, England) consistent with archeological and historical data indicating that at that time the main active European mines were those of Germany and England.

Abstract ID: 34012

Final Number: GA44A-0129

Title: Rock-Magnetic Proxies of Dredging and Flood Events in Portus, the Ancient Harbor of Imperial Rome

Presenter/First Author: Agathe Lisé-Pronovost, La Trobe University, Fitzroy,

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Co-authors: Guillaume St-Onge, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada; Andy IR Herries, La Trobe University, Bindoore, VIC, Australia; David Heslop, Australian National University, Canberra, Australia; Ferréol Salomon, University of Southampton, Southampton, United Kingdom; Jean Philippe Goiran, CNRS, Lyon, France

Published Material: Part of it was presented at the Casthe meeting 2014.

Abstract Body: Exceptionally high average accumulation rates (up to 1 cm/a) were recently reported in the ancient harbor of Rome, Portus, which was constructed on the Tiber delta (Tyrrhenian Sea) during the first century AD and filled with fine sediments during the first millennium AD. With such rapid harbor infill, Romans had to dredge sediments to allow passage. Dredging complicates the work of geoarchaeologists by introducing chronostratigraphic hiatuses and reworked sediments that are not readily identifiable in extruded sediment cores. Here we present high-resolution physical, rock-magnetic and paleomagnetic data from an undisturbed piston core in order to better constrain the chronostratigraphy of Portus.

Core CPS-1 contains ca. 4 m of harbor sediment and was recovered in the *canale Traverso*, an artificial paleochannel that linked the Tiber River to the harbor. High-resolution analyses were performed, including CT scanning, high-resolution digital imaging, density measurement by gamma ray attenuation, spectrophotometry, magnetic susceptibility, hysteresis properties, natural, anhysteretic and isothermal remanent magnetizations. The CT scans, digital images and data reveal a dredging scar within laminated harbor mud and overlaid by 0.8 m of reworked sediment. A hyperpycnal flow deposit (0.6 m) was also identified using magnetic susceptibility, paleomagnetic inclination and ferrimagnetic grain size and coercivity indicators. The rock-magnetic signature of these dredging and flood events contrast with the background harbor sediment, which is dominated by low coercivity magnetic minerals, stable natural remanent magnetizations and inclinations varying around the expected geocentric axial dipole, suggesting a genuine geomagnetic signal. The precise identification of an event-corrected harbor sequence combined with high-precision radiocarbon dating and possible paleomagnetic dating are useful to better constrain the chronostratigraphy at Portus and highlight the potential of rock-magnetism and paleomagnetism for geoarchaeology.

GEOMAGNETISM AND PALEOMAGNETISM

Abstract ID: 33165

Final Number: GP14A-0166

Title: Timinig of Volcanism and initiation of rifting in Omo-Turkana Depression southwestern Ethiopia: Evidence from Paleomagnetism

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Co-authors: Tesfaye Kidane, Addis Ababa University, Addis Ababa, Ethiopia; Francis Harold Brown, University of Utah, Salt Lake City, UT

Abstract Body: This Paleomagnetic study was carried out on Gombe Group basalts from the lower Omo Valley in southwestern Ethiopia. The objective of the study is to narrow a wide ranged previous geochronological data about timing of volcanism and initiation of rifting in the area. 80 oriented core samples were taken from nine sites. Pilot specimens were subjected to alternating field (AF), thermal demagnetization (TH) and acquisition experiments. The Natural Remnant Magnetization (NRM) direction comprises two vector components in most samples. The first component of magnetization was easily erased at 5 to 25mT AF and 120°C to 250°C TH demagnetization. A step wise increasing application of magnetic field to selected specimens revealed a saturation magnetization at about 300°C. The magnetization curve results from the acquisition experiment together with TH demagnetization of the same specimens and AF demagnetization results indicates that titanomagnetite is the dominant magnetic carrier. About 50% of magnetization is removed between Temperature ranges of 250^{0}C and 430^{0}C suggesting that pseudo single domains as a primary carrier of magnetic remanence. From total sites, six sites show reversed polarity and two sites show normal polarity. The normal and reversed polarities are antipodal to one another. The overall mean direction for reversed polarity is (D_S=186.1, I_S=-1.9,K_S=38.8, α_{95}=10.9) where as the remaining two sites with normal polarity yield (D_S=348.4, I_S=4.6, K=378.9, α_{95}=12.9).By using the available upper age control of Moiti tuff and Naibar tuff which have never been noted to be intruded by the Gombe Group basalts; Gombe basalts are correlable with the late Gilbert Chron of Cande and Kent (1995). Comparison of this result with the petrographically and geochemically similar basalts (Haileab *et al.,* 2004) in northern Kenya reflects the same polarity. Paleomagnetic data presented in this paper and previous age data results indicates, Gombe Group basalts in southwestern Ethiopia and Northern Kenya erupted during a short period geological time between 4.18Ma and 4.02Ma.Recent paleomagnetic study (Kidane, 2014) of sediments from the base of the rift is also similar with Gombe Group. This suggests that the present architecture of the basin might have been attained soon after the emplacement of the Gombe Group basalt.

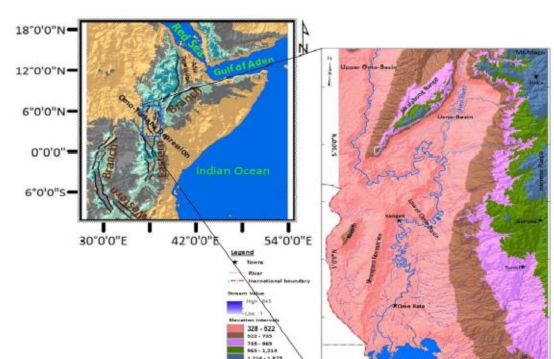

Figure 1: Location Map of the study area.

Abstract ID: 33863

Final Number: GP14A-0167

Title: Mapping Petroleum Migration Pathways Using Magnetics

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Co-authors: Mark A Sephton, Imperial College London, London, United Kingdom; Alastair Fraser, Imperial College London, London, United Kingdom; Jonathan S. Watson, Imperial College London, London, United Kingdom; Trevor Almeida, , London, United Kingdom; Paul Southern, University College London, London, United Kingdom

Abstract Body: We report the formation of magnetic minerals in petroleum reservoirs. Eleven wells from Wessex- Basin in Dorset, southern England, were sampled from the British Geological Core Store, across the main reservoir unit; Bridport Sandstone and the overlying Inferior Oolite, which forms the caprock. Sampling was carried out based on physical evidence of oil stain and a high magnetic susceptibility reading. The samples were chemically extracted to determine which were naturally stained with hydrocarbon and which were not. Magnetic analysis was carried out on all the samples: this including hysteresis analysis at low temperatures (5-15K) and room temperature, and low-temperature thermogmagentic analysis. The results indicated a marked increase both in abundance and strength of magnetic materials in samples found to be stained by hydrocarbon.

Abstract ID: 34128

Final Number: GP14A-0168

Title: Palaeomagnetic Analysis on Late Bronze Age Pottery from Santorini: New Data from the Akrotiri Excavation and Estimation of the Deposition Temperatures of the Minoan Pyroclastic Products.

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Published Material: The results presented here have been submitted for publication in Geophysical Journal International and the submitted paper, entitled: " Palaeomagnetic analysis on pottery as indicator for the pyroclastic flow deposits temperature: New data and statistical interpretation from the Minoan eruption of Santorini, Greece" by Tema et al. is currently under review.

Abstract Body: Palaeomagnetic analysis on Late Bronze Age pottery from Santorini was carried out in order to estimate the thermal effect of the Minoan eruption on the pre-Minoan habitation level. Carefully selected pottery fragments found on the surface of the pre-Minoan palaeosol and covered by the first pyroclastic products of the Minoan eruption have been collected and studied. Samples come from five sites situated at the central and south part of the island while for the first time palaeomagnetic results on ceramic fragments from the Akrotiri archaeological site are presented. Stepwise thermal demagnetizations reveal that most of the samples carry a two-component remanent magnetization. The deposition temperatures of the first pyroclastic products have been estimated by the maximum overlap of the re-heating temperature intervals given by the individual fragments at site level. A new statistical elaboration of the temperature data has also been proposed, calculating at 95% of probability the re-heating temperatures at each site. The obtained results show that the precursor tephra layer and the first pumice fall of the eruption were hot enough to re-heat the underlying ceramics at temperatures between 160 and 230 ^{o}C in the non inhabited sites while the temperatures recorded inside the Akrotiri village are slightly lower, varying from 130 to 200 ^{o}C. The decrease of the temperatures registered in the human settlements suggests that there was some interaction between the buildings and the pumice fallout deposits while the buildings debris layer caused by the preceding and syn-eruption earthquakes has probably also contributed to the decrease of the temperatures experienced by the ceramics.

Abstract ID: 34349

Final Number: GP14A-0169

Title: Paleomagnetic Dating of the Genesis of the Early Cretaceous Aliva Zn-Pb Ore Deposit, Northern Spain

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Published Material: paper submitted

Abstract Body: The Aliva Mississippi Valley-type (MVT) Zn-Pb deposit is hosted in strata of the 309±3Ma (Late Carboniferous) Picos de Europa limestone formation in the Picos de Europa Unit of the Cantabrian zone. Paleomagnetic analyses of 193 specimens from 23 sites in MVT mineralization and surrounding dolomite gives a characteristic remanent magnetization (ChRM) with a paleopole at 80.7°N, 268.1°E (A_{95} =5.3°) that resides mainly in magnetite-titanomagnetite with minor pyrrhotite. A negative fold test shows that the ChRM postdates Variscan orogenic deformation at >95% confidence and that the ore is not syngenetic or syndiagenetic. Plausible tectonic corrections indicate further that the Aliva MVT deposit: 1) resides in dolomitzed zones in olistoliths of the Picos de Europa limestone that slumped into the overlying 305±1Ma Lebena shale formation during Variscan orogenesis; 2) was formed epigenetically at 112±8 Ma (Early Cretaceous) as Iberia rotated away from Eurasia to open the Bay of Biscay, most likely from rift-related hydrothermal fluids ascending into Iberia's coastal margin; and, 3) was tilted 10°±3° downward to the north by N-S compression as Iberia collided with Eurasia during the Oligocene-Miocene Pyrenean Orogeny.

Abstract ID: 36679

Final Number: GP14A-0170

Title: Great Slave Lake Supergroup paleomagnetism:Local rotations, apparent polar wander, true polar wander, or anomalous geodynamo?

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Published Material: 20% Fall AGU 2013

Abstract Body: Previous paleomagnetic studies of Slave Craton, in northwestern Canada, revealed a sinuous apparent polar wander (APW) path referred to as the Coronation Loop, wherein paleomagnetic poles oscillate over 110° with ages ranging from ca. 1900 to 1850 Ma. We collected paleomagnetic samples across a broad region in the East Arm of Great Slave Lake (GSL), in order to determine if the rotations documented by the Coronation Loop are due to local structural anomalies, craton-scale tectonic motions or peculiar characteristics/behavior of the Orosirian geomagnetic field. Samples were collected at ~3m stratigraphic resolution over 700m of continuous homoclinal sections of the Tochatwi (red sandstone), Portage Inlet (mainly red siltstone), and Pearson (gray basalt) Formations. Paleomagnetic remanence commonly includes post-folding overprint signals of the Mackenzie Diabase (1270 Ma), which outcrops nearby, or the Hudsonian orogeny s.l. (1850-1750 Ma). We isolate a dual-polarity characteristic remanent magnetization (ChRM) direction that is generally shallow North or South in tilt-correct coordinates. Near the Portage Inlet / Pearson Formation contact, we sampled at several localities across folds that are likely related to movement on the McDonald fault at ca. 1850-1800 Ma; the ChRM passes the fold test at >99% statistical level. However, we observe ChRM declinations to vary by tens of degrees across the Christie Bay stratigraphy, even within homoclinal sections. This suggests that some of the previously recognized discordance of the GSL poles is due to APW, or perhaps geodynamo variations, as opposed to local structural rotations. If due to APW, whether it represents oscillatory true polar wander (as suggested by Mitchell et al., 2010, Precambrian Research) awaits similarly detailed paleomagnetic records from other cratons through this time period.

Abstract ID: 35318

Final Number: GP14A-0171

Title: Preliminary Magnetic Studies of the Helen Mine 'Kill Zone' Soils, Wawa, Ontario, Canada

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Abstract Body: As part of a larger study on using magnetic properties to examine mining-related pollution in Canada, the present-day distribution of iron-oxides emitted from the closed Helen Mine iron sintering plant near Wawa (Ontario, Canada) has been investigated. In this area, the vegetation cover has been severely disturbed, thus providing an excellent setting to investigate variations in magnetic properties. A total of 50 sites were sampled on cross-sections perpendicular (X-X') and parallel (Y-Y') to the dominant wind direction in order to investigate magnetic properties as a function of both wind direction and distance from the source. The *in-situ* surficial magnetic susceptibility (measured using a Bartington MS2D) decreased away from the source. Remanence and hysteresis measurements (2G Cryogenic Magnetometer, Magnetic Measurements VFTB) suggest that the primary magnetic mineral was magnetite; however, a biplot of IRM_{-100mT}/SIRM vs ARM_{40mT}/SARM indicated minor greigite. The laboratory analysis also showed that the highest susceptibility was not observed at the surface but in the subsoil. Similarly, magnetic spherules were not observed in magnetic extracts from the topsoil samples (0-5cm) but samples from the subsoil (5-10cm) contained magnetic spherules (2μm-10μm). EDS analysis shows that the spherules contain high weight percentages of Fe (up to 85%) and O (up to 48%), with some samples showing minor concentrations of other elements (e.g. Al, Ti, Mg). The vertical distribution of magnetic spherules and susceptibility could be due to vertical migration or to post-mining soil development.

Abstract ID: 35713

Final Number: GP14A-0172

Title: Saddleback Basalt as a Terrestrial Analog to Highly Magnetized Martian Crustal Rocks

Presenter/First Author: Kathryn J Murdock, Univ. of Mass. Amherst, Beverly, MA

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Abstract Body: The magnetic anomalies detected from rocks located in Mars's southern hemisphere have led to extensive investigations into the mineral assemblage and crystal size of the apparent host rock -- basalt -- and the ancient magnetic field Mars had at 4Ga. The lack of a currently active field on Mars indicates that remanence is the source. Investigations are of two types: investigating the rocks themselves, with an hypothesis that a unique mineral assemblage and/or grain size within the rock allow for it to acquire and retain high magnetization, thus different than most terrestrial basalts; or investigating the original magnetic field on Mars which was able to magnetize basalts with strong and stable remanence. The main purpose of this study is to identify a variety of terrestrial basalts to determine if any have the magnetic properties necessary for high magnetization for long periods of time. Samples were taken from diverse locales including divergent plate boundaries, hot spots, continental volcanic complexes, and volcanic arcs. While the terrestrial samples shared similar geochemical characteristics with Martian samples, the magnetic properties were not comparable and did not have, and most likely not retain, high magnetization over billions of years. However, one flow within the Saddleback Basalt located in southern California has a fairly high magnetization for an Earth basalt and could be analogous to the highly magnetized Martian basalts. This is an interesting development due to the fact that currently the Saddleback Basalt is used to simulate the regolith on Mars for rover missions. NRM values for the Saddleback range from 0.1238 – 43.201 A/m with an average of 3.697 A/m. Hysteresis measurements indicate small PSD-sized grains. Magnetic susceptibility ranges from 0.151 to 5.77 x10^-2 with an average of 1.286x10^-2. The results of this study may indicate the Saddleback Basalt could be a better analog to Martian crustal rocks than previously thought.

Abstract ID: 35039

Final Number: GP21A-01

Title: New Paleomagnetic Secular Variation records from various lakes on the Tibetan Plateau

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Abstract Body: To understand the dynamics of the paleo-geomagnetic field requires detailed observations around the globe. Suitable paleomagnetic records on the Tibetan Plateau (TP) and adjacent areas are, however, extremely scarce. Here, we derive paleomagnetic records from independently radiocarbon dated sediments from various lakes on the TP. Studied through alternating field demagnetization of u-channel samples, characteristic remanent magnetization (ChRM) directions document

similar inclination patterns in multiple sediment cores for the late Holocene. Comparisons to existing records from a varve dated sequence from the Makran Accretionary Wedge, Lakes Issyk-Kul and Baikal, and a stack record from East Asia reveal many similarities in inclination. This regional similarity demonstrates the high potential of inclination to compare records over the Tibetan Plateau and eventually date other Tibetan records stratigraphically. Paleomagnetic Secular Variation (PSV) similarities over such a large area (>3,000 km) might indicate a large-scale core dynamic origin rather than small scale processes like drift of the non-dipole field often associated with PSV records. In addition, a record covering the past 15.8 ka cal BP was derived from sediments from Tangra Yumco, a large lake on the southern-central Tibetan Plateau. This new record reveals many similarities to the inclination record from of Lake Baikal, which is the only record in the “vicinity” reaching that far back in time. In the near future, these studies will be extended by a new record from Taro Co (250 km west of Tangra Yumco) covering almost 30,000 years.

Abstract ID: 33798

Final Number: GP21A-02

Title: 9000 years of archeomagnetic field intensity variations in the Middle East

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Abstract Body: Thanks to its rich archeological and historical heritage, the Middle East offers the possibility to travel back through the geomagnetic field history over most of the Holocene. Archeomagnetic studies conducted up to now were mainly focused on the Bronze and Iron Age archeological periods, allowing a better characterization of the regional geomagnetic field intensity behavior for the last 3 millennia BC. These studies have revealed significant field intensity variations, and in particular a series of intensity maxima between c. 2600 and 2500 BC, between c. 2300-2000 BC, around 1500 BC and at the very beginning of the first millennium BC. These studies have further shown that the beginning of the first millennium BC was most probably marked by the highest geomagnetic field intensity detected so far during the Holocene. Archeointensity data available for the pre-Bronze Age period remain scarce. However, several possibilities exist to sample archeological sites older than 3000 BC. This is particularly true for the 6th and 7th millennia BC, which saw the development of the Hassuna and Halaf cultures throughout the northern Mesopotamian region. We will mainly discuss our recent acquisition of new archeointensity results dated to between c. 7000 and c. 5000 BC from two Syrian archeological sites (Tell Halula and Tell Masaikh). These results were obtained from 225 pottery fragments using the Triaxe protocol, which takes into account both the thermoremanent magnetization anisotropy and cooling rate effects on intensity determinations. We will then report on a geomagnetic field intensity variation curve for the Middle East encompassing the past 9000 years, which makes it presently the longest known regional archeomagnetic intensity record.

Abstract ID: 35109

Final Number: GP21A-03

Title: Building and Using Archeomagnetic Field Models

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Published Material: Part of the talk will rely on previous work published in Licht, A., Hulot, G., Gallet, Y., Thébault, E., Ensembles of low degree archeomagnetic field models for the past three millennia, *Phys. Earth Planet. Int.*, 224, 38-67, 2013, doi :10.1016/j.pepi.2013.08.007

Abstract Body: Since the publication of the first global archeomagnetic field models in the late 1990s, considerable efforts have been made in collecting reliable archeomagnetic, volcanic and sedimentary data, assembling these data in documented compilations and producing improved global models of the geomagnetic field over part or most of the Holocene. These efforts have led to the publication of several families of models now used for quite a wide range of applications. How these models are being built, the way they are intended to be used and the issues encountered during the modeling process, however, can differ from one model to another. It is important for the community willing to use these models to be aware of these differences, in particular when using these models as input to test geophysical properties, or newly acquired data. In this talk, we will report on our own ongoing experience in building such models and discuss the advantages and limitations of the models currently available, as well as the way forward to further improve models.

Abstract ID: 35740

Final Number: GP21A-04

Title: Exploring high latitude geomagnetic field behaviour in the northern hemisphere over the past four millennia

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Abstract Body: Geomagnetic field observations at the Earth’s surface provide a powerful probe of the dynamics of the top of the core, and ultimately of the whole geodynamo. Field reconstructions for the present day are characterised by the two pairs of intense high latitude flux patches at the core mantle boundary, which are approximately symmetric about the equator. These so-called *flux lobes* have remained relatively stationary over the past four centuries, which has been interpreted in terms of mantle control on the geodynamo. The recently published pfm9k family of models, based on palaeomagnetic data, suggests a more dynamic field behaviour on millennial times scales, predicting dominant westward drift of flux lobes over the past 4000 years. These models were intentionally smoothed in time (approximately averaged over 400 years) to address the large chronological uncertainties and also often low temporal resolution of the sedimentary palaeomagnetic dataset. Here we will investigate ways to increase the temporal resolution of the models with an emphasis on using selected high-resolution sediment records from mid to high latitudes in the northern hemisphere. The results are used to inform the robustness of the pfm9k model predictions and provide new insights into the millennial scale behaviour of the geomagnetic field.

Abstract ID: 36148

Final Number: GP21A-06

Title: NZPSV1k and NZPSV10k: New Palaeosecular Variation Master Records for New Zealand – Applications for Dating and Field Modelling

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Published Material: My presentation at the recent Dec 2014 AGU meeting, San Francisco included the raw data. The current presentation contains further analysis and the development of master records.

Abstract Body: We present new palaeosecular variation master records for New Zealand on both archaeological and Holocene timescales. These have been compiled using continuous data from the detrital remanent magnetization of lake sediment cores with high-resolution C-14 based chronology, and are constrained and calibrated using directions and absolute palaeointensities obtained from the thermoremanent magnetizations of archaeological materials and volcanic rocks. All data has been “migrated” to a standard geographical location (40°S, 175°E) using a virtual geomagnetic pole (VGP) transformation. By a reciprocal VGP process, the master records can be used to calculate accurate palaeosecular variation records for all locations within the New Zealand region. The new record improves upon and extends by a factor of five the existing 20 year-old record. The geomagnetic field alternates between active periods of high amplitude swings from 12000 to 8000 BP and over the past 4000 years, and a relatively inactive period from 8000 to 4000 BP. The current field (Dec = 21.5° E, Inc = - 65.4°, F = 55.4 mT at 40°S, 175°E) represents a rare steep and easterly extreme in direction, but is close to average in intensity. The palaeointensity record mirrors to some extent the variation of the virtual axial geomagnetic moment seen in the global dataset, but shows some notable differences. We investigate the use of the archaeomagnetic master record as a dating tool, and the effect of including the Holocene record in global spherical harmonic-based field models.

Abstract ID: 33778

Final Number: GP21A-07

Title: Holocene Southern Atlantic Earth's Magnetic Field Variations

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Published Material: The new data have been presented at recent AGU and SEDI meetings. First, very preliminary modelling results using all the data have partly been presented at fall AGU 2014.

Abstract Body: Sediment records of past Earth's magnetic field resolving variations in the southern hemisphere during the Holocene are sparse to the present day. Spherical harmonic field models provide magnetic field component predictions for the whole globe, but might show too little or even unreliable spurious structure in the regions not constrained sufficiently by data.

We have carried out paleomagnetic investigations of sediment cores from six locations at southern hemisphere and equatorial latitudes to better constrain field variation shown by global models in particular in the southern Atlantic region. Lakes Chamo and Chew Bahir are located in Ethiopia. Marine records ODP 1078 and 1079 lie off the coast of Angola, GeoB6517-2 and ODP 1076D are located in the Congo Fan and M35003-4 is situated southeast of Grenada in the Tobago Basin. In addition to the paleomagnetic work all cores were subjected to a comprehensive set of rock magnetic measurements. Age-depth models based on radiocarbon dating were determined for the Ethiopian sites. For all the marine cores, published age-depth models were available from earlier climatic studies at these sites.

We include the new records in millennial scale global models of the CALSxk type. We discuss magnetic field variations in the southern Atlantic region as shown directly by the data and as described by new and previous models. We conclude that robust variation structures are emerging but some characteristics of records and models require further investigation. Even more new data are important to improve the reliability of global models regarding southern hemisphere field variations.

Abstract ID: 35290

Final Number: GP21A-08

Title: Long-Term Character of Paleomagnetic Secular Variation from the Southern Hemisphere over the last Glacial Cycle – Evidence from ODP Leg 202- Chile Margin

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Abstract Body: Paleomagnetic secular variation (PSV) records from Sites 1233-1235, ODP Leg 202, Chile Margin (35°-40°S) provide a reproducible look at full-vector PSV variability (both intensity and directions) for the last 70,000 years. The paleointensity records correlate strongly with equatorial paleointensity records from Indonesia and mid-latitude Northern Hemisphere records from the Atlantic Ocean. But, beyond that, there are significant differences in the regional character of PSV in the various regions. Indonesia and the North Atlantic show a Laschamp excursion that is Class 1, characterized by out-of-phase millennial-scale cyclicity, while Chile sees a Laschamp Excursion that is Class II, characterized by in-phase directional variations and local full-polarity reversal. Indonesia and Chile see a Class 1 excursion in MIS 4 (~62, ka), but none is noted in the North Atlantic Ocean. PSV in Chile and the North Atlantic follows a distinctive decrease in amplitude for 30,000 years after the Laschamp Excursion; but it is not obvious that such is noted in Indonesia. These directional differences occur within a context of similar intensity variations. This spatial character should provide insight into the spatial-scale of coherent flux regeneration within the outer core.

Abstract ID: 33051

Final Number: GP22A-01

Title: Attempting to Pierce the Metamorphic Veil in the Grenville Orogen of the Canadian Shield

Presenter/First Author: David J Dunlop, University of Toronto, Toronto, ON

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Abstract Body: The Grenville Province of the Canadian Precambrian Shield is a mélange of tectonic domains and terranes, containing Archean as well as Proterozoic rocks and assembled in a series of collisions with successive margins of the main Laurentian craton. The details of the accretionary events are obscured by the deep burial and consequent metamorphism of most presently exposed domains and terranes – the Grenvillian metamorphic veil. Post-metamorphic erosional uplift and cooling were extremely slow: cooling from 550ºC to 250ºC typically required 200-300 million years. Although it has proven extremely difficult to "see through" the Grenvillian orogeny to the magnetic record of pre-metamorphic events, partial thermoremanent magnetizations (pTRMs) acquired as different grain-size fractions of magnetite (and on occasion hematite) cooled through their blocking temperatures provide a record of post-metamorphic apparent polar wander (APW). Time calibration of this post-metamorphic Grenvillian APW path is provided by $^{40}Ar/^{39}Ar$ plateau ages of minerals like hornblende, actinolite, biotite, muscovite, plagioclase and K-feldspar with known closure temperatures to Ar diffusion and on occasion also by U/Pb ages of sphene. The partnership between isotopic thermochronology and paleomagnetism has been very successful in delineating the 1000-800 Ma APW of "Grenvillia" – and by implication the rest of Laurentia, since the accreted terranes were firmly welded to the craton prior to uplift. Despite quibbles about the details of the Grenvillian polar track, this part of the Laurentian APW path remains better documented than that of almost any other Precambrian time interval, younger or older. The multiple pTRM overprints are also amenable to determination of paleofield intensities (occasionally two paleointensities of different ages for a single rock), the main uncertainty being the correction to be applied for slow cooling in nature compared to that in laboratory heatings and coolings.

Abstract ID: 34372

Final Number: GP22A-02

Title: Paleomagnetism and U-Pb Geochronology of the Western End of the Grenville Dyke Swarm: Rapid Changes in Paleomagnetic Field Direction at ca. 585 Ma Related to Polarity Reversals

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Published Material: A paper in the Journal *Precambrian Research* has just appeared on line. The paper is an invited one to present these findings.

Abstract Body: A paleomagnetic study of the western end of the ~585 Ma Grenville dyke swarm shows that individual dykes are characterized by high coercivity and unblocking temperature magnetizations that can differ in direction by as much as 90°. Field tests including baked contact studies and the continuity of paleomagnetic direction along dyke strike, suggest that the magnetizations are primary. Precise U-Pb baddeleyite dating on these dykes indicates that changes in magnetization direction of ~90° occur in less than 4 million years, and their close temporal association with reversals of the axial dipole field suggest that certain dykes are recording a paleo-equatorial dipole field as a transitional field between opposite polarity states. This equatorial field may be local and related to a core disturbance beneath the Sutton plume, the source of the dyke swarm. The documented instability in the Earth's field occurs less than 10 Myr before the first recorded appearance of macroscopic multi-cellular organisms on Earth, inviting speculation that an extended period of frequent magnetic reversals may play a part in faunal evolution.

Abstract ID: 34562

Final Number: GP22A-03

Title: Ediacaran Paleomagnetism of Well-dated Units in Laurentia and West Avalonia: Implications for Models of Oscillatory True Polar Wander, Equatorial Dipoles and Rapid Continental Drift

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Co-authors: Michael A Hamilton, University of Toronto, Toronto, ON, Canada; Joseph P Hodych, Memorial University, St. John'S, NL, Canada

Abstract Body: Ediacaran paleomagnetic data from Laurentia are complex, with inclinations of presumed primary remanences that differ by up to 90° or more, often within single geological units. These unusual data have been variously interpreted as due to magnetic overprinting, very rapid continental drift, one or more episodes of oscillatory ~90° true polar wander (TPW), or unusual behaviour of the geomagnetic field such as an equatorial dipole. Here we review the Laurentia data in the 615-565 Ma period. The ages assigned to steep and normal components, if they are primary, appear to require at least two full oscillations during the period in question. There is growing evidence (especially from the Grenville and Rideau dyke swarms for which 9 precise U-Pb baddeleyite ages are now available) indicating that the magnetic directional changes are much too rapid to accommodate either rapid drift or TPW (using current theoretical models). In addition, the paleomagnetic data do not always conform to an equatorial dipole model in which paleopoles should differ by 90°. We also review the paleomagnetic data from well-dated (606-570 Ma) Ediacaran units of the West Avalonia microcontinent, which appear to be simpler than those from Laurentia. Unlike Laurentia units, individual units of West Avalonia usually carry a single presumed primary remanence direction (of dual polarity), rather than two discrete remanence directions or directions that are streaked along a great circle that might record rapid TPW. Large directional (mainly declination) changes *between* units are usually interpreted as due to block rotations, but alternatively could reflect TPW or unusual behaviour of the magnetic field. However, the corresponding paleopole changes are significantly less than the 90º expected for an equatorial dipole model. Taken together, the Ediacaran Laurentia and Avalonia data do not appear consistent with current models of oscillatory TPW, an equatorial dipole or unusually fast drift.

Abstract ID: 36623

Final Number: GP22A-04

Title: The Nature of the Ediacaran to Early Cambrian Geomagnetic Field

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Co-authors: John Anthony Tarduno, University of Rochester, Rochester, NY

Abstract Body: A rotation of the entire solid Earth by 90°, in what has been called an inertial interchange true polar wander (IITPW) event, has been linked to the significant increase in biotic diversity during Ediacaran to early Cambrian (~635-530 Ma) times. Evidence for the IITPW event has been suggested by previously reported nearly orthogonal directions from the Sept-Îles (ca. 565 Ma) intrusion (Quebec, Canada) on the basis of whole rock analyses. We have demonstrated that only one direction (shallow) is carried by single domain magnetic grains and thus can be considered primary (Bono and Tarduno, Geology, 2015). Moreover, we find that the

geomagnetic field was reversing during cooling of the intrusion; the small spatial scales on which we see antipodal directions suggest a rapid reversal rate. New Total Thermoremanent Magnetization paleointensity experiments on single feldspar crystals from the Sept-Îles intrusion imply a very low field value, somewhat lower than values recorded by single feldspars from Jurassic basalts (Tarduno and Cottrell, JGR, 2005). The high geomagnetic reversal rate and low geomagnetic field intensity that characterize a portion of the Jurassic (ca. 165 Ma) may be an analog for field behavior during the Ediacaran to early Cambrian. We will discuss further paleointensity experiments aimed at testing this hypothesis.

Abstract ID: 36558

Final Number: GP22A-05

Title: Paleomagnetism of Paleoproterozoic Rocks from Lofoten, Norway: Can They Provide a Baltica Pole for 1.8 Ga?

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Co-authors: Suzanne A McEnroe, Norwegian University of Science and Technology, Trondheim, Norway

Published Material: 10% of the information (magnetic properties of the anorthosite samples) was published in a chapter of IAGA Special Sopron Book Series, Vol 1, in 2011.

Abstract Body: Paleoproterozoic rocks including paragneisses and AMCG suite rocks dominate the landscape in the southern Lofoten islands of Norway, sandwiched between the Scandinavian Caledonides to the east and offshore Mesozoic basins to the west. Published geochronology on the AMCG suite and the metamorphism of the gneisses they intrude range from 1.9 to 1.8 Ga, suggesting tectonic activity in this area was coincident with the formation of the supercontinent Columbia. Twenty-seven sites were drilled into these rocks from Moskenesøy and Flakstadøy to investigate their paleomagnetic character and possible determination of a Paleoproterozoic pole for Baltica. Magnetic susceptibility for all the 27 sites averages 6.95 x 10^{-2} SI, but only one site has a low susceptibility (5.4 x 10^{-4}); all other sites have susceptibilities greater than 1 x 10^{-2}. NRM values range from 0.5 A/m to 4.6 A/m, with an average of 2.0 A/m. Hysteresis properties of at least one sample per site indicate MD magnetite is the predominant oxide, but demagnetization studies show that a high coercivity phase is commonly present and is likely the source of the stable remanence. Both normal and reversed polarities, nearly antipodal, are observed, with a mean direction of I = -48.0° and D= 209.4° (α_{95} = 9.1°, N = 22) with a corresponding (inverted) paleopole at 47°N, 154°E. The paleolatitude from this study (61°) puts the current northwestern side of Baltica at high latitudes at this time, similar to published reconstructions for Columbia, although the Lofoten pole longitude is displaced some 65° from other Sveconorwegian poles.

Abstract ID: 35343

Final Number: GP22A-06

Title: METAMORPHIC AND STRUCTURAL INSIGHT FROM INVESTIGATIONS OF ELUSIVE AEROMAGNETIC ANOMALIES WITHIN THE CANADIAN SHIELD

Presenter/First Author: Jeffrey Robert Webber, The University of Vermont, Burlington, VT

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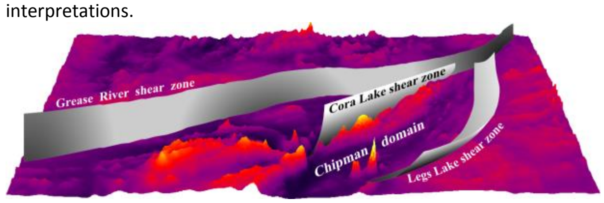
Co-authors: Laurie L Brown, University of Massachusetts Amherst, Amherst, MA; Michael L Williams, University of Massachusetts, Amherst, MA

Published Material: Some of these findings have been publlished in Tectonophysics and were presented at NE GSA and GSA previously. However, new material is will be presented.

Abstract Body: The acquisition of aeromagnetic data across the Canadian shield lead to a renaissance of Precambrian geology, from which crustal scale structures and lithotectonic domains where defined, correlated, and placed within a plate-tectonic framework. However, many local aeromagnetic anomalies do not directly correlate to changes in mapped lithology and are often overlooked. We suggest that many anomalies may reflect aspects of the metamorphic and structural history of a region that may be used to gain insight into crustal processes beyond simple map correlations. An excellent location to investigate this relationship is the the Chipman domain of the Athabasca granulite terrane due to the occurrence of significant aeromagnetic anomalies across a relatively homogeneous tonalitic batholith. The western portion of the domain is defined by a large plateau of elevated total field intensity. Volumetrically minor mafic dikes, lozenges, and schlieren hosted by the 3.2 Ga tonalite occur throughout the domain and display significant variations in magnetic susceptibility with observed values in excess of 0.5 SI to below 0.0005 SI. Although low magnetic susceptibilities occur throughout the entire domain, elevated values are restricted to the west. Investigations of isothermal remanent magnetization acquisition curves and analytical petrology indicate that variations in the volume percent of magnetite are likely responsible for most of these anomalies. Furthermore, the occurrence of magnetite is likely a function of metamorphic reactions, some of which involve hydration / dehydration. Two-dimensional finite element modeling of aeromagnetic anomalies supports the characterization of six petrophysically distinct domains with representative magnetic susceptibilities. We suggest that the western and eastern portions of the Chipman domain experienced distinct metamorphic histories that are expressed by the regional aeromagnetic data. Further characterization and modeling of magnetite-producing and consuming reactions will enable the correlation of local petrophysical observations to larger scale interpretations.



Abstract ID: 35701

Final Number: GP22A-07

Title: The geodynamo as recorded in Archean and Hadean zircons

Presenter/First Author: Rory Danielle Cottrell, University of Rochester, Rochester, NY

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Co-authors: John Anthony Tarduno, University of Rochester, Rochester, NY; Richard K. Bono, University of Rochester, Rochester, NY

Abstract Body: Isotopic studies of nitrogen (Marty et al., Science, 2013) suggest a lack of the fractionation expected if the early atmosphere was eroded by the early, intense solar wind in the absence of magnetic shielding. Recent estimates of core thermal conductivity and mantle evolution modeling, however, question the presence of a geomagnetic field prior to ~3.5 Ga. To investigate this paradox, we are developing techniques to test the presence/absence of Hadean-Paleoarchean magnetic fields through measurement of zircons from the Jack Hills

metaconglomerate (Yilgarn Craton, Western Australia). Magnetic force microscopy shows the presence of single-domain magnetic inclusions within the zircons. An ultra-sensitive 3-component DC SQUID magnetometer (noise floor, 10^{-11} emu) that has been optimized for single silicate crystal studies is used for these experiments. We choose zircons with initial natural remanent magnetizations between 1-3 x 10^{-9} emu for analyses. These select samples have been handpicked from a sample crush, and examined with transmitted and reflected light microscopes to exclude specimens with visible cracks or large opaque inclusions. Thellier-Coe and total thermal remanent magnetization experiments using a CO_2 laser system have been designed to obtain paleointensity estimates while limiting potential laboratory-induced alteration. We employ a routine that stacks multiple orthogonal component magnetizations at each demagnetization step to reduce measurement noise. After paleointensity analysis, these samples are then analyzed with a Sensitive High Resolution Ion Microprobe (SHRIMP) to obtain age information. We will present data from our ongoing analyses, and discuss the potential of measuring even weaker samples using a SERF magnetometer, currently under development by the University of Rochester and TwinLeaf LCC.

Abstract ID: 34090

Final Number: GP24A-0173

Title: A Holocene High Resolution Geomagnetic Field Record from Rio Martino Cave (Western Alps, Northern Italy)

Presenter: Evdokia Tema, University of Turin, Torino,

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Co-authors: Eleonora Regattieri, , , ; Giovanni Zanchetta, University of Pisa, Pisa, Italy; Ilaria Isola, INGV, Pisa, Italy; Luca Lanci, University of Urbino, Urbino, Italy

Abstract Body: Speleothems are considered excellent archives for the Earth's Magnetic Field changes in the past, as they are able to continuously record its variations, can be easily dated, and acquire a mostly "instantaneous" magnetic remanence at a high-resolution timescale. The latter ensures the possibility to detect short and/or high-frequency events, thus providing high-quality Paleosecular Variation (PSV) data. Unfortunately, the low magnetic intensities often characterizing speleothems limit their study. Here we present a paleomagnetic study performed on a flowstone from Rio Martino cave (Western Alps, Italy). U/Th dating of the flowstone indicates that its deposition started at the beginning of the Holocene. The flowstone is characterized by high magnetization intensity, due to the metaophiolites in the area, which provide the magnetic detrital input. The collected 60 cm-long core was cut in small slices, 3 mm-high, permitting a 60 yr time resolution. Magnetic measurements point at detrital magnetite as the remanence carrier. The Characteristic Remanent Magnetization (ChRM), isolated after stepwise AF demagnetizations, is well defined, with Maximum Angular Deviation (MAD) lower than 10°. Relative paleointensity was obtained by analysis of the Arai diagrams. Regression lines always provided a correlation coefficient lower than 0.850. Paleomagnetic directions and paleointensity data allow reconstruction of the PSV curves during the Holocene for the area. The results are compared to the Italian archaeomagnetic SV curve and to the regional and global geomagnetic field models. The comparison shows that the Rio Martino flowstone has faithfully recorded the Earth's Magnetic Field in the past. The obtained high resolution results, together with the high quality dating, provide promising data both for the detection of short time geomagnetic field variations and completion of past regional PSV curve, where well-dated data are scarce.

Abstract ID: 35450

Final Number: GP24A-0174

Title: A New Archeomagnetic Field Intensity Variation Curve from Southern Quebec for the Past Four Centuries.

Presenter: Yves Gallet, CNRS, Paris,

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First Author Student?: No

Co-authors: Yves Monette, University of Montreal, Montreal, QC, Canada

Abstract Body: New archeointensity data were obtained in Quebec from twelve groups of ceramic and brick fragments dated from the early 17th to late 19th century AD. These data were derived using the Triaxe magnetometer and a tailored experimental protocol. The results show a decrease in intensity in Quebec between the 17th and the early 18th century, followed by an increase until 1900. Similar variations are predicted in Quebec City by the gufm1 geomagnetic field models regardless of whether the calibration uses the assumption of a strong, low or null linear decrease of the dipole moment between 1600 and the mid-19th century AD. However, the amplitudes of the predicted variations appear lower than those displayed from the new data, the latter showing a marked minimum during the 18th century. These new results, together with previous data obtained in France and Brazil, argue in favor of an oscillatory behavior rather than a linear evolution of the dipole moment between 1600 and 1850.

Abstract ID: 36712

Final Number: GP24A-0175

Title: Holocene Paleomagnetic Secular Variation: What Relationships Between Mid and Polar Latitudes tell us About Geomagnetic Dynamics

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Published Material: As a synthesis, part of these results have been published, but the understanding that will be presented has not.

Abstract Body: Longitudinal comparisons of high quality, high resolution, and independently dated archeomagnetic and paleomagnetic secular variation (PSV) records from the NE Pacific (Alaska & Hawaii), North America, North Atlantic, and Europe during the Holocene show generally coherent multi-centennial to millennial scale variations of specific PSV parameters. These observations illuminate two primary alternating modes (although there are likely others), which we have called the European

mode (EM) and North American mode (NAM) because of their consistency with the late Holocene and historical time average field morphologies, respectively. Here we further explore how alternations between these modes compare with observations made at locations sensitive to the geomagnetic field derived from the Arctic tangent cylinder. High resolution paleomagnetic records obtained from a series of cores retrieved from two Ellesmere Island lakes (Sawtooth Lake, 79º21 N, 83º56 W and Lower Murray Lake, 81°34 N, 69°54 W) with varve based chronologies allow us to define regional PSV and paleointensity (PI) patterns for the last ~5 kyr. Although PSV and PI derived at these polar latitudes are both distinct from those observed at mid latitudes and prediction made from global field models, consistencies in timing suggest that these records are dynamically related. This duality is illustrated by variations in virtual geomagnetic pole (VGP) latitude, where those derived from polar latitude sites are both in phase and out of phase with those derived from mid latitude sites and global reconstructions. Axial VGP latitudes are observed during EM and NAM maximums, whereas mid latitude and global reconstructions show axial VGPs during NAM and maximum tilt during EM. It is also illustrated by patterns of PI where repeating progression of PI highs and lows are observed mid and polar latitudes. Together these define coherent oscillations showing that geomagnetic behavior in the tangent cylinder is distinct from, but influenced by, large scale oscillations in flux observed at mid latitudes.

Abstract ID: 36621

Final Number: GP24A-0176

Title: Late Pleistocene and Holocene Paleomagnetic Records from the Gulf of Alaska: Preliminary Results of IODP Expedition 341 Sites U1418 and U1419

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Abstract Body: During IODP Expedition 341 in the Gulf of Alaska, Sites U1418 and U1419 were drilled in the upper part of the Surveyor Fan and on the continental shelf edge, respectively. These Sites recovered exceptionally expanded records containing information on climatic, oceanographic, glacial, tectonic and geomagnetic field changes in the eastern North Pacific region over at least the last 60 kyr. As a first step in evaluating the potential of the sediments of Sites U1418 and U1419 to record a reliable relative paleointensity (RPI) signal, the shipboard natural remanent magnetization (NRM) at 20 mT was normalized by magnetic susceptibility and compared with the shipboard inclination record. At Site U1419, two intervals of low normalized intensity and reversed inclination were recovered with preliminary ages consistent with the Laschamp and Norwegian-Greenland Sea geomagnetic excursions at ~ 41 and ~ 61 ka, respectively. U-channel and discrete sample studies to verify these observations are ongoing. A first series of u-channels from Site U1418 were analyzed using stepwise alternating field demagnetization to further clarify the shipboard paleomagnetic observations. These data indicate that a strong, well-defined, single component magnetization with maximum angular deviation (MAD) values generally lower than 5^{o} is preserved. Moreover, alternating gradient force magnetometer analyses at Site U1418 imply that the sediments at the Site consist mainly of low coercivity minerals in the pseudo-single domain range. These preliminary results indicate that the Gulf of Alaska sediments preserve a promising high-resolution paleo-geomagnetic record. The shipboard data will be complimented by more detailed u-channel studies in order to establish a stratigraphic framework and investigate geomagnetic field dynamics during the Late Pleistocene and Holocene.

Abstract ID: 35778

Final Number: GP24A-0178

Title: A new archaeointensity dataset from the SW Pacific: implications for global geomagnetic field models

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Co-authors: Mimi J Hill, University of Liverpool, Liverpool, L69, United Kingdom; Richard T Holme, University of Liverpool, Liverpool, L69, United Kingdom; Elliot Hurst, University of Liverpool, Liverpool, United Kingdom; Gillian M Turner, Victoria University of Wellington, Wellington, New Zealand; Peter Sheppard, University of Auckland, Auckland, New Zealand

Published Material: Preliminary archaeointensity results were presented at the AGU Fall Meeting in 2014.

Abstract Body: Palaeomagnetic data from the southern hemisphere are sparse, in particular absolute intensity data. To improve global geomagnetic field models and to answer key questions about the millennial scale behaviour of the geodynamo, more data are needed from this region. We present new archaeointensity data from a collection of ceramics from the SW Pacific Islands including Fiji, Tonga, Papua New Guinea, New Caledonia and Vanuatu covering the past 3000 years. The microwave method has predominantly been used with a variety of experimental protocols including IZZI and Coe variants. Standard Thellier archaeointensity experiments using the IZZI protocol have also been carried out on selected samples. The data are presented and compared to regional predictions from the recently published pfm9k family of geomagnetic field models. We explore the influence of the new data on constraining global geomagnetic field models and investigate possible analogies to the present field and the South Atlantic Anomaly. We discuss the physical implications as well as the robustness of these new results.

Abstract ID: 33141

Final Number: GP24A-0179

Title: Paleomagnetism in South East Australia from Archaeological Artefacts, Lava Flows and Lake Sediments

Presenter/First Author: Agathe Lisé-Pronovost, La Trobe University, Fitzroy,

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Co-authors: Andy IR Herries, La Trobe University, Bindoore, VIC, Australia

Published Material: Oral presentation at the 2014 Australian Archaeology Association meeting (Cairns, December 2014)

Abstract Body: Late Quaternary paleomagnetic data from the Southern Hemisphere is limited. One reason for this is because archaeological artefacts, lava flows and most high-resolution sedimentary sequences are found on and near the continents and islands, which represent only about one fourth of the Southern Hemisphere surface. The Australian continent is one of these regions and despite its long human occupation since ca. 50,000 cal BP and abundant materials likely suitable for archaeo- and paleomagnetic studies including fireplaces, heat retainers, heat treated stone tools, bricks, kilns, pottery, ovens, lake sediment and volcanic rocks, it remains poorly documented. Here we present archaeo- and paleomagnetic results derived from a variety of burnt archaeological artefacts (from ca. 25,000 to 15,000 cal BP and since 4000 cal BP), young

lava flows (ca. 35, 000 and 30,000 cal BP) and lake sediments (since ca. 250,000 cal BP) from south-east Australia. Standard procedures of alternating field and thermal demagnetization as well as Thellier-Coe archaeointensity determinations with partial thermoremanent magnetisation checks on selected lava flows and archaeological samples were performed at The Australian Archaeomagnetism Laboratory (TAAL). The results reveal generally strong and stable remanent magnetisation, often displaying single components that are ideal for palaeointensity determinations. Some of the archaeological materials also display complex heating histories informing on the formation, firing conditions and usage of the campfires. This was further investigated with experimental cobbles and clay balls heat retainers in order to document the magnetic remanence acquisition under different firing conditions. The new paleomagnetic direction and intensity data from southeast Australia are compared with global reference curves, geomagnetic field models and the nearest available records. Altogether the results highlight the great potential of archaeo- and paleomagnetic research in Australia for better understanding past behaviour of the Earth's magnetic field in the Southern Hemisphere and for building the first Australian Archaeomagnetic Dating Reference Curve.

Abstract ID: 33376

Final Number: GP24A-0180

Title: Recording and dating geomagnetic reversals, events and excusrions in palaeokarst and pseudokarstic deposits from southern Africa and Australia

Presenter/First Author: Andy IR Herries, La Trobe University, Bindoore, VIC

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Co-authors: Tom Mallett, La Trobe University, Bundoora (Melbourne), Australia; Peter Kappen, , ,

Abstract Body: This paper outlines the use of caves and palaeokarstic deposits for the recording and dating of high resolution Plio-Pleistocene geomagnetic field data from the southern hemisphere; including magnetic reversals, events and excursions. Examples are given of recently discovered high resolution magnetic reversals in palaeocave sediments from South Africa, including the base of the Olduvai SubChron and an event at ~2.047-2.005 Ma based on the direct uranium-lead dating of the speleothem. This is somewhat younger than recent estimates for the Huckleberry Ridge excursion based on other methods, but older than estimates for the Pre-Oluvai excursion at ~1.977 Ma. Two short geomagentic field events are dated to slightly later than 2.069 and 1.959 Ma at a second cave and could incorporate both the Huckleberry Ridge and Pre-Olduvai excursions. However, in all cases full normal polarity directions are recorded, suggesting these are perhaps events, not excursions. In an older flowstone, another event is recorded and dated to between 2.38 and 2.24 Ma, suggesting that it relates to the older Réunion event at ~2.20 Ma. X-ray fluorescence microscopy and X-ray absorption spectroscopy at the Australian Synchrotron has been used to map iron within the speleothems, identify areas of potential recrystalisation and identify the main magnetic minerals present. This work, combined with palaeomagnetic and mineral magnetic analysis indicates that while the remanence is carried by detrital magnetite, this constitutes only a few percent of the overall iron mineralogy within the speleothems. This work indicates that recystalisation can have an effect on the palaeomagnetic signal in spelothem and so it is important to evaluate this through thin section analysis. Micromorphology has also been used to evaluate the potential effects of sedimentary structures on the geomagentic field data recorded from cave sediments. This work shows the great potential of Pliocene and Pleistocene cave deposits for recording geomagnetic field data in high resolution as well as the direct dating of reversals, events and excursions, but also highlights the difficulties and new challenges faced in this work. The potential of younger pseudokarstic sea caves are also highlighted, including the direct dating of the Punaruu Event (1.11 and 1.09).

Abstract ID: 34694

Final Number: GP24A-0181

Title: Improving our Knowledge of the Geomagnetic Field Intensity in South America: New Archaeointensity Data from Potsherds Derived from Three Archaeological Sites in Ecuador.

Presenter/First Author: Emilio Herrero-Bervera, University of Hawaii at Manoa, Honolulu, HI

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Co-authors: Evdokia Tema, University of Turin, Torino, Italy; J. Stephen Athens, International Archaeological Research Institute (IARII), Honolulu, HI

Abstract Body: Archaeomagnetic data from the south hemisphere are still very scarce and most of the global geomagnetic field models suffer from this lack of data as well as from their uneven geographical distribution. In this study we present new archaeointensity data from three dated prehistoric archaeological sites in northern highland Ecuador (South America). Potsherd fragments come from the archaeological excavations of Atuntaqui, Otavalo (towns), Mounds and La Chimba (named after the hacienda were it is located), dated at 571 BP, 651-622 BP and 2586-2120 BP respectively, based on available radiocarbon dating. Successful archaeointensity data have been obtained from thirty five potsherds using the Thellier-Coe protocol. Rock magnetic experiments including low-field versus temperature (k-T) plots, Isothermal Remanent Magnetization (IRM) acquisition curves, as well as hysteresis loops and back-fields, have been performed in order to characterize the magnetic behavior of the samples and determine their main magnetic carriers. The Curie temperatures indicate the presence of at least two magnetic mineral phases (i.e. 220-255^{o}C and 560-590^{o}C), with predominant Curie temperatures typical of magnetite. The results of the magnetic grain size analyses suggest the presence of particles in the Pseudo-Single Domain (PSD) range, according to the distribution on the modified Day et al. diagram (Dunlop 2002 a and b) for magnetite. The successful absolute palaeointensity determinations yielded archaeointensity values of 43.9 ± 1.4 μT for Atuntaqui, 37.6 ± 0.8 μT for Otavalo Mound 3 (upper charcoal lens, ca 622 years old BP), 29.6 ± 1.1 μT for Otavalo Mound 3 (lower charcoal lens, 651 years old BP) and 38.0 ± 3.1 μT for La Chimba. The new results are in good correlation with archaeomagnetic data from the Palpa area in South Peru, located within a 900 km radius around the Ecuadorian sites in question. These data are the first archaeointensity results from Ecuador for the last 1500 years and aim to enrich our knowledge of the geomagnetic field intensity variations in the south hemisphere, together with previously published data from South America.

Abstract ID: 35635

Final Number: GP24A-0182

Title: The history of the South Atlantic Anomaly as viewed from southern Africa: Potential influences of the African LLVSP on the geodynamo

Presenter/First Author: John Anthony Tarduno, University of Rochester, Rochester, NY

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Co-authors: Eric Blackman, Univ of Rochester, Rochester, NY; Thomas Niel Huffman, University of the Witwatersrand, Johannesburg, South Africa; Michael Keith Watkeys, University of Kwazulu Natal, Durban, South Africa; Rory Danielle Cottrell, University of Rochester, Rochester, NY

Abstract Body: A broad low intensity area in Earth's recent magnetic field spans the southern Atlantic Ocean, Africa and South America. This is

commonly called the South Atlantic Anomaly (SAA). The SAA allows a relatively close approach of Earth's radiation belts, affecting spacecraft operations. The low magnetic intensity decreases the efficiency of magnetic shielding in the region, which can influence atmospheric ozone. Many believe the SAA is linked to the dramatic decay of the dipole geomagnetic field intensity during the last 160 years, and the growth of a reversed core flux patch beneath South Africa. Some have even speculated Earth is heading toward a geomagnetic field reversal. But understanding these phenomena within the context of longer-term geomagnetic history has been limited by a lack of Southern Hemisphere archeomagnetic data. We have recently presented the first archeomagnetic data from Iron Age sites of southern Africa (∼1000-1650 AD) (Tarduno et al., 2014). Magnetic data show a sharp intensity drop at ∼1300 AD, at a rate comparable to modern field changes in the SAA (but to lower values). These changes motivated our conceptual model whereby the recurrence of low field values reflects magnetic flux expulsion from the core, promoted by the unusual core-mantle boundary composition and structure beneath southern Africa defined by seismology (specifically the African Large Low Velocity Seismic Province, or LLVSP). Because the African LLVSP is a longstanding structure, we expect this region to be a steady site of flux expulsion, and perhaps the triggering site for reversals, on time scales of millions of years. Here we discuss our ongoing efforts to extend the archeomagnetic record from southern Africa back in time, and further develop the flux expulsion- African LLVSP hypothesis.

Abstract ID: 34365

Final Number: GP31A-01

Title: Frontiers in Planetary Dynamos Through High-Performance Computing

Presenter/First Author: Bruce A Buffett, University of California Berkeley, Berkeley, CA

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Abstract Body: High-performance computing has enabled scientific breakthroughs in our understanding of planetary dynamos. While current numerical models still fall far short of reaching realistic values for the viscosity of liquid metal, the goal of producing fully turbulent dynamos may be within reach on the world's largest computers. To achieve this goal we have undertaken a series of performance and accuracy benchmarks on a large supercomputer (XSEDE Stampede). We have used the results to identify approaches that enable numerical dynamo models to run efficiently on 10^5 compute cores. Dynamo codes included in the benchmark exercise include a variety of numerical methods (spectral, finite difference, finite element, and hybrid methods) and rely on different strategies for domain decomposition. Our analysis of the results suggests that spectral methods can achieve the required efficiency using a two-dimensional domain decomposition. Estimates for scalability of a new community dynamo code called {\it Rayleigh} are presented and used to define the parameter regime that should be feasible on present-day computers. We also describe an ongoing project through the DOE INCITE program to run planetary dynamo models on Mira, the fifth fastest computer in the world.

Abstract ID: 35086

Final Number: GP31A-02

Title: High Resolution Geodynamo Simulations with Strongly-driven Convection and Low Viscosity

Presenter/First Author: Nathanaël Schaeffer, ISTerre, Grenoble,

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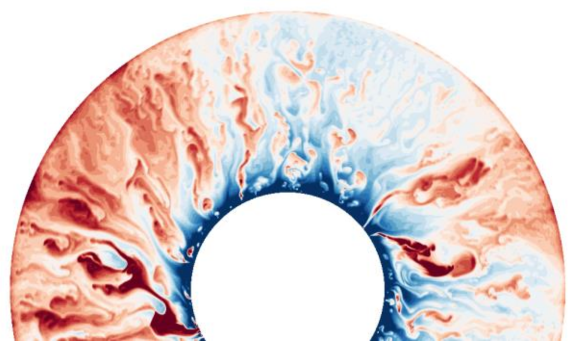
Co-authors: Alexandre Fournier, Institut de Physique du Globe de Paris, Paris, France; Dominique Jault, University Joseph Fourier Grenoble, Grenboble, France; Julien Aubert, Institut de Physique du Globe, Paris, France

Published Material: These findings will also be presented at the EGU meeting in april 2015.They have already been presented in two workshops in 2014.No paper has been submitted yet, but I hope it will be submitted by then !

Abstract Body: Numerical simulations have been successful at explaining the magnetic field of the Earth for 20 years. However, the regime in which these simulations operate is in many respect very far from what is expected in the Earth's core. By reviewing previous work, we find that it appears difficult to have both low viscosity (low magnetic Prandtl number) and strong magnetic fields in numerical models (large ratio of magnetic over kinetic energy, a.k.a inverse squared Alfvén number).
In order to understand better the dynamics and turbulence of the core, we have run a series of 3 simulations, with increasingly demanding parameters. The last simulation is at the limit of what nowadays codes can do on current super computers, with a resolution of 2688 grid points in longitude, 1344 in latitude, and 1024 radial levels.
We will show various features of these numerical simulations, including what appears as trends when pushing the parameters toward the one of the Earth.
The dynamics is very rich. From short time scales to large time scales, we observe at large scales: Inertial Waves, Torsional Alfvén Waves, columnar convective overturn dynamics and long-term thermal winds. In addition, the dynamics inside and outside the tangent cylinder seem to follow different routes.
We find that the ohmic dissipation largely dominates the viscous one and that the magnetic energy dominates the kinetic energy. The magnetic field seems to play an ambiguous role. Despite the large magnetic field, which has an important impact on the flow, we find that the force balance for the mean flow is a thermal wind balance, and that the scale of convective cells is still dominated by viscous effects.



Abstract ID: 35957

Final Number: GP31A-03

Title: Numerical/Experimental Canonical Models of Geophysical and Astrophysical Flows

Presenter/First Author: Adolfo Ribeiro, Organization Not Listed, Washington, DC

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Co-authors: Jean-Luc Guermond, , , ; Jonathan M Aurnou, , ,

Published Material: Title: "Canonical Models of Geophysical and Astrophysical Flows:Turbulent Convection Experiments in Liquid Metals" Authors: A.Ribeiro, J-L Guermond, J.M Aurnouunder revision, Metals Paper

Abstract Body: System-scale magnetic fields are observed to develop in galaxies, stars, planets, moons, and even asteroids. In all these systems, magnetohydrodynamic dynamo action occurs via the conversion of the kinetic energy of flowing electrically-conductive fluids into magnetic field energy. Generated by the motion of the electrically-conductive fluid, dynamo fields typically evolve on length and time scales related to the underlying flows. \\

Present-day numerical models do not yet model dynamo action in liquid metals with a thermal Prandtl number, $Pr <1$ and a magnetic Prandtl number, $Pm \ll 1$. Metal dynamo simulations should become possible, though, within the next decade. In order then to better understand the turbulent convection phenomena occurring in geophysical or astrophysical fluids and next-generation numerical models thereof, we present here canonical, end-member examples of thermally-driven convection in liquid gallium, first with no magnetic field or rotation present, then with the inclusion of a background magnetic field and then in a rotating system (without an imposed magnetic field). In doing so, we demonstrate the essential behaviors of convecting liquid metals that are necessary for understanding and for building accurate, robust models of magnetohydrodynamic processes in $Pm \ll Pr < 1$ geophysical and astrophysical systems. \\

Abstract ID: 35067

Final Number: GP31A-04

Title: A Sparse Fully Spectral Method for Simulations in Spherical, Cylindrical and Cartesian Geometries

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Co-authors: Michael A Calkins, University of Colorado, Boulder, Boulder, CO; Jonathan M Aurnou, University of California Los Angeles, Los Angeles, CA; Keith A Julien, Univ of Colorado--Boulder, Boulder, CO

Published Material: Preliminary results where presented at the AGU fall meeting 2014.

Abstract Body: Due to the complexity of core flow problems, they need to be tackled from all possible angles. Direct Numerical Simulations (DNS), asymptotically reduced models and lab experiments allow for the investigation of different aspects related to core dynamics. While a majority of DNS studies are performed in spherical geometries, reduced models and lab experiments often involve Cartesian and cylindrical geometries as well; thus requiring efficient numerical methods that are applicable to a variety of coordinate systems. Furthermore, for numerical stability, accuracy and performance, the linear terms of the governing equations need to be treated implicitly. For example, the explicit treatment of the Coriolis force leads to a stringent timestep constraint. We have developed a fully spectral coding framework that is capable of solving a variety of equation sets in many different geometries. Depending on the geometry, it uses a combination of Chebyshev series, Fourier series and spherical harmonics for the numerical discretization. By using the quasi-inverse method, our approach produces very sparse matrices that allow for the efficient solution of very large coupled systems of equations. We will present our coding framework as well as nonlinear results for different geometries.

Abstract ID: 33825

Final Number: GP31A-05

Title: Generation of magnetic fields by large-scale vortices in rotating convection

Presenter/First Author: Celine Guervilly, University of Leeds, Leeds,

Presenter/First Author Email: c.guervilly@leeds.ac.uk

Published Material: Part of this work has been presented at the 2014 fall meeting of the AGU.

Abstract Body: Recent computational studies have described the formation of large-scale vortices in rotating turbulent convection in planar geometry. These vortices, which are long-lived and depth-invariant, form by the merger of convective thermal plumes. In this presentation, we will show that for magnetic Reynolds numbers below the threshold for small-scale dynamo action, such flows can sustain large-scale magnetic fields - i.e. fields with a significant component on the scale of the system.

Abstract ID: 34911

Final Number: GP31A-06

Title: Core Merging After Giant Impacts and Core Stratification in the Late Stages of Earth's Formation

Presenter/First Author: Maylis Landeau, Johns Hopkins University, Baltimore, MD

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Co-authors: Peter Olson, Johns Hopkins University, Baltimore, MD; Renaud Deguen, Institut de Mécanique des Fluides de Toulouse, Toulouse, France; Ben Hirsh, Johns Hopkins University, Baltimore, MD

Published Material: Findings partly (about 50 %) reported at fall AGU meeting 2014.

Abstract Body: The fluid dynamics of core merging after giant impacts during planetary accretion provides constraints on core stratification, early magnetic field generation and metal-silicate equilibration. The energy released during giant impacts, such as those thought to have formed Earth's Moon and the crustal dichotomy on Mars, likely resulted in melting of the impactor and much or all of the protoplanet's mantle. Under these conditions, the liquid core of the impactor migrates through a fully-liquid magma ocean, and merges with the protoplanet's core.

We present experiments on liquid blobs released into another liquid consisting of two immiscible layers, representing the magma ocean and protocore, respectively. In contrast with the laminar flow in numerical simulations, liquid impact experiments can produce turbulence, as expected during core formation. The released liquid is immiscible in the upper layer, miscible in the lower layer, and denser than the upper layer. We characterize the impact at the immiscible interface varying the upper layer depth and the released fluid density. With a shallow upper layer, the relevant regime for giant impacts, a turbulent cloud of released and upper liquid penetrates in the lower layer, collapses and spreads at the immiscible interface. This behavior contrasts with direct core merging found in impact simulations, and suggests that, because of turbulence, metal-silicate chemical equilibration extends deep inside the protocore. Experimental scalings for low-density releases suggest that compositional stratification is likely in the aftermath of core formation, and the stratified layer detected by seismology at the top of Earth's core is compatible with a moon-forming impact. By implication, the early core dynamo had to overcome compositional stratification to initiate.

Abstract ID: 35382

Final Number: GP31A-07

Title: Revisiting Earth's Thermal Evolution: A Solution to the Mantle and Core Paradoxes

Presenter/First Author: Peter E Driscoll, University of Washington Seattle Campus, Seattle, WA

Presenter/First Author Email: ped13@uw.edu

Abstract Body: Recent discoveries relating to the thermal and magnetic history of the Earth have revealed that a solid surface and a dynamo generated magnetic field have persisted over almost all of its history. However, the geochemically inferred radioactivity and geodynamically inferred heat loss efficiency predict wide spread mantle melting, a "thermal catastrophe", only 2−3 Ga. Similarly, paleomagnetic observations that indicate a geodynamo as old as 3.4 Gyr are at odds with the "new core paradox", which claims insufficient energy to drive the ancient geodynamo prior to inner core nucleation ~ 1 Ga in light of recent revisions to the thermal conductivity of the core. We present a single solution to both paradoxes that invokes a high core heat flow of ~13 TW, a low mantle secular cooling rate of ~13 TW, and an inner core age of ~800 Myr. By including light element depression of the core solidus as the inner core grows and enriches the outer core, core radioactivity is inferred to be ~1 TW or less. This new model has important implications for the history of the geodynamo, including a switch from top driven thermal convection to mixed thermo-chemical convection following inner core nucleation. We propose that this switch is evident in existing paleomagnetic observations.

Abstract ID: 34943

Final Number: GP31A-08

Title: On the Secular Variation of Saturn's Magnetic Field

Presenter/First Author: Sabine Stanley, University of Toronto, Toronto, ON

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Co-authors: Jeremy Bloxham, Harvard Univ, Cambridge, MA

Abstract Body: Saturn's nearly axisymmetric observed magnetic field is problematic for dynamo theory and requires unique processes occurring in its dynamo generation region. The leading explanation is that zonal flows in a stably stratified layer surrounding the dynamo source region attenuate the non-axisymmetric components of the field. Here we demonstrate an important theoretical consequence of this axisymmetrization process: the secular variation of the axisymmetric field components must be extremely slow. Observational evidence suggests this may be the case for Saturn. In addition, we present numerical dynamo simulations that reproduce the observed axisymmetry of Saturn's field and confirm the extremely slow secular variation rates in highly axisymmetric models. A consequence of this result is that we can use time variation of the axisymmetric field to learn about the non-axisymmetric field components which are not observed in present data from Cassini.

HYDROLOGY

Abstract ID: 35453

Final Number: H11A-01

Title: Connection of a ^{90}Sr Groundwater Plume with Local Tree Swallows

Presenter/First Author: David R Lee, AECL, Chalk River, ON

Presenter/First Author Email: leed@aecl.ca

Published Material: Some of this material was presented at the 2013 GSA meeting in Denver, emphasizing the methods used to quantify mass flux of Sr-90 into the littoral zone. This submission, however is an update. It will feature the findings of 2013 and 2014 and the linkage between tree swallows and the local groundwater system.

Abstract Body: We traced the movement of a strontium-90 (^{90}Sr) plume from source to tree swallows. The source was leakage from a nuclear fuel storage pool. Swallow nest boxes were placed so parent birds would feed their nestlings with insects that emerged from sediments in the ^{90}Sr groundwater discharge zone and from sediments in background control sites. Nest boxes were observed regularly during nest building, egg laying, brooding, hatching and fledging. When nestlings were 12-days-old, one nestling from each of 12 nests at sites labelled with ^{90}Sr (as a result of groundwater discharge) and one nestling from each of two nests at background sites were taken under a Federal Permit and an approved animal care protocol. Gross beta concentrations in the bone and body of nestlings were consistent with the proximity of the nest boxes to the ^{90}Sr-groundwater discharge area. Lower leg samples from nestlings from the ^{90}Sr-labelled site had 7 to 9 times more gross beta radiation than whole bodies, consistent with the expectation that the excess radioactivity was due to ^{90}Sr concentrated in bone. Gross beta of the lower legs vs. bodies for all 14 samples were highly correlated ($r^2 = 0.94$). Although the paucity of control site nestlings prevented statistical comparisons, a preliminary conclusion is that there was no reproductive impairment of swallows at ^{90}Sr-labelled sites. Conservative estimates of internal doses, due to 5 Bq $g^{-1}$of ^{90}Sr/^{90}Y in maximally burdened nestlings, were 8 uGy hr^{-1}as compared with 40 uGy hr^{-1}, which is an internationally recognized benchmark for protection of riparian and terrestrial animals. This study marks an initial effort to perform a biota- dose assessment of ^{90}Sr groundwater plumes where these plumes constitute a nutritional connection between the groundwater system and the local ecology. Future work will use tree swallows to assess the potential for offsite transfer of ^{90}Sr in edible waterfowl and to quantify radioecological effects, if any.

Abstract ID: 33973

Final Number: H11A-02

Title: Geophysical and Hydrological Investigation of Rock Glacier in the Canadian Rockies

Presenter/First Author: Alexandra Mozil, University of Calgary, Calgary,

Presenter/First Author Email: alexandra.zheltikova@yandex.ru

Co-authors: Laurence R Bentley, University of Calgary, Calgary, AB, Canada; Masaki Hayashi, University of Calgary, Calgary, AB, Canada

Abstract Body: Anticipated climate warming will lead to increases in the global temperature and evapotranspiration. These changes will affect the peak of the mountain river runoff by shifting it to earlier in the year, away from the peak demand of summer and autumn. The effects of global warming may be buffered by groundwater that is stored temporarily in overburden material such as talus, moraine and rock glaciers, before discharging into mountain streams. Therefore, it is important to understand the contributions of these landscape units to the hydrological cycle in alpine watersheds in order to predict consequences of the climate warming for these natural water reservoirs.

In this project, a rock glacier in the Helen Lake Creek watershed in Banff National Park, Alberta was explored using electrical resistivity tomography, seismic refraction and ground penetrating radar. The main objectives were to identify the presence of ice in the subsurface, determine the depth to bedrock and trace the pathways of groundwater water flow.

Resistivity images showed areas with large resistivity values indicating possible ice locations. Seismic refraction data was consistent with a two-layer system with the velocity range of the lower layer typical for the bedrock. Ground penetrating radar data were consistent with the seismic refraction and resistivity interpretations by showing reflections at the bedrock boundaries.

The geophysical data indicate the location of the bedrock surface, groundwater flow paths and ice in the rock glacier. Their role in the storage and release of water to sustain the late-summer base flow in Helen Lake will be discussed.

Abstract ID: 36195

Final Number: H11A-03

Title: The future risk and uncertainty of livelihood development of the villagers on banks of the Lower Mekong Basin (LMB), Cambodia

Presenter/First Author: Serey Sok, Royal University of Phnom Penh, Phnom Penh,

Presenter/First Author Email: sokserey@gmail.com

Published Material: In Cambodia, the Lower Mekong Basin (LMB) represents 86% of its territory and 32.3% of its population is living in. This paper examines current and past risk and uncertainty (2000-2010) faced by villagers regarding resources scarcity; natural hazards and climatic change; man-made activities and catastrophes; and socio-economic impacts. The recent and likely future trends in livelihoods of the past 10 years (2011-2020) and over the next decade (2011-2020) are then explored under plausible scenarios of natural resource conditions. The upper, middle, and lower parts of the River are selected for different characteristics with a sample of 548 households. The upper part is Ramsar and the lower part is Mekong Delta, which borders Laos and Vietnam, respectively. The primary data collection methods are applied including field survey and other participatory tools. The study reveals that villagers are threaten by (1) resources scarcity, natural hazards, climatic change, and socio-economic impacts; (2) man-made activities cause severe catastrophes and make livelihoods become uncertain; (3) lack of suitable infrastructures results in low agricultural productivity and increases hazard impacts; (4) there is dependency on water-related recourses without alternative livelihoods and low adaptation capacity leads villagers to high poverty and vulnerabilities within this decade; and (5) future trends over the next decade remain risky and uncertain to the poor, when development is only influenced by growth, but not sustainable development.

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Abstract ID: 33789

Final Number: H11A-04

Title: Water budget imbalance and error source for Canada's major drainage basins

Presenter/First Author: Shusen Wang, Natural Resources Canada, Ottawa, ON

Presenter/First Author Email: shuwang@NRCan.gc.ca

Published Material: PART of the presentation was recently accepted by Hydrological Process.

Abstract Body: Assessing water budget closure helps identify knowledge gaps, data quality issues and research needs for better understanding the water cycle and water resources. This study assessed the 30-year (1979-2008) water budget closure for 19 large drainage basins in Canada covering an area of 3.5 million km^2, or about 35% of the entire Canadian landmass. Datasets recently developed for precipitation (P), land surface evapotranspiration and water surface evaporation from the land surface model EALCO, in situ streamflow measurements, and total water storage (TWS) from the GRACE satellite observations were used for the assessment. The objectives are to quantify the magnitudes of the water budget imbalance (e) over Canada and to assess the sources of errors. Results show that the water budget was closed within 10% of the P on average for all the basins. The e showed a general pattern of positive values in the south and negative values in the north and mountainous regions. The positive and negative values of e among the 19 basins were largely offset and the all-basin average e was close to zero. Water imbalance in the north and mountainous regions were large mainly due to inaccurate precipitation. There are 11 basins showing significant trends in TWS over 2003-2008, which accounted for 31% of their e on average. As such, long-term average ET calculated using surface water budget approach (i.e., ET=P-Q) might induce large errors. Improvements in the observation network, data quality assurance, and spatial models for P are critical for further improving the water budget closure.

Abstract ID: 34783

Final Number: H11A-06

Title: Bukhtarma Reservoir water availability fluctuations on the China-Kazakh trans-boundary Irtysh River

Presenter: Jay Sagin, Saskatchewan Polytechnic, Saskatoon, SK

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First Author: Shamshagul Mashtayeva, Organization Not Listed, Astana,

First Author Email: shamsha2001@mail.ru

First Author Student?: No

Co-authors: Saltanat Sadvakasova, , , ; Talgat Usmanov, , ,

Abstract Body: Reduction of surface runoff in the Irtysh River Basin in recent decades is leading to disastrous consequences on the aquatic

ecosystem in the region. As a result of the runoff reduction the Bukhtarma reservoir and connected Lake Zaysan are experiencing dramatic problems with water availability. The major tributary is the Black Irtysh River with the upstream located in China. The research work is based on data collected for the period 1960 to 2014. We used the water fluctuations of river runoff, water levels and water release from the Bukhtarma reservoir. Scenarios of the future changes were analyzed with analyses of the natural and anthropogenic impacts on the water availability fluctuations on the Bukhtarma reservoir. With the water intake from the Irtysh River estimated at 2 km^3 per year, flow decreases by 21.8% compared to the natural conditions in average watered years. When water subtraction is equal to 3 km^3 per year, river flow during the dry year can be reduced by 69.0% compared to the natural conditions.

Abstract ID: 35406

Final Number: H11A-07

Title: Coupling System Dynamics and SahysMod Models for Participatory Soil Salinity Management in the Rechna Doab Region, Pakistan

Presenter/First Author: Jerome Boisvert-Chouinard, McGill University, Montreal, QC

Presenter/First Author Email: jerome.boisvert-chouinard@mail.mcgill.ca

Co-authors: Johannes Halbe, McGill University, Montreal, QC, Canada; Jan F Adamowski, McGill University, Montreal, QC, Canada

Abstract Body: The principles of Integrated Water Resource Management outline the importance of stakeholder participation in water management processes, but in practice, there is a lack of meaningful engagement in water planning and implementation, and participation is often limited to public consultation and education. When models are used to support water planning, stakeholders are usually not involved in their development and use, and the models commonly fail to represent important feedbacks between socio-economic and physical processes.

This paper presents the development of a holistic model of the Rechna Doab basin in Pakistan, that simulate socio-economic and physical processes related to soil salinity management. The model consists of two sub-components: a System Dynamics (SD) model, and a physically based model. The SD component was developed in collaboration with key stakeholders in the basin, and was coupled with SahysMod, a soil salinity model. The coupled models were used to assess the environmental and socio-economic impacts of different management scenarios proposed by stakeholders.

Results indicate that coupled SD – physically-based models can be used as effective tools for participatory water planning and implementation. The participatory modeling process provides a structure for meaningful stakeholder engagement, and the models themselves can be used to transparently and coherently assess and compare different management options.

Abstract ID: 36130

Final Number: H11A-08

Title: Natural and anthropogenic geomorphological changes of Ural River, Kazakhstan

Presenter: Gulzhiyan Kabdulova, Kazakh National Space Company, Astana,

Presenter Email: g.kabdulova@gharysh.kz

First Author: Baglan Kaziyev, National Academy of Science of the Republic of Kazakhstan, Astana,

First Author Email: b.kaziyev@gharysh.kz

First Author Student?: No

Co-authors: Jay Sagin, Saskatchewan Polytechnic, Saskatoon, SK, Canada

Abstract Body: The geomorphological changes of the Ural River in the West Kazakhstan have been studied by our group during the dozens of years. The number of outstanding floods in the Ural River has been registered during the observations, in 1914, 1922, 1923, 1931, 1940-1942, 1946-1948, 1957, 1970, 1993-1995. The main factors determining the high floods are due to rapid snow melting, high runoff due to the small hydrologic conductivity of the frozen soil. The historical river bed studies with the application of the earth observation satellites (EOS) were applied for this research work. The historical cartographic and EOS images were used to determine the river bed positions at different time slices with analysis of the river bed evolution changes. The estimated shifts, meandering intensification of the Ural River were modeled. The magnitude and speed of the river bed shifts have been determined with geomorphological dynamics, including meandering, bifurcating, straight lined intensity changes. The analysis of river beds evolution with river bed morphology changes were analyzed by the nature and intensity of river bed deformations due to natural and anthropogenic processes. Detection of regional patterns in the development of river bed adjustments and their forecast estimates give the opportunity to analyze the probability of certain geomorphological changes for the prevention of the adverse consequences. The future research work is planned with the data applications from EOS KazEOSat-1. The KazEOSat-1 is a high-resolution observation satellite, which was built by Astrium for the Space Company Garysh Sapary of the Republic of Kazakhstan. KazEOSat-1 satellite was launched in the first quarter of 2014 (KazEOSat on 30 April 2014 and KazEOSat-2 is planned to be launched on 20 June 2015). KazEOSat-1 satellite provides high-quality panchromatic, 1 m, and four multispectral channels, 4 m, for a wide range of applications. KazEOSat-2 satellite provides medium-quality five multispectral channels, 6.5 m, for a wide range of applications. The current stage of the satellite's data applications for geomorphological research work is also to be discussed. The research results are used for the long-term forecasts of river bed regime changes.

Abstract ID: 33917

Final Number: H11B-01

Title: The Hydrological Challenges of Scale Dependency

Presenter/First Author: Howard S. Wheater, University of Saskatchewan, Saskatoon, SK

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Abstract Body: From the earliest beginnings of Hydrology, the scale dependence of catchment response has been explicitly recognised, for example in regional analyses of flood frequency and unit hydrograph response. And when continuous simulation conceptual rainfall-runoff models evolved to the point where the need for parsimony in parameterisation was recognised, regionalisation for ungauged catchments led to explicit quantification of parameter scale-dependence. However, for physics-based models, there has been a failure to account for the scale-dependence of parameters, despite clear evidence that appropriate representation of basic physical properties within models is dependent on the scale of model temporal and spatial discretization. There has perhaps been a naïve belief that physically-based properties are by definition scale-independent. Failure to progress understanding of these issues poses an urgent set of challenges. For example atmospheric models are now routinely applied at km scale over continents, but despite recent discussion of hyper-resolution modelling, the implications for associated

hydrological discretization and parameterization are unclear. This paper discusses these issues and a framework for analysis. Methods include numerical experimentation to determine emergent properties, empirical analysis of alternative discretization scales and methodologies, and the analysis of large-scale model performance. Current examples from Western Canada are presented.

Abstract ID: 33537

Final Number: H11B-02

Title: Seamless prediction of water fluxes across scales

Presenter/First Author: Luis E Samaniego, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig,

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Co-authors: Oldrich Rakovec, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; Rohini Kumar, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; Juliane Mai, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; David Schaefer, Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany; Matthias Cuntz, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; Martin Schrön, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; Stephan Thober, Helmholtz Centre for Environmental Research UFZ Leipzig, Leipzig, Germany; Matthias Zink, Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany; Sabine Attinger, Helmholtz Centre for Environmental Research-UFZ, Leipzig, Germany

Published Material: Some results have been presented at previous AGU and EGU meetings 2014. mHM/MPR related issues were published in Samaniego et al. 2010 WRR, Kumar et al. 2013ab WRR, as well as, in Samaniego et al. 2011 JHM. Manuscript in preparation for WRR.

Abstract Body: Developing the ability to seamlessly predict streamflow and other state variables like soil moisture at catchment, regional, continental or global scales with spatial resolutions varying from hundreds to thousands of meters is fundamental for improving our understanding of the water balance at scales relevant for decision making as well as for improving our understanding of the potential impacts of climate change on water resources. Hydrologic observations, however, are hardly available at the scale at which the predictions are needed. Streamflow, for example is a quite reliable signal but it represents the integral response over the whole basin. In situ soil moisture observations have a very small control volume and are hardly available at a regional scale. Remote sensing products such as the total water storage anomaly or soil moisture, on the other hand, are spatially explicit but observed at resolutions much larger than those required. It is therefore necessary to develop a framework that incorporates observations at their native resolutions into a hydrologic model without the need of using ad hoc up/downscaling techniques to match observations.

Here, we show the capability of the Multiscale Parameter Regionalization (MPR) technique within the mesoscale Hydrologic Model (mHM) to perform this task. MPR is an effective method to find quasi scale invariant parameter sets tested over 250 Pan-EU river basins varying from 100 - 500,000 km^2. The model is forced using the E-OBS data set available at a (0.25×0.25)° resolution from ECA&D during the period 1951-2012. The effective parameters obtained with simulations at this scale can effectively reproduce the total water storage anomalies retrieved by GRACE (NASA) at the spatial resolution (1 × 1)°, the gridded evapotranspiration estimated by LandFlux (ETH) (0.5×0.5)° as well as at tens of eddy flux stations (FLUXNET) whose footprint is about 1 hm^2. Cross-validation experiments lead to the conclusion that mHM estimated water fluxes are robust since less than 25% of river basins exhibit NSE of 0.4 or less for daily discharge. Likewise, the TWS anomalies, exhibit a large spatial correlation with those obtained from GRACE. Comparison against observed latent heat indicates that the dynamics and magnitude of the simulated values are well captured by the model at most locations.

Abstract ID: 35285

Final Number: H11B-03

Title: Evaluating the Scalability of a Process-Consistent Hydrologic Model

Presenter/First Author: Tyler J Smith, Clarkson University, Potsdam, NY

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Co-authors: Lucy Amanda Marshall, University of New South Wales, Sydney, NSW, Australia; Brian L McGlynn, Duke University, Durham, NC; Kaitlin D Hayes, Clarkson University, Potsdam, NY

Published Material: A portion of the results were presented at the 2014 AGU Fall Meeting and are part of a manuscript under review in Water Resources Research.

Abstract Body: Hydrologic models often fail to generate simulations that are consistent with internal watershed processes, despite commonly being able to match streamflow dynamics (following calibration). This shortcoming is particularly attributed to simple, conceptual models due to a lack of physical realism. At the same time, hydrologic model simulations are confronted with complications caused by a potential shifting of dominant processes with scale. In this study, we explore the scalability, sensitivity, and transferability of the parameters of the Catchment Connectivity Model (CCM). The CCM was developed following a dominant process conceptualization based on empirical hillslope hydrologic connectivity observations at the Tenderfoot Creek Experimental Forest (TCEF; Montana, USA). The three-parameter CCM is a spatially explicit model structure that has been validated against extensive field observations of hillslope hydrologic connectivity (an internal process simulated by the model) to demonstrate its internal consistency, in addition to a traditional assessment to the external streamflow dynamics. Specifically, we explored the variation in model parameterization across multiple scales across seven nested TCEF watersheds. A diagnostic model calibration analysis was considered where the role of a priori parameter ranges was explored in relation to both external (streamflow) and internal (hydrologic connectivity) model performance. This investigation allowed us to develop a more in-depth understanding of the model structure, its scalability, its sensitivity, and its transferability from one watershed to the next.

Abstract ID: 33506

Final Number: H11B-04

Title: Multi-scale studies of Permafrost Thaw Impacts on Eco-Hydrology in the Southern Fringe of Permafrost, Northwestern Canada.

Presenter/First Author: William L Quinton, Wilfrid Laurier University, Waterloo, ON

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Co-authors: Jennifer Lynn Baltzer, Wilfrid Laurier University, Waterloo, ON, Canada; Oliver Sonnentag, University of Montreal, Montreal, QC, Canada; Aaron A Berg, University of Guelph, Guelph, ON, Canada; Laura Chasmer, Wilfrid Laurier University, Waterloo, ON, Canada; Ryan Connon, Wilfrid Laurier University, New Hamburg, ON, Canada

Abstract Body: The southern Taiga Plains ecoregion is one of the most rapidly warming regions on Earth, and is experiencing unprecedented rates

of industrial expansion and related human disturbance. The permafrost in this region is relatively warm, thin and discontinuous. As a result, permafrost thaw is widespread and often leads to the transformation of forested permafrost terrains to permafrost-free, tree-less wetlands. Such permafrost thaw-induced landcover change has the potential to disrupt the hydrological cycle at local and regional scales. However, the hydrological implications of this permafrost-thaw induced land cover transformation remain poorly understood despite its demonstrated pan-arctic occurrence. As a result, there is an urgent need for an improved understanding of, and ability to predict permafrost thaw and its hydrological consequences. This paper presents the results of a long term field study on permafrost thaw-induced land-cover change and the resulting hydrological impact; and demonstrates how this new knowledge is applied to improve predictive capacities. Field measurements were conducted between 1999 and 2014 at Scotty Creek in the peatland-dominated southern fringe of discontinuous permafrost near Fort Simpson, Northwest Territories. Field studies at Scotty Creek have focussed on 1) improving the understanding of the volume and timing of runoff for different ground thaw and moisture conditions; 2) simulating the major water flux and storage processes controlling runoff; 3) characterising permafrost impacts at larger scales through field investigation and subsequent adaptation of a regional-scale permafrost model; and 4) estimating future quantities of runoff and surface water storage under possible scenarios of climate warming and human disturbance. Progress on each of these areas of will be the described.

Abstract ID: 34091

Final Number: H11B-05

Title: Frequency Bias Correction (FBC) - A new alternative for addressing GCM dependence biases for hydrological applications

Presenter/First Author: Ashish Sharma, University of New South Wales, Sydney, NSW

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Co-authors: Nguyen Ha, , , ; Rajeshwar Mehrotra, University of New South Wales, Sydney, NSW, Australia

Abstract Body: Addressing systematic persistence biases in GCM simulations is being increasingly recognised as a first step before any hydrological climate change impact assessment. This is in contrast to many bias correction procedures that focus on correcting biases in moments and are referred to as distribution-based bias correction approaches. The current options for addressing persistence biases comprise of the Nested Bias Correction (NBC) or its recursive variant, the Recursive NBC (RNBC), which correct lag 1 autocorrelation biases across specified nesting time scales. While these represent the only alternatives available to correct persistence biases (and hence are of considerable use in storage related applications in hydrology), the assumption of pre-defined time scales and a focus on the lag 1 autocorrelation limits their generality in representing persistence.

Here we present the Frequency Bias Correction (FBC) as an alternative to the NBC, that aims to correct for biases in the spectral representation of the data. Focussing on the entire spectrum instead of a handful of time-scales allows a more comprehensive treatment of any persistence related biases that may exist in the GCM simulations being processed. The FBC is was tested for MIROC5 precipitation simulations across the Australian land mass and compared to the empirical quantile mapping (EQM) and RNBC in terms of its ability to maintain distribution and persistence related attributes. Results indicate that the FBC corrects distributional and dependence attributes relevant in hydrological design and operation of water storage systems.

Abstract ID: 36066

Final Number: H11B-07

Title: A Model for Water Flow in Patterned Glacial Till Incorporating Coupled Multi-Scale Heterogeneity Effects

Presenter/First Author: Xicai Pan, University of Saskatchewan, Saskatoon, SK

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Co-authors: Melkamu Ali, University of Saskatchewan, Saskatoon, SK, Canada; Andrew M Ireson, University of Saskatchewan, Saskatoon, SK, Canada; Warren Helgason, University of Saskatchewan, Saskatoon, SK, Canada

Abstract Body: Representing subgrid-scale heterogeneity is becoming increasingly more feasible in land surface modeling and large scale hydrological modeling with the advance of computational power. However, in complex environments, such as the internally drained prairie basins, with highly variable snowpack and soil properties, our understanding of spatiotemporal storage dynamics and flow paths is still incomplete. An extensive and comprehensive field monitoring program was implemented to assess the field-scale water balance within a heterogeneous prairie pasture site. A 2-D hydrological model, including a novel representation of the patterned glacial till and associated surface properties, was developed. Instead of assuming homogeneous precipitation and soil properties over grids, the key soil parameters for two representative profiles were identified by inverse modeling using a simple 1-D hydrological model and field measurements of soil temperature, water content and water level. Then the parameters for spatial variability of those two profiles and boundary conditions were determined by near-surface soil water content surveys. The modeling results will be discussed in conjunction with the observed features.

Abstract ID: 36370

Final Number: H11B-08

Title: Assessment of Hydrological Behaviour of a Snowmelt-Dominated Catchment at Different Scales

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Abstract Body: Snow-dominated catchments are subject to different water input dynamics than their rainfall-dominated counterparts. Therefore, such catchments might experience different runoff generating processes, which might not be appropriately reproduced by the existing conceptual rainfall-runoff models. As a result, understanding about the dominant physical controls on the response of snowmelt-dominated watersheds is crucially important in the selection of hydrologic models. The focus of this research is on the Grand River watershed (7000 km^2), the largest watershed in southern Ontario in Canada, which comprises 25 per cent of the Canadian land area draining into Lake Erie. To gain insight into the hydrological functioning of the Grand River watershed – at different spatial scales – data obtained during snowmelt season are used. The data are obtained from numerous sampling experiments in different sub-basins and at multiple points along the main river. The variations in hydrographs over time and scale are analyzed to investigate how they are combined to yield the observed hydrological response of the entire watershed. Subsequently,

a structurally flexible hydrologic model (called RAVEN) is designed to reproduce the watershed hydrological response. The model will also be used to address nested hydrologic responses (at different scales).

Abstract ID: 35790

Final Number: H12A-01

Title: Stochastic Interpretation of Thermal Response Test with Complex Ground Heat Exchanger Model

Presenter/First Author: Philippe Pasquier, Polytechnique Montreal, Montreal, QC

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Co-authors: Denis Marcotte, , ,

Published Material: The presentation will present original material and sumarize the work presented in the following contributions: Marcotte, D. & Pasquier, P., 2008. Fast fluid and ground temperature computation for geothermal ground-loop heat exchanger systems. *Geothermics*, 37(6), pp.651–665. Pasquier, P. & Marcotte, D., 2014. Joint use of quasi-3D response model and spectral method to simulate borehole heat exchanger. *Geothermics*, 51, pp.281–299. Pasquier, P., 2015. Stochastic interpretation of thermal response test with TRT-SInterp. *Computers & Geosciences*, 75, pp.73–87.

Abstract Body: Integrating the temperature measurements made in the grout or in the vertical pipes of a ground heat exchanger during a thermal response test can be challenging for conventional interpretation methods. To fill this gap, a quasi-3D thermal response and capacity model is used to generate the transfer functions of the borehole at the location of the temperature probes. The transfer functions are then convolved in the spectral domain with an input function describing the variation of the heating power to obtain the simulated temperatures at the probes location. The unknown thermal parameters (thermal conductivity and volumetric heat capacity of the ground and grout, pipes spacing, initial ground temperature) are identified by an inversion method. It is shown that use of a spectral method combined with a response model allows integration in a stochastic framework of the measurements made at various depth in the borehole.

Abstract ID: 35686

Final Number: H12A-02

Title: Simulation of Borehole Thermal Energy Storage with the Haar Wavelet Method

Presenter/First Author: Alain Nguyen, Ecole Polytechnique de Montreal, Montréal, QC

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Co-authors: Philippe Pasquier, Polytechnique Montreal, Montreal, QC, Canada

Abstract Body: In recent years, use of borehole thermal energy storage systems has become more frequent as these systems allow a significant reduction of the overall energy consumption of buildings located in cold climates. To predict the performances of a system, assess the influence of regional groundwater flow on the thermal storage or simply predict the ground temperature for a given input heat load signal, numerical simulations are usually performed. In this work, a thermal resistance and capacity model is used to simulate a borehole thermal energy storage system under the effect of heat advection driven by regional groundwater flow. The resulting model is a stiff ordinary differential equation system which can present numerical challenges for conventional implicit multistep or Runge-Kutta solvers. To speed up the solution of the problem, the Haar wavelet method is used in conjunction with a multistep segmentation approach which recalculates the step size at each iteration based on the local truncation error estimation given by the Adams-Bashforth method. The method presented in this conference is compared with commercial stiff solvers. Current results indicate that the proposed method is efficient in terms of memory usage and is always 2 to 10 times faster than state-of-the-art solvers.

Abstract ID: 36562

Final Number: H12A-03

Title: Numerical Simulation of Deep Bore Heat Pumps

Presenter/First Author: Venkata Ramesh Melanathuru, University of Windsor, Windsor,

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Co-authors: Tirupati Bolisetti, University of Windsor, Windsor, ON, Canada; Stan Reitsma, GeoSource Energy Inc., Caledonia, ON, Canada; David S K Ting, University of Windsor, Windsor, ON, Canada

Abstract Body: Depletion of fossil fuels in the nature poses a greater threat to our civilization. To meet the energy challenges, environmentally friendly renewable energy sources are being explored. The availability of underground energy is more abundant and comparatively easy to extract. One such technology deals with exploitation of earth’s energy referred to as geothermal energy. Deep Bore Heat Pumps, that extract energy during winter times and discharge temperatures during summer, are gaining prominence and popularity due to its simplicity and reliability. Commissioning of this system requires large investment, which usually relies on reliable, powerful guesstimating tools. Therefore, there is a strong need to develop tools to arrive at optimal sizing of deep borehole exchangers.

This paper presents the results of a three-dimensional numerical simulation model for a U-Tube type of heat exchanger. This may be a gross simplification of the fact that there is grout and earth surrounding the exchanger. But, this approximation of considering a constant temperature reduces much pre-processing and computational effort. The PVC is considered as pipe material and water is as heat exchanger fluid. The heat is transferred from the outer surface to the water because of the conductivity of the solid material of the pipe and flow of the water. A velocity inlet and pressure outlet model is assumed. By solving the energy equation and laminar flow, the velocity and pressure profiles are obtained.

A thorough parametric study is conducted by using different span lengths, diameter of the pipe, velocity of the fluid and conductivity of the material. This study helped us in establishing the empirical equations for the temperature rise, power requirements and variables of the process viz., velocity, pressure drop etc.

Abstract ID: 35646

Final Number: H12A-04

Title: The use of shallow geothermal energy for bridge deck deicing

Presenter/First Author: Konstantinos Velegrinos, University of Manitoba, Winnipeg,

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Co-authors: Hartmut Michael Hollaender, University of Manitoba, Winnipeg, MB, Canada; Rob Sinclair, , ,

Abstract Body: Bridges are examples of critical infrastructures in Canada. Exposure to the extreme winter conditions of the Prairies produces rapid freezing conditions from heat loss through both the top and bottom bridge deck surface and these results in hazardous ice and snow conditions. A practical and cost-effective geothermal system to de-ice bridges in a timely manner will significantly reduce both accident and salt corrosion concerns. The subsurface soil and rock contain very large volumes of stored energy, mainly from solar radiation; in spite of this natural-stored energy, temperature declines have and will occur in geothermal systems without seasonal thermal balancing. Manitoba (MB) faces a very cold and long winter. Consequently, this high energy requirement requires a heat pump system for the rapid temperature rise required for bridge deck heating.

A 30-year climate record was obtained from Environment Canada. The data allowed defining standard air temperature curves. We calculated the expected energy consumption for heating bridges based on these curves. The simulation software FEFLOW is capable of simulating heat conduction, groundwater advection, surface radiation, spatial ground property variation, and mass transport around a set of ground heat exchangers. We used soil temperature data from the Highway 210 Test Site, near Ile des Chenes, MB to calibrate the model. The model predicted the groundwater temperature for the life cycle of 50 years. We show in this presentation that winter heating loads require at least the same energy load to be added to the aquifer in the summer.

Abstract ID: 35468

Final Number: H12A-05

Title: Development of a Thermo-Hydro-Chemical (THC) Model for Studying the Hydrogeochemical Behavior of Standing Column Wells

Presenter/First Author: Fanny Eppner, Ecole Polytechnique de Montreal, Saint-Hubert,

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Co-authors: Philippe Pasquier, Polytechnique Montreal, Montreal, QC, Canada; Paul Baudron, Polytechnique Montreal, Montreal, QC, Canada

Abstract Body: Standing column wells are ground heat exchangers that provide cooling or heating energy to buildings. In certain cases, they might allow to realize energy savings compared to other low temperature systems. Nonetheless, as they use groundwater directly as heat carrier fluid, they favor scaling and precipitation of minerals in the heat exchanger and well, therefore reduce the generated energy savings and increase the operation costs. With the aim to study the hydrogeochemical behavior of a standing column well and identify potential mitigation measures, a coupled thermo-hydro-chemical (THC) model is presented. In this work, geochemical reactions are expressed as slow chemical reactions for precipitation and dissolution while fast reactions are used to model local equilibrium reactions. The resulting model involves nine solute chemical species and three slow elementary reactions involving calcite. Reaction rate constants of these reactions are obtained through empirical relations taking into account groundwater temperature. The geochemical reactions are integrated within a heat and transport standing column well model that couple temperature, flow and chemical reactions. The transport equations are solved for three total concentrations under the constraint that a local equilibrium of the solute species is established. In order to validate the approach used, a simplified thermo-hydro-chemical model was developed and compared with reference solutions provided by PHREEQC. Both approaches show consistent results in terms of concentration of the aqueous species with a relative error lower than 10 %. Current simulation results confirm that dissolution in the rock around the well is possible and that a significant mass of calcite could precipitate in the well and within the mechanical equipment. Therefore, this study provides the first evidence that maintaining water quality and system's integrity in a standing column well could require water treatment systems.

Abstract ID: 36232

Final Number: H12A-06

Title: Analytical Approaches to Modelling Temperature Variations for a Vertical Ground-Coupled Heat Pump System

Presenter/First Author: David Tyler Gordon, University of Windsor, Windsor,

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Co-authors: Tirupati Bolisetti, University of Windsor, Windsor, ON, Canada; Stan Reitsma, GeoSource Energy Inc., Caledonia, ON, Canada; David S K Ting, University of Windsor, Windsor, ON, Canada

Abstract Body: When designing a vertical ground-coupled heat pump (GCHP) system it is important to optimize

the system by considering the thermal potential of the subsurface and various economic factors.

This paper reviews the analytical models used to size the ground heat exchanger (GHX)

component of the system; the models under consideration include the infinite-line source (ILS)

model, the infinite-cylindrical source (ICS) model, and the composite cylindrical

source (CCS) model. For comparison purposes, each model is applied to an example building utilizing a

single borehole system. The ILS model has been proven to be acceptable when investigating

long-term trends whereas the ICS and CMC models are more appropriate

for short-term trends. For a cycling system, attention should be placed on the

transient behavior of a GCHP during the first minutes of operation. Using data from building

loads and time of operation for the heat pump, the temperature variations of the heat transfer

fluid and the borehole wall are predicted for the system. It is discussed that when a system is

sized according to the larger of its peak heating or cooling demand, in situations where one is

larger than the other, annual ground temperature imbalances may result and degrade the performance of the system over time. The possible benefits of properly cycling a geothermal heat

pump include the reduction of annual ground temperature imbalances and economic savings.

This paper investigates the appropriateness of using the CCS model for illustrating the short-

term ground and fluid temperature responses when cycling a GCHP.

Abstract ID: 33871

Final Number: H12B-01

Title: Projected changes to hot air-temperature spells for Canada based on a Regional Climate Model ensemble

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Abstract Body: Extreme hot spells can have significant impacts on human society and ecosystems, and therefore it is important to assess how these extreme events will evolve in a changing climate. In this study, the impact of climate change on hot days, hot spells, and heat waves, over 10 climatic regions covering Canada, based on 11 Regional Climate Model (RCM) simulations from the North American Regional Climate Change Assessment Program (NARCCAP) for the June to August summer period, will be presented. These simulations were produced with six RCMs driven by four Atmosphere-Ocean General Circulation Models (AOGCM), for the A2 emission scenario, for the current 1970–1999 and future 2040–2069 periods. Two types of hot days, namely HD-1 and HD-2, defined respectively as days with only daily maximum temperature (Tmax) and both Tmax and daily minimum temperature (Tmin) exceeding their respective thresholds (i.e., period-of-record 90th percentile of Tmax and Tmin values), are considered in the study. Analogous to these hot days, two types of hot spells, namely HS-1 and HS-2, are identified as spells of consecutive HD-1 and HD-2 type hot days. In the study, heat waves are defined as periods of three or more consecutive days, with Tmax above 32°C threshold. Results suggest future increases in the number of both types of hot days and hot spell events for the 10 climatic regions considered. However, the projected changes show high spatial variability and are highly dependent on the RCM and driving AOGCM combination. Extreme hot spell events such as HS-2 type hot spells of longer duration are expected to experience relatively larger increases compared to hot spells of moderate duration, implying considerable heat related environmental and health risks. Regionally, the Great Lakes, West Coast, Northern Plains, and Maritimes regions are found to be more affected due to increases in the frequency and severity of hot spells and/or heat wave characteristics, requiring more in depth studies for these regions to facilitate appropriate adaptation measures.

Abstract ID: 35828

Final Number: H12B-02

Title: Sensitivity of Summer Stream Temperatures to Climate Variability in the Pacific Northwest United States

Presenter/First Author: Charles Luce, USDA Forest Service, Boise, ID

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Co-authors: Brian P Staab, US Forest Service, Portland, OR; Marc G Kramer, University of Florida, Ft Walton Beach, FL; Seth J. Wenger, University of Georgia, Athens, GA; Dan Isaak, USDA Forest Service, Boise, ID; Callie McConnell, , ,

Published Material: Recently published in a paper in Water Resources Research (Summer 2014). No presentation has been made at a professional society meeting.

Abstract Body: Estimating differences in thermal response among streams to a warming climate is important for prioritizing native fish conservation efforts. While there are plentiful estimates of air temperature responses to climate change, the sensitivity of streams, particularly small headwater streams, to warming temperatures is less well understood. A substantial body of literature correlates sub-annual scale temperature variations in air and stream temperatures driven by annual cycles in solar angle; however, these may be a low-precision proxy for climate change driven changes in the stream energy balance. We analyzed summer stream temperature records from forested streams in the Pacific Northwest for interannual correlations to air temperature and standardized annual streamflow departures. A significant pattern emerged where cold streams always showed lower sensitivities to air temperature variation, while warm streams could be insensitive or sensitive depending on geological or vegetation context. A pattern where cold streams are less sensitive to direct temperature increases is important for conservation planning, although substantial questions may yet remain for secondary effects related to snow, runoff, groundwater, or vegetation changes induced by climate change.

Abstract ID: 33872

Final Number: H12B-03

Title: River Temperature Dynamics and Corresponding Surface / Streambed Heat Fluxes

Presenter/First Author: Daniel Caissie, Fisheries and Oceans Canada, Moncton, NB

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Co-authors: Barret Kurylyk, University of Calgary, Calgary, AB, Canada; Nassir El-Jabi, , , ; André St-Hilaire, Institut National de la Recherche Scientifique - centre Eau, Terre et Environnement, Quebec city, QC, Canada; Kerry T B MacQuarrie, University of New Brunswick, Fredericton, NB, Canada

Published Material: Some of the findings within the presentation was published in the Journal of Hydrology (2014: 519: 1441-1452)

Abstract Body: The thermal regime of rivers plays an important role in the overall health of aquatic ecosystems. River water temperature is important for water quality parameters that are considered when conducting environmental impact assessments and developing effective fisheries management. As such, it is important to understand the thermal behaviour of rivers and related heat exchange processes. This study looks at different heat exchange processes responsible for water temperature variability on both temporal (e.g., diel, daily, seasonal) and spatial scales (small vs. large rivers). Both surface and streambed heat fluxes were quantified within the studied watercourses. Surface heat flux was quantified using data from instream microclimate stations whereas streambed heat flux was quantified using measured temperatures within the streambed. Accordingly, streambed temperatures were measured at different depths and were used as a tracer to predict the magnitude and direction of

groundwater flow using an inverse solution to the advection-conduction heat transport equation. The streambed flux analysis was carried out under different conditions, namely under natural surface water temperature conditions (i.e., as measured in the field), under steady-state conditions (e.g. under stream ice cover) and for conditions where the surface water temperatures followed a sinusoidal function. Modeling examples will be presented, including the implication of using water temperature models as a tool to better understand and protect important fisheries resources under current climate as well as under future climate conditions.

Abstract ID: 36620

Final Number: H12B-04

Title: Using Distributed Temperature Sensing (DTS) and LDCA to Parse Thermal Forcings in Small Creeks

Presenter/First Author: Christine E. Hatch, University of Massachusetts Amherst, Amherst, MA

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Co-authors: David A Boughton, NOAA Fisheries, Santa Cruz, CA; Ethan Mora, , ,

Published Material: Method published in WRR 2014, partially presented at AGU's Fall meeting in 2012

Abstract Body: Temperature has long been used as an indicator of ecosystem health and suitability for aquatic species, particularly in sensitive areas crucial to the persistence of declining fish populations. Typically, stream temperature surveys have long duration but only at point locations, limiting the precision of efforts to predict stream temperatures or understand broader climate linkages, and single–logger data give no insight into the spatial heterogeneity of thermal conditions often exploited by biota. Distributed Temperature Sensing (DTS) provides temperature data at high spatial and temporal resolution up to 5–km in length, allowing for detailed assessment of a creek's heat budget. Rather than calculating a detailed energy balance from a single site or using a statistical approach, here we describe a hybrid method that uses Least Dependent Component Analysis (LDCA) capable of taking advantage of DTS data density in time and space. The method identifies distinct thermal components in the stream's heat budget, using only temperature data and an algorithm based on mutual information that parses signals in the temperature data into dominant components or groups of parameters that force temperature signals in similar ways. These signals can be interpreted as sets of heat-flux elements sharing coordinated (non-independent) dynamics, both simplifying the number of heat budget components as well as the number thermally forcing stream temperatures. Comparing these components to meteorological data and fluvial system structure allowed us to relate the groups back to causal heating and cooling mechanisms, which can be tested directly with targeted heat-budget studies. We applied this method to a small, arid–land creek, and found that a minimum of three distinct components were necessary to describe the thermal heterogeneity of a 1–km reach. We could also estimate a spatial response profile of each component, yielding insight into possible links between stream geomorphology and function. This method shows promise to aid with siting and defining detailed heat–budget studies, determining the dimensionality of heat budgets in natural streams, and more broadly for associating thermal components to fluvial structure and processes.

Abstract ID: 35155

Final Number: H12B-05

Title: Quantifying Groundwater-Surface Water Interactions with a Stream Energy Balance, Cordillera Blanca, Peru

Presenter/First Author: Lauren Dorothy Somers, McGill University, Montreal,

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Abstract Body: Communities and industries in the Cordillera Blanca mountain range, Northern Peruvian Andes, rely extensively on streams fed by both groundwater and glacier meltwater for water during the dry season. It is hypothesized that groundwater baseflow accounts for at least half of the overall stream discharge during the dry season. Heat tracing (energy balance) was used to determine groundwater advection to the stream. Data was collected along a 4 km reach of the Quilcayhuanca River, including meteorological observations, stream discharge, stream dimensions, groundwater temperature, shading and view to sky observations. Stream temperature was also recorded using thermochrons at 39 points along the stream for 4.9 days. Field data was used to determine boundary conditions for a numerical stream temperature model, HFLUX (http://hydrology.syr.edu/hflux.html). The model calculates all energy fluxes entering and leaving the stream, including solar radiation, advection of groundwater, evaporative heat flux, sensible heat flux, and streambed conduction. The model, which calculates a stream temperature profile through time, was calibrated to measured temperatures. A groundwater baseflow profile for the stream is derived from the calibrated model. It is observed that groundwater baseflow dampens diurnal temperature fluctuations and that, during most of the day, the groundwater temperature is warmer than the stream temperature. Model sensitivity analysis showed that the simulations were, in decreasing order, most sensitive to solar radiation, groundwater baseflow volume, and groundwater temperature. These results suggest that groundwater-surface water interactions in the Cordillera Blanca have a significant impact on the stream thermal regime system and that the stream energy balance may be a viable way to quantify groundwater contributions.

Abstract ID: 34769

Final Number: H12B-06

Title: Spatial Variability of Thermal Refuges Analysed in Relation to Landscape Hydromorphology in the Restigouche River Watershed

Presenter: Normand Bergeron, INRS, Quebec, QC

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First Author Student?: No

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Published Material: The findings are currently in the proofing stage and will be imminently published in Remote Sensing of Environment.

Abstract Body: Water temperature is an important variable governing the distribution and behaviour of fish. Salmonids are particularly intolerant of high temperatures and survive heat waves using discrete units of cold water, known as 'thermal refuges'. Currently, patterns of thermal refuge distribution and the mechanisms governing it are poorly understood, especially at large scales. However, given that climate change poses a threat to salmon populations in Europe and North America, these cold

water units are increasingly important for salmonids in the summer. We used airborne thermal infrared thermal imaging (TIR) to characterise the spatial distribution of thermal refuges in nearly 700 km of rivers in the Restigouche River watershed. Thermal refuges were classified into different categories, with those identified as groundwater-driven proving to be the most abundant. GIS analysis was used to assemble a series of landscape metrics that were tested for links with the spatial distribution of groundwater thermal refuges. Jacobs' selectivity index was used to investigate the relationship between landscape metrics and the local-scale occurrence of thermal refuges. Results showed that the presence of thermal refuges was significantly associated with high values of channel curvature (X2 $p < 0.05$, df = 9). Regression analysis was used to assess correlations between landscape metrics and the larger-scale density of thermal refuges (no. refuges per river km). Using a quadratic model ($R^2 = 0.83$, $p < 0.05$), we observed a strong correlation between the river's entrenchment ratio (a measure of channel confinement) and the density of thermal refuges. Our results indicate that the spatial distribution of groundwater thermal refuges is strongly connected to landscape hydromorphology. This is the first study to examine the spatial distribution of thermal refuges at riverscape scales and it is hoped that such data will help conservation efforts to preserve critical thermal habitats in rivers threatened by climate change.

Abstract ID: 36608

Final Number: H12B-07

Title: Preserving, augmenting, and creating cold-water thermal refugia in rivers: concepts derived from research on the Miramichi River, New Brunswick

Presenter/First Author: Barret L Kurylyk, Organization Not Listed, Fredericton, NB

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Published Material: This research has been published online in the journal *Ecohydrology* under the same title as this abstract (DOI: 10.1002/eco.1566).

Abstract Body: Summer water temperatures are rising in many river systems in North America, and this warming trend is projected to intensify in the coming decades. Cold-water fish may alleviate thermal stress in summer by aggregating in discrete cold-water plumes that provide thermal refuge from high ambient river temperatures. Reliance on cold-water thermal refugia is expected to increase in a warming climate, and many river reaches already lack suitable thermal refugia as a result of an absence of thermal diversity. A comprehensive fish management strategy could proactively address this imminent threat to cold-water fish populations across North America by preserving existing thermal refugia, augmenting thermal anomalies to improve performance as refugia, and creating new thermal refugia in uniformly warm river reaches.

We provide practical recommendations on how these measures can be accomplished based on insight derived from recent research focused on the Miramichi River, New Brunswick. Opportunities include limiting land use change, construction aggregate extraction (e.g. sand and gravel pits), and groundwater pumping/consumption. Existing thermal anomalies can be enhanced by controlling advective thermal mixing between cold-water tributaries and the river mainstem flow, installing riparian shading, and adding temporary structures for protection from avian predators. New refugia can be created by temporarily pumping groundwater to discrete points within the river during periods of thermal stress. These concepts are discussed in the context of a comprehensive thermal refugia management strategy.

Abstract ID: 35587

Final Number: H12B-08

Title: Multi-layer stratification of groundwater temperatures in Ordovician and Silurian aquifers at the Victor Diamond Mine, as evidence of groundwater recharge under past cold climate conditions and limited deep groundwater circulation in James Bay Lowlands, near Attawapiskat, Ontario

Presenter/First Author: Simon Gautrey, AMEC, Hamilton,

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Co-authors: Patrick Rummel, , , ; Brian Steinback, , ,

Abstract Body: The Victor Diamond Mine is located in the James Bay Lowlands, approximately 90 km west of Attawapiskat. The mine site is underlain by up to 270 m of flat lying sedimentary bedrock capped by up to 60 m of marine sediments from the post glacial Tyrell Sea. Groundwater temperatures collected from monitoring locations around the mine reveal three horizons of stable groundwater temperature, in addition to a shallow horizon of seasonal variation. These horizons are: an upper horizon of approximately 150 m of predominantly limestone bedrock with temperatures between 4.0 to 4.5 °C; a middle horizon of predominantly limestone from approximately 150 to 220 m depth with temperatures between 2.5 to 3.3 °C, and a lower horizon from 220 to 270 m depth of mudstone with temperatures greater than 5.0 °C. While the temperature of the upper horizon matches the average annual groundwater temperature in the overburden suggesting the temperatures are advection controlled, and the temperature of the lower horizon can be explained by the geothermal gradient, the temperature of the middle horizon is anomalously low. Based on groundwater chemistry data, previous investigators at the site had hypothesized that there was relic Tyrell Sea Water trapped in some aquifers. The temperature data presented herein supports this hypothesis. The presence of a wide area of low temperature groundwater at the site, approximately 4,400 years after the retreat of the Tyrell Sea and 7,900 years after the retreat of the glaciers suggests that there is limited groundwater circulation in the deeper limestone aquifers of the James Bay Lowlands. Furthermore, given the Tyrell Sea was present in the area for 3,500 years, the data implies either more active groundwater circulation during the Tyrell Sea period, or different hydrogeologic conditions possibly driven by a glacial advance over sea water.

Abstract ID: 35736

Final Number: H13A-01

Title: Soil and vegetation development affect the evolution of hydrological pathways in engineered hillslopes

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Published Material: Parts of this work have been presented at the GSA annual meeting in Vancouver, October 2014.

Abstract Body: The structure and hydraulic properties of soils and bedrock within a hillslope combined with the timing and rates of water availability control the partitioning of precipitation into vertical and lateral flowpaths. In natural hillslope sites, heterogeneity in both soil texture and structure are the result of long-term landscape evolution processes and consequently can be assumed to be static relative to the timescale of rainfall-runoff processes. However; engineered hillslopes, constructed commonly as reclamation covers overlying mine waste, have been observed to undergo rapid changes in hydraulic properties over relatively short timescales (i.e. 3-5 years) as a result of weathering and vegetation growth. Rainfall-runoff responses on such hillslopes would therefore not only be expected to reflect seasonal dynamics, but also the evolution of the system from a relatively homogeneous initial condition to a system with increasing heterogeneity of soil texture and structure.

We present results of a combined field and modeling study of three prototype soil covers on a saline-sodic shale overburden dump north of Fort McMurray, Canada. Since their construction in 1999, soil properties, hydrological response to atmospheric and vegetative demands, and vegetation properties have been extensively monitored. The three covers have undergone substantial evolution due to freeze-thaw and wet-dry cycles processes and aggrading vegetation, increasing rooting depth and density.

In this work, we quantify hydrological processes in the reclamation covers, focusing on inter- and intra-annual patterns. To this purpose we analyzed the long-term hydrometric data with field sampling of the distribution of salts and the stable isotopes of water within soil water and subsurface flow in the base of the cover. We use a 2D Hydrus model to explore the co-evolution of soil and vegetation and quantify its effect on flow partitioning and salt movement into the soil.

Abstract ID: 36501

Final Number: H13A-02

Title: Hydrological Functioning of a Constructed Watershed

Presenter/First Author: Scott J Ketcheson, University of Waterloo, Waterloo, ON

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Abstract Body: Reclamation in the oil sands areas requires the reconstruction of entire landforms and drainage systems. Much reclamation research has focused on assessing the performance of individual hillslopes; however, there is a need for an integrated, catchment-scale approach to fully develop an understanding of the hydrological functioning of constructed watersheds. This research aims to couple the controls on water distribution, storage and release within individual landforms (reclaimed slopes, tailings sand upland aquifer and fen peatland) to their hydrologic role (i.e., storage or conveyor) within the context of the larger scale landscape in a constructed system.

The oldest slope (reclaimed in 2007) exhibited a surface infiltration rate three times larger than slopes reclaimed more recently (2012). Consequently, soil water storage was reduced on the 2012 slopes and infiltration-excess surface runoff generation conveyed water rapidly downslope during intense precipitation events. In the fen peatland, high water table levels were sustained throughout the summers of 2013 and 2014, with persistent ponded water in localized depressions in the surface of the placed peat. Large upward hydraulic gradients measured in the fen suggest strong connectivity with the tailings sand upland aquifer; however very low surface infiltration rates on the capping upland reclamation soil constrained recharge to the sand aquifer, which remains below designed water contents in much of the upland.

Abstract ID: 36276

Final Number: H13A-03

Title: Controls on Plot-Scale Evapotranspiration from a Constructed Fen in a Post-Mined Oil Sands Landscape, Fort McMurray, Alberta

Presenter/First Author: Sarah Scarlett, University of Waterloo, Waterloo, ON

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Co-authors: Richard M Petrone, University of Waterloo, Waterloo, ON, Canada; Jonathan S Price, University of Waterloo, Waterloo, ON, Canada

Abstract Body: In the oil sands development region of the Western Boreal Plains (WBP) mining companies now recognize the importance of peatland ecosystems, as they cover >60% of the regional pre-mined landscape. To date, reclamation efforts have been focused on uplands and open water marsh wetlands. However, these wetland systems are not abundant in the sub-humid climate of the WBP due to high evaporative demand, where evapotranspiration (*ET*) is the dominant hydrologic flux from wetlands in this region. Suncor's pilot constructed fen was completed in 2013, engineered with the intent to support natural fen vegetation and hydrologic processes. The purpose of this study is to evaluate the influences of vegetation and treatment types on evapotranspiration demands from the constructed fen. Multiple study sites (31) were monitored across the fen during the 2014 field season, located in vegetation plots (control/moss/vascular) with varying treatments (mulched/unmulched). Plot-scale actual *ET* was quantified with weighing lysimeters and chamber measurements. These measurements were used to adjust equilibrium *ET*, calculated using Priestly-Taylor for control and moss plots and Penman-Monteith for seedling plots, where values of stomatal resistance and leaf area index were available. A roaming meteorological station was used to quantify available energy over individual plot types. *ET* rates were, on average, lower in moss plots than control and vascular. Mulch further reduced *ET*, with lowest rates in mulched moss plots. These trends were likely caused by different thermal regimes and lower available energy in mulched plots, where ground temperatures were ~3°C lower. Mulch further provided a favorable microclimate for moss establishment by elevating near-surface relative humidity. Currently, these reclamation practices have not yet been well tested in this region and have relied on knowledge from other study areas where climate is dissimilar. The results of this study will provide insight into effective reclamation practices for reducing evaporative stress and ensuring successful establishment of functioning peatland ecosystems in the WBP.

Abstract ID: 36472

Final Number: H13A-04

Title: Examining the Water Use Efficiency of a Constructed Fen-Upland Watershed in Alberta, Canada.

Presenter/First Author: George Sutherland, University of Waterloo, Waterloo, ON

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Co-authors: Richard M Petrone, University of Waterloo, Waterloo, ON, Canada

Abstract Body: Oil sands development in the western boreal plains (WBP), northern Alberta, involves widespread surface mining, which disturbs natural ecosystems. More than 50% of the land cover impacted by oil sands leases are wetlands--the majority of which are fen peatlands. Recently, oil sands companies have focused on testing the concept of constructing peatlands into their post-extraction closure landscape. This research uses eddy covariance and climate monitoring systems to examine the fluxes of energy, H2O, and CO2 between a constructed fen-upland watershed and the atmosphere. The objective of this is to characterize the hydro-meteorologic functioning and initial trajectory of the constructed watershed relative to natural upland-fen systems over a two year (2013-2014) monitoring period following construction. Results from 2013 indicate that while evapotranspiration (ET) from the constructed fen was greater than ET from the upland, both fell below climate normals and ET measured from natural fen peatlands in the same region. In addition, both the constructed fen and upland were sources of CO2 in 2013; however, the constructed fen shifted to a small sink of CO2 in 2014, while increasing its ET by 50% relative to 2013. Precipitation and soil moisture were limiting factors in the constructed upland, which remained a source of CO2 in 2014 and experienced ET rates comparable to 2013. With vegetation growth, both the constructed fen and upland experienced an increase in their water use efficiency (WUE) over the two year study period.

Abstract ID: 34037

Final Number: H13A-05

Title: Multi-Year Water Balance Assessment of a Constructed Wetland, Fort McMurray, Alberta

Presenter/First Author: Erin Nicholls, McMaster University, Hamilton,

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Co-authors: Sean Kevin Carey, McMaster University, Hamilton, ON, Canada; Gordon B Drewitt, , , ; Elyn Humphreys, Carleton University, Ottawa, ON, Canada; M. Graham Clark, Carleton University, Ottawa, ON, Canada; Carl A Mendoza, University of Alberta, Edmonton, AB, Canada

Abstract Body: Surface mining for oil sands strips away the boreal landscape, leaving behind open pits, tailings and overburden piles. While previous reclamation efforts have focused on upland forests, rebuilding wetland systems is less well understood. The success of constructed wetlands is dependent on the supply and storage of water to promote wetland vegetation, peat accumulation and limit elevated salinity. In 2012, Syncrude Canada Ltd. completed construction of the Sandhill Fen Watershed (SFW), a 52-ha upland-wetland system designed to evaluate wetland reclamation strategies. SFW includes upland hummocks, vegetated swales, a water storage pond, fen wetland and an underdrain system. The objective of this study is to develop a water balance for the SFW. A semi-distributed water balance approach was utilized to quantify fluxes and stores within different landscape units. Fresh water was pumped into the system from a nearby lake, and outflow was measured at a weir and sump that collected surface and subsurface drainage. ET was measured using three eddy covariance towers at upland and lowland sites. Precipitation was quantified using tipping buckets, snow surveys, and continuous depth and SWE measurements. 29 near surface wells measured water table fluctuations in along with deep piezometers measuring deeper flow pathways. Results reported range from January 2013 through October 2014 and present the calculation of water balance components in the upland and lowland areas. In 2013, lateral inflow and outflow dominated hydrological fluxes and precipitation was higher than the climatic normal. In 2014, pumps remained mostly off, with vertical fluxes controlling the water balance. Lateral redistribution of water from uplands to wetlands was observed in 2014. Higher ET rates were observed in 2013 than 2014 at upland and lowland locations, with higher ET from the lowland tower in both years. Water table in 2013 fluctuated greatly, while in 2014, water table slowly declined throughout the summer and responded to large rain events in the fall. With 2013 highly managed, and 2014 climatically normal with little artificial controls, comparisons between these years provide insight on how management practices influence the hydrologic dynamics and the overall water balance of the SFW.

Abstract ID: 35995

Final Number: H13A-06

Title: Carbon and water vapour fluxes for the first two years of a constructed wetland.

Presenter/First Author: M. Graham Clark, Carleton University, Ottawa, ON

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Co-authors: Elyn Humphreys, Carleton University, Ottawa, ON, Canada; Sean Kevin Carey, McMaster University, Hamilton, ON, Canada

Abstract Body: The Sandhill Fen Watershed project is a pilot study by Syncrude Canada Ltd. involving the construction of a 50 ha mixed upland (forested) and lowland (wetland) watershed. The project is the first large scale attempt in constructing a boreal peatland and as such will help assess certification for mine closure. The physical construction was completed in 2012 with the initial re-vegetative planting occurring in the same year. In 2013 pumps were used to simulate ground water through-flow and in 2014 the pumps were disengaged to allow the system to naturally respond. Throughout this period the vegetation, both planted and colonized, developed a substantial cover over soil and peat substrates. This study contrasts the first two years of atmospheric energy, water, and carbon fluxes to the atmosphere during the wetland ecosystem's initial development. In 2013 there was a net loss of carbon from the lowland regions, but by 2014 the carbon balance was almost neutral. Evapotranspiration from the ecosystem also increased over the same period. As the lowlands mature, energy and carbon fluxes appear to be shifting towards what is observed in naturally formed boreal peatlands. Furthermore, over the two years, and despite high concentrations of sulphur, preliminary evidence suggests that methanogenic communities appear to be establishing in the wetland.

Abstract ID: 34402

Final Number: H13A-08

Title: Evaluating the Effectiveness of an Inversion Technique for Well-Pad Restoration to a Peatland Ecosystem: Ecohydrological Conditions and Carbon Exchange

Presenter/First Author: Maria Strack, University of Calgary, Calgary, AB

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Co-authors: Matthew Coulas, , , ; Bin Xu, Northern Alberta Institute of Technology, Peace River, AB, Canada; Gabrielle Préfontaine-Dastous, , , ; Line Rochefort, , ,

Published Material: Vegetation data from 2013 was presented as a poster at a small scientific meeting for industry and academic partners.

Abstract Body: A large portion of the oil sands deposit in boreal Alberta is accessible only by in situ extraction techniques that involve the construction of well pads distributed across the boreal landscape. Given that at least 30% of the region is covered by peatland, many of these well-pads are constructed within these wetland ecosystems. We tested a well-pad inversion technique involving either complete removal of the mineral soil pad and inversion of the previously buried peat or inversion of some of the pad and peat (resulting in mineral soil burial). On top of the resulting peat surface, the moss layer transfer technique was used to reintroduce plants to the site with donor material sourced from areas dominated by 1) *Sphagnum* moss, 2) brown mosses or 3) Polytrichum moss. These treatments were compared to areas without plant reintroduction both with and without straw mulch. During the second full growing season following plant reintroduction, total vegetation cover was over 60% across the pad, being lowest in the section without plant introduction or mulch. Bryophyte cover was lower and graminoid cover higher than the neighbouring undisturbed peatland. There was little effect of the source of vegetation material on the resultant plant cover. Water table was on average deeper than the neighbouring peatland, although both wetter and drier areas were present with no clear effect of inversion type. The ecohydrological conditions combined to result in greater productivity on the restored well-pad than in the surrounding peatland. Although initial ecohydrological conditions remain dissimilar to the undisturbed peatland, the rapid revegetation by wetland plants including bryophytes, favourable water table position, and uptake of carbon dioxide during the growing season suggest that inversion is a promising technique for restoration of well-pads to peatland ecosystems.

Abstract ID: 33677

Final Number: H13B-01

Title: Integrating weather and climate predictions for seamless hydrologic ensemble forecasting: A case study in Yalong River basin

Presenter/First Author: Aizhong Ye, Beijing Normal University, Beijng,

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Co-authors: Qingyun Duan, Beijing Normal University, Beijing, China; Xiaoxue Deng, Beijing Normal University, Beijing, China; Feng Ma, BNU Beijing Normal University, Beijing, China; Zheng Zhou, Beijing Normal University, Beijing, China

Abstract Body: The accuracy of precipitation forecasts by numerical weather and climate models has been improved in recent years. However, these forecasts still cannot be used directly for hydrological forecasting and must be post-processed to extract useful predictive information. In this paper, we study how different designs of canonical events can help post-processing of Global Ensemble Forecast System (GEFS) precipitation forecast products and improving hydrological forecasting in Yalong River basin, China. First, we selected different types of canonical events for precipitation and compared post-processed precipitation with observed precipitation. Second, we used the post-processed precipitation to drive a distributed hydrological model to obtain hydrological ensemble forecasts and compared those forecasts with observed streamflow. We found that design of canonical events can help extract more useful information, especially using up to date observed precipitation to set up canonical events. We also revised the “Schaake shuffle” to improve the accuracy of precipitation forecasts from combined events. Last, we integrated GEFS and Climate Forecast System version 2 (CFSv2) precipitation forecasts and used them to generate seamless hydrological forecasts across different time scales. The integrated streamflow forecasts have longer lead times and higher accuracy than ESP streamflow forecasts and the forecast based on original CFSv2 precipitation forecasts.

Abstract ID: 34773

Final Number: H13B-02

Title: The Dynamics of East African Climate and the Suitability of crop Mapping over the Mountainous Areas in a changing climate

Presenter/First Author: George Otieno, University of Nairobi, Nairobi,

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Abstract Body: The East African region is bordered by mountains that are crucial in modulating the climate of the region. The current evidence of climate change and climate variability poses risks to the sustainable development of the society.

The study examined trends in projected rainfall and air temperature and suitability of growing major staple food under a changing climate around the mountainous areas of Kenya, Uganda, Tanzania and Ethiopia.

The data used were observed rainfall, temperature, the second version of African Rainfall Climatology (ARC2) for the period 1981-2010 and future projection from 2011-2040, model estimates of future climate scenarios under Representative Concentration Pathway (RCP 4.5) was obtained from Coupled Model Inter-comparison Project Phase 5(CMIP5). The Mann-Kendal test was used for trend analysis and the FAO ECO-crop model was used for suitability mapping of various agricultural zones for production of maize and beans at the lowlands and down slope of the mountainous areas.

At least ten stations indicated a temperature rise of 0.3 per decade. High seasonal rainfall variability was experienced during March-May and October-December seasons. The values of Mann-Kendal were in the range of 0.8 - 2.0. The projection showed that temperature will continue to rise by about 0.5 per decade.

There was marginal suitability for production of beans and maize over most parts of the four countries. Most of the western and central part of Kenya showed high potential for production of the two crops. This trend was also reported in central Part of Uganda and coastal area of Tanzania.

The future suitability mapping for crops production showed quite similar patterns as the current situation. The highland and rift valley regions would no longer be suitable for growing the crops. The increased human activities around these regions like deforestation probably could account for the decline in suitability of growing these crops.

The threats from climate change are likely to impact negatively on the agricultural activities around the mountainous areas. The farming community living around the slopes of the mountainous areas should diversify the farming activities and best practices to cope with current climate variability and adapt to future climate changes.

Abstract ID: 36161

Final Number: H13B-04

Title: Forecasting of Rainfall under rainfed agriculture of Pakistan

Presenter/First Author: Mukhtar Ahmed, Organization Not Listed, Rawalpindi,

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Co-authors: Fayyaz ul Hassan, Comsats Institute of Science and Technology, Islamabad, Pakistan

Abstract Body: Farmers in dry areas are vulnerable to climatic fluctuations and they need adjustment in the agricultural management to the amount and timing of rainfall to optimise yield and economic returns for a given season at a specific location. Skilful long-range forecasts of rainfall can increase the preparedness of farm managers above a level that is solely based on past experiences. The two prominent modes of interannual variability that impact the Indian subcontinent are the El-Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Forecasting of intermittent rainfall in dryland areas of Pakistan like Pothwar poses

number of major challenges. One of the challenges relates to modelling zero, skewed, non-stationary, and non-linear data. To address this, a probabilistic statistical model to forecast monsoon and wheat growing period rainfall was applied to three dryland areas of Pothwar. The model uses logistic regression through Generalised Additive Models (GAMs) to determine the probability of rainfall, occurring in the systems. This study explores climatic predictors (Indian and Pacific Ocean SSTs indicating states of the ENSO and the IOD) those influence rainfall variability over the Indian subcontinent for their usefulness in forecasting seasonal rainfall (monsoon rainfall and three rainfall intervals during the wheat growing season). The output revealed that in the study region the occurrence and variability of rainfall was driven by SSTs, therefore forecasts can be made with good skill to bridge the gaps between potential and average wheat yield by management decisons like adjusting sowing time and use of appropriate genotypes. Furthermore the model validation for rainfall forecasting was evaluated by forecasting skill scores like R^2, NSE (Nash–Sutcliffe model efficiency coefficient), RMSE (Root Mean Square Error), S% (Skill Score S), LEPS (Leniar error in probability space), BSS (Brier Skill Score) and ROC (Receiver Operating Characteristics, p-value) to confirm the effeciency of GAM and to make comparison between different validation skills to do cross validation of forecast rainfall. Similarly, application of forecast systems across the whole value chain in agricultural production offers considerable benefits in improving overall operational management of agricultural production.

Abstract ID: 36210

Final Number: H13B-07

Title: Wavelet-based cross-correlation analysis of Pacific Ocean climate data and streamflow for long-term streamflow forecasting

Presenter/First Author: Andres M Ticlavilca, Utah State University, Montgomery Village, MD

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Co-authors: Inga Maslova, American University, Washington, DC; Mac McKee, Utah Water Research Laboratory, Logan, UT

Abstract Body: Wavelet-based cross-correlation analysis is performed in both time and frequency domains to study lead-lag relationships between Pacific Ocean climate data and streamflow in Utah, US. The Pacific Ocean climate data are Southern Oscillation Index, Pacific sea surface temperature and sea surface temperature anomaly. The data are decomposed into meaningful components formulated in terms of wavelet multiresolution analysis. The results from the wavelet-based cross-correlation analysis are used to select the data to build a forecasting model based on a Bayesian machine learning approach. This new methodology can incorporate key information from the trends of the Pacific Ocean climate time series to produce improved long-term streamflow predictions up to 12 months ahead.

Abstract ID: 34473

Final Number: H13B-08

Title: Analysis Of The 2012 Flooding Events Downstream Of Shiroro Reservoir, A Case Of Gurmana Niger State, Nigeria

Presenter/First Author: Bahago Abubakar Rukayyah, Federal University of Technology, Minna,

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Co-authors: Halilu Shaba Ahmad, National Space Research & Development Agency, Abuja, Nigeria; Aishetu Abdulkadir, , ,

Abstract Body: This study carried out geospatial analysis of the 2012 Flood event, downstream of Shiroro Reservoir at Gurmana in Niger State, Nigeria as an input to contingency planning and emergency management. Satellite imageries, topographic map of Niger State, administrative map of Nigeria, SRTM DEM, GPS coordinates, and flood photographs were integrated to map the flooding event, analyze the spatial extent and disaster risk areas. The results indicated that out of 67.896km² about 0.33385km² of land were flooded. Farmlands and transportation routes were severely affected with about fifty (50) members of the households in the study area were displaced. The vulnerability analysis indicated that the areas between 0-100m are highly vulnerable and between 101-200m are less vulnerable. This shows that if no measures are taken to prevent the population of buildings on the floodplains, the next flood could be a major disaster to Gurmana. On this note, I strongly recommend that the people of Gurmana should be relocated. The field observation indicates that the occurrence of flood in the study area was due to the heavy rain, which coincided with river inundation and land use land cover leading to backwash to the village since the flow into the mains were impeded. Hence a comprehensive geospatial analysis and mapping for emergency management, disaster management and flood contingency planning in the region is inevitable.

Abstract ID: 36457

Final Number: H13C-01

Title: Record ice cover on Lake Superior in 2014: Observations and implications

Presenter/First Author: Jay A Austin, University of Minnesota Duluth, Duluth, MN

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Co-authors: Daniel Titze, , ,

Abstract Body: Record-breaking cold in the Laurentian Great Lakes region during the winter of 2013-2014 resulted in abnormally long and intense ice cover on Lake Superior. The ice climate on Superior fell well outside the recent range of observed variability. Mooring observations from three locations in the western, central and eastern portions of the lake provide insight into the behavior of the lake during heavy ice cover. Surface heat fluxes were dramatically dampened during the season, and the character of the circulation in the upper water column changed dramatically. Observations of ice drift velocities were made using an ADCP, showing that ice drift direction was consistent with local winds, and ice drift speeds were a consistently about 3% of wind speeds across a wide range of wind speeds. This close coupling suggests that the force balance on the ice is a simple balance between wind and water drag. Ice keels of 6m thickness occurred on a regular basis throughout the season, and ice keels of up to 12m depth were observed. The impact of the high ice cover was felt through the remainder of the year, with the onset of stratification delayed in the lake until early to mid-August, resulting in a short, cool summer season.

Abstract ID: 34316

Final Number: H13C-02

Title: An Observational Study of the Influence of Ice Formation on Heat and Water Loss from the Upper Great Lakes.

Presenter/First Author: Peter Blanken, University of Colorado, Boulder, Boulder, CO

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Co-authors: Christopher Spence, Environment Canada Saskatoon, Saskatoon, SK, Canada; John D Lenters, LimnoTech, Ann Arbor, MI; Andrew Gronewold, NOAA Ann Arbor, Ann Arbor, MI

Abstract Body: Ice cover on the Great Lakes is highly variable in both space and time, and poorly understood feedbacks between the lakes and atmosphere hinder our ability to predict fluctuations in water levels due to wintertime ice conditions. The economic costs of ice can be large, with an estimated shipping loss alone of $705 million in 2013-14. When ice is present, its cover is usually discontinuous with areas of exposed water in direct contact with the atmosphere. Using time-lapse photography and remote sensing, we detailed the development of ice formation on northern Lake Michigan, and related this to simultaneous direct measurements of the turbulent fluxes of sensible and latent heat using the eddy covariance approach. Footprint analysis of the area contributing to the turbulent fluxes together with the fraction of ice cover in the sampling area allowed us to examine the dynamic changes in sensible heat and evaporative water loss that occur as ice developed. Significant decreases in the sensible and latent heat fluxes occurred when an ice cover of 30% was achieved. Annually, compared to adjacent ice-sparse northern Lake Huron, ice resulted in a 43% reduction in the evaporative water loss, and a 57% reduction in the sensible heat loss.

Abstract ID: 33480

Final Number: H13C-03

Title: Elucidating the Primary Mechanisms Responsible for the Rapid Warming of the Laurentian Great Lakes

Presenter/First Author: Michael Notaro, University of Wisconsin-Madison, Madison, WI

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Co-authors: Yafang Zhong, University of Wisconsin Madison, Madison, WI; Stephen J Vavrus, Univ Wisconsin, Madison, WI

Published Material: We have not written a publication on these results yet. We presented the results at the 2014 AGU Fall Meeting. We were invited to submit an abstract for an invited talk by John Lenters.

Abstract Body: During the last three decades, the Laurentian Great Lakes have exhibited rapid warming, particularly the deep portions of Lakes Superior and Michigan. The fact that the lakes are warming more rapidly than air over nearby coastal regions is counterintuitive from the simple perspective of heat capacity. The summertime lake warming is characterized by a distinct step function jump between 1997 and 1998. The currently accepted paradigm for this rapid lake warming is the ice albedo feedback, triggered by a rapid decline in lake ice cover since the late 1970s. Here, we challenge this paradigm through the application of a high-resolution regional climate model, focusing specifically on the 1997-1998 transition as the primary cause for the long-term lake temperature trend. Through a series of carefully designed manipulation experiments, we decompose the relative contribution of antecedent wintertime lake conditions (e.g. lake temperatures, ice cover) versus synchronous, springtime-to-summertime large-scale meteorological forcings (e.g. air temperature, solar radiation) towards the abrupt lake warming from 1997 to 1998. Both the long-term trend (1979-pres.) and 1997-1998 transition are characterized by positive trends in 500-hPa heights, air temperatures, and solar radiation and negative trends in cloud cover during spring-summer across the basin. Over the deep lake areas, the amplified summertime warming of the lakes, compared to air, is largely attributed to antecedent warming of the wintertime lake temperatures and their subsequent support for earlier lake stratification. In contrast, the warming of shallow lake areas is primarily in response to large-scale meteorological drivers during spring-summer, namely greater solar radiation and air temperatures. Changes in winter-spring ice cover between 1997 and 1998 produce minimal impacts on the timing of lake stratification or subsequent summer lake temperatures, thereby challenging the existing ice albedo paradigm.

Abstract ID: 34991

Final Number: H13C-05

Title: The Great Lakes Evaporation Network (GLEN): More than just evaporation

Presenter/First Author: John D Lenters, LimnoTech, Ann Arbor, MI

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Co-authors: Peter Blanken, University of Colorado, Boulder, Boulder, CO; Christopher Spence, Environment Canada Saskatoon, Saskatoon, SK, Canada; Andrew Gronewold, NOAA Ann Arbor, Ann Arbor, MI; Branko Kerkez, University of Michigan Ann Arbor, Ann Arbor, MI; Norma Froelich, Northern Michigan University, Marquette, MI; Wendy Leger, , ,

Abstract Body: The North American Great Lakes constitute the largest freshwater surface in the world. Beginning in the late 1990s – a period that commenced with a strong El Niño event – the Great Lakes experienced a regime shift in winter ice cover and summer water temperatures that resulted in higher summer evaporation rates, followed shortly thereafter by a dramatic decline in water levels. Recent research suggests that evaporation rates over the lakes have, for the most part, remained high since then, due primarily to warmer summer water temperatures and an earlier start to the evaporation season. On the other hand, cold, high-ice winters such as 2013-14 cause occasional deviations from this trend, highlighting the large interannual variability in the Great Lakes system and the continued need for long-term observations. A growing ensemble of in situ measurements – including offshore eddy flux towers, buoy-based sensors, and vessel-based platforms – are being deployed through an ongoing, bi-national collaboration to reduce uncertainties in the Great Lakes water balance, provide a more robust basis for short- and long-term projections, and fill a significant gap in over-lake flux measurements and related meteorological data. Here, we provide an overview of this initiative, known as the Great Lakes Evaporation Network (GLEN). Although the network was initiated in response to the need for improved estimates of Great Lakes evaporation, it is intended to be of utility for a wide range of applied and basic research needs – not just evaporation and water levels. As such, we provide an overview of the latest data collection efforts, the current and planned array of instrumentation and platforms, and the network of heat, moisture, carbon flux, and meteorological observations that are likely to be of interest to research scientists, operational forecasters, commercial shipping, recreational boaters, and other stakeholders in the Great Lakes community.

Abstract ID: 35347

Final Number: H13C-06

Title: Recent advances in Environment Canada's modelling efforts in the Great Lakes

Presenter/First Author: Frank Seglenieks, Environment Canada, ,

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Co-authors: Vincent Fortin, Environment Canada Dorval, Dorval, QC, Canada; Dorothy A Durnford, Meteorlogical Service of Canada, Dorval, QC, Canada; Bruce Davison, Environment Canada, Saskatoon, SK, Canada; Erika Klyszejko, Environment Canada, Ottawa, ON, Canada; Murray MacKay, Environment Canada Toronto, Toronto, ON, Canada; Etienne Gaborit, Environment Canada Dorval, Dorval, QC, Canada; Milena Dimitrijevic, Environment Canada Dorval, Dorval, QC, Canada; Frederic Dupont, , , ; Stéphane Bélair, Environment Canada, Dorval, QC, Canada; Gregory C Smith, Environment Canada, Quebec, QC, Canada

Published Material: As this presentation will share results from many different researchers it is possible that some it may have been previously reported in scientific meetings or the media.

Abstract Body: The Laurentian Great Lakes are an important region of Canada both in terms of its natural resources and economic activity. Environment Canada has made this region a priority in its modelling efforts. In particular, Environment Canada has developed a coupled lake-atmosphere-hydrological modelling system consisting of the Canadian Regional Deterministic Prediction System (RDPS), which is based on the Global Environmental Multiscale model (GEM), the MESH (Modélisation Environnementale Surface et Hydrologie) surface and river routing model, and a hydrodynamic model based on the three-dimensional global ocean model Nucleus for European Modelling of the Ocean (NEMO) coupled to the Community Ice Code (CICE) see ice model.

Other modelling efforts in the region include: runoff comparisons with other agencies, short-term lake level forecasts, and examining effects of future climate forecasts on lake levels, streamflow, evaporation, soil moisture and snow water equivalent. This presentation will highlight the recent efforts by Environment Canada researchers to model the different aspects of the hydrological cycle within the Great Lakes.

Abstract ID: 36678

Final Number: H13C-07

Title: Streamflow Prediction in the Great Lakes Basin Using Two Watershed Discretization Schemes

Presenter/First Author: Amin Haghnegahdar, University of Waterloo, Waterloo, ON

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Co-authors: Bryan Tolson, University of Waterloo, Waterloo, ON, Canada; Eric D Soulis, University of Waterloo, Waterloo, ON, Canada; Etienne Gaborit, Environment Canada Dorval, Dorval, QC, Canada; Vincent Fortin, Environment Canada Dorval, Dorval, QC, Canada

Abstract Body: The North American Great Lakes are fundamental to the society, economy, and environment in the United States and Canada. Consequently, a proper management of the Great Lakes water system is crucial for both countries. Large-scale distributed physically-based models are one of the key tools used to inform policy makers for integrated and sustainable water and environmental resources management. Representation of the heterogeneity in nature remains one of the main challenges for these models and is accomplished primarily via watershed discretization. In this work two watershed discretization schemes are compared for the application of a semi-distributed Land Surface-Hydrological modelling system, MESH (Modélisation Environmentale–Surface et Hydrologie), in the Great Lakes Basin. One scheme is simpler neglecting the within pixel heterogeneity. The second scheme is more complex representing within pixel heterogeneity using spatial land cover info. These schemes are compared in terms of their skill to predict streamflow as well as their calibration cost. Results from this work enables MESH modellers to evaluate the gain in model performance by adding more info and computational time, and select the better one that suits their interest at the end.

Abstract ID: 35993

Final Number: H13C-08

Title: Closing the Gap Between the Geologic and Historical Records in the Laurentian Great Lakes by Providing the Most Detailed Account of Paleo Lake Level, Ranging from Decades to Five Millennia.

Presenter/First Author: John W Johnston, University of Waterloo, Waterloo, ON

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Co-authors: Kenneth E Lepper, North Dakota Univ, Fargo, ND; Erin Argyilan, Indiana University Northwest, Gary, IN; Douglas A Wilcox, , , ; Steve J Baedke, James Madison University, Harrisonburg, VA; Todd A Thompson, , ,

Published Material: A portion was recently published in a scientific journal: Johnston. J.W., Thompson, T.A., and Wilcox, D.A. (2014) Paleohydrographic reconstructions from strandplains of beach ridges in the Laurentian Great Lakes, in Martini, I. P., and Wanless, H. R., eds., Sedimentary Coastal Zones from High to Low Latitudes: Similarities and Differences: Geological Society, London, Special Publications, 388, 213-228. http://dx.doi.org/10.1144/SP388.22

Abstract Body: The current temporal and spatial context of water-level change, drivers of change, and possible future scenarios of the Laurentian Great Lakes is controversial. Paleohydrographs are being constructed from measured subsurface elevations of paleo-swash zones and modelled ages in strandplains of beach ridges that are preserved in embayments along the margins of the lakes. More than 800 elevations and 200 ages have been collected from 15 strandplains to construct site-specific strandplain paleohydrographs. Paleo shoreline elevations from whole strandplains or sets of correlative paleo-beaches within strandplains are then used to establish an outlet paleohydrograph for each lake. Adjusting strandplain paleohydrograph elevations to account for glacial isostatic adjustment (GIA) and refining age models help define the outlet paleohydrograph. This iterative approach helps identify common basin-wide water-level patterns and changes in outlet location or conveyance. Systematic patterns of elevation and geomorphic/sedimentologic properties in individual, groups and sets of beach ridges in strandplains suggest that long-term patterns of water-level change and sediment supply occurred on decadal, centennial, and millennial scales. Current data from strandplains of Lake Huron are being compared to data from Lake Michigan (Baedke & Thompson 2000) to produce an outlet paleohydrograph representative of this large hydraulically connected lake. Comparison with the outlet paleohydrograph of Lake Superior (Johnston et al. 2012) will help to decipher a more accurate understanding of GIA, water-level fluctuations, and outlet conveyance. These refinements are expected to complement the instrumental lake-level record back through time. The extended record can then be used to augment knowledge of natural (climate-driven) fluctuations and, thereby, to contribute to the effective management of the largest fresh, surface-water system in the world.

Abstract ID: 34233

Final Number: H13D-01

Title: Regional Analysis of Baseflow Contribution to the Grand River, Ontario, Canada

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Published Material: Journal of Hydrologic Engineering; published in fall 2014

Abstract Body: With uncertainty surrounding long-term projection of in-stream flow needs, baseflow estimation is an increasingly important component of hydrology and hydrologic modelling. With several methods available to chose from, it is important to understand the advantages and disadvantages of traditional and newer methods of baseflow recession analysis. Operationally, recursive digital filtering (RDF) techniques are commonly applied; however, questions have been raised about the reliability and parameterization of these methods. A comparison of three baseflow separation methods is performed, including two popular RDFs (HYSEP and BFLOW) and one hydrologic model (WATFLOOD). The methods are applied to two baseflow dominant sub-basins of the Grand River Basin in southern Ontario, Canada. The Eramosa River and Whiteman's Creek sub-basins are similar in size (236 and 383 km^2, respectively) and have similar annual runoff distributions, yet significantly different physiography governing runoff generation. Sub-basin physiographic characteristics result in significant differences in annual baseflow distributions, and stable water isotopes (SWIs) are applied for verification of baseflow contribution. Results are shown to support the application of SWIs for regional hydrograph separation and highlight the need for more efficient, yet physically-based baseflow separation in regions with complex physiography.

Abstract ID: 35221

Final Number: H13D-03

Title: Human impacts on the carbon cycle of large river basins in boreal rivers of eastern Canada

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Abstract Body: Carbon sources and cycling in boreal environments are currently the focus of a growing number of investigations in Eastern Canada, mainly beacause of the importance of hydropower and its potential in this region. Here, we investigate inorganic and organic carbon cycling in large eastern canadian river basins. Some of these rivers are impounded (La Grande 3400 m^3/s, Eastmain, St. Lawrence 12 100 m^3/s, Ottawa 1950 m^3/s and Nelson 2370 m^3/s) and some a pristine (Great Whales 680 m^3/s and Koksoak) river systems. These major rivers were sampled monthly at their outlet for at least one year. The St. Lawrence River has been under investigation since June of 1997 on a bi-weekly basis. Also, synoptic surveys were undertaken in August 2008 on the La Grande and Great Whales Rivers. At each visit, physico-chemical parameters were measured and samples were collected for the analysis of i) major ions concentrations; ii) $\delta^{13}C$ of dissolved inorganic and organic carbon as well as particulate organic carbon (respectively DIC, DOC and POC); iii) $\delta^{18}O$ and $\delta^{2}H$ of the water molecule; and iv) radio-isotopes (Uranium series and Strontium). In all the sampled river systems, POC concentrations were at least an order of magnitude smaller than the dissolved forms. As a result, the dissolved forms will be the focus of this investigation. Rivers draining carbonates (St.Lawrence and Nelson Rivers) present higher DIC concentrations and higher ⍰^{13}C in DIC, in response to the dissolution of soil carbonates. DOC/DIC ratios above 2.4 are observed in rivers draining silicates; their lower ⍰^{13}C-DIC content directly reflects the organic matter oxidation in soils. However, the DIC isotopic composition of impounded rivers draining silicates reflects both the organic oxidation origin of DIC and CO_2 degassing along the reservoir. The striking feature of this boreal data set is the homogeneity of the isotopic composition of DOC (-27.4±0.2‰ vs V-PDB). Moreover, C:N ratios and ^{14}C activity (A^{14}C) of bulk dissolved organic matter (MOD) measured in the La Grande River reveal that this most of the DOC is relatively fresh and young (A^{14}C higher than 100% MC).

Abstract ID: 36699

Final Number: H13D-04

Title: Controls of longitudinal variation in $\delta^{13}C$-DIC in rivers: A global meta-analysis

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Published Material: These findings are in review in the journal Ecosystems.

Abstract Body: Gas exchange between the water and the atmosphere strongly influences the $\delta^{13}C$ signature of the inorganic carbon pool in large rivers. Because the $\delta^{13}C$ signature of DIC at isotopic equilibrium with the atmosphere ($\delta^{13}C\text{-}DIC_{equilibrium}$) is dependent on pH and temperature, we were interested in determining if these physicochemical variables could be used to generate an isoscape, or a map of the stable isotope variation in DIC, in rivers. We conducted a literature survey to examine the relationship between $\delta^{13}C$-DIC and $\delta^{13}C\text{-}DIC_{equilibrium}$ in rivers throughout the world. We then used generalized additive mixed models to investigate if deviations from $\delta^{13}C\text{-}DIC_{equilibrium}$ ($\delta^{13}C\text{-}DIC_{disequilibrium}$) and $\delta^{13}C$-DIC in lotic ecosystems were related to ecological variables including the partial pressure of dissolved CO_2, elevation, and Strahler order. To evaluate if carbonate weathering or groundwater inflow was responsible for longitudinal variation in $\delta^{13}C$-DIC, we compared within-river trends in weathering products and groundwater inflow with within-river trends in $\delta^{13}C$-DIC in the main stem of 18 of the rivers. For more than 99% of the samples, DIC was more depleted in ^{13}C than $\delta^{13}C\text{-}DIC_{equilibrium}$. The GAMMs revealed that, whereas morphometric variables (elevation, Strahler order) explained a large fraction of the variation in $\delta^{13}C\text{-}DIC_{disequilibrium}$, morphometric and geochemical variables (DIC, pH, pCO_2) explained a large fraction of the variation in $\delta^{13}C$-DIC. In all rivers with limited groundwater inputs, headwaters were isotopically heavier than downstream reaches, suggesting greater inputs of DIC from groundwater than from terrestrial ecosystems. Rivers with groundwater inflow in both upper and lower reaches had higher rates of change in $\delta^{13}C$-DIC than rivers where groundwater inflow was limited to lower reaches, indicating that rivers with groundwater inputs in headwaters will be more suitable for use of $\delta^{13}C$ in analyses of the spatial ecology of consumers.

Abstract ID: 36715

Final Number: H13D-06

Title: Carbon isotopic ratios reveal complex strategies in the use of the hydrological network by fish in a large river ecosystem

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Abstract Body: By reducing the connectivity within large river systems, dams perturb the completion of the life cycle of many mobile organisms that depend on upstream tributaries not only to reproduce but also to feed on alternate food sources. The isotopic signatures of sessile organisms, such as invertebrates, can be used to map the isotopic baselines or "isoscapes" of river systems, against which fish isotopic ratios can be compared for evidence of sendentarity or movement. Here we exploit the clear distinctiviness in carbon isotopic ratios of inorganic and organic fractions from a large tributary of the St-Lawrence River Canada compared to the river main stem to track throughout the year the movements and feeding in nine species of potentially highly mobile fish. Carbon isotope data of fish muscle tissues allowed us to identify three general migration patterns and sources of productivity in this large river system. Our study offers a better understanding of fish movements in large rivers, providing a tool to predict with more confidence the possible impacts of dam building projects on fish assemblages.

Abstract ID: 36635

Final Number: H14A-0184

Title: *Transport of oil sands process-affected water from tailings sands to a constructed fen peatland*

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Abstract Body: Reclamation of the Athabasca oil sands region requires the reconstruction of fen peatlands in which mine waste materials (e.g.,petroleum coke and tailings sand) and salvaged reclamation materials (including peat) are commonly used. Tailings materials used to construct the upland areas that provides water to a constructed fen on the Suncor Energy lease have elevated concentrations of sodium (Na) and Naphthenic acids (NAs) being transported into the fen via a permeable layer beneath the peat. Peat (2 m thick) is expected to disperse and adsorp Na and NAs moving upwards through the peat profile. Water chemistry samples taken in 2013 and 2014 indicate the presence of Na and NAs at the base of the peat profile, and little in the rooting zone. For example, in 2013 Na concentrations averaged 314 mg/L in the upland (tailings sand) and 121 mg/L, 78.5 mg/L, and 87.3 mg/L in the fen peat at 150, 90, and 50 cm depths, respectively. In 2014, Na concentrations averaged 154.6 mg / L in the upland and 109 mg/L, 70.6 mg/L, and 82.1 mg/L in the fen at comparable depths, which indicates that Na present in the system was diluted. However, in 2013 NAs concentrations averaged 24.1 mg/L in the upland and 12.5 mg/L, 1.19 mg/L, and below detection in the fen at 150, 90, and 50 cm depths, respectively, generally increasing in 2014 to 26.8 mg/L in the upland and 11.1 mg/L, 5.47 mg/L, and 1.23 mg/L in the fen at comparable depths. The different behavior of Na versus NAs may be a result of NAs moving through “windows” faster than the mean rate; further assessment is required to understand this.The success of future reclaimed fen peatlands depend on designs accounting for the management of water quality. Further monitoring is required to characterize the rate of solute movement.

Abstract ID: 36183

Final Number: H14A-0185

Title: Assessment the pools and potential redistribution of sodium in a constructed fen peatland system

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Abstract Body: A constructed fen peatland on a post-mined oil sands landscape in northern Alberta incorporates materials from the mining site into the constructed system. Peat is used for the fen, tailings sand is used for the upland and petroleum coke is used for a high permeability connecting basal layer. The use of these byproducts of oil production requires an understanding of the transport and attenuation mechanisms of potential solutes they may contain such as sodium (Na), since they may impact the plants and microbial community of the fen. To meet this goal we need a prior understanding of the type of solutes, their concentration and movement. We believe sodium (Na) to have the highest potential toxicity to plants. Material digestion results indicate that following construction peat contained the highest concentration of Na (445 mg/kg) compared with coke (215 mg/kg) and sand (80 mg/kg). However, results of a batch experiment showed that peat has the lowest range of available Na of the building materials examined. Using the results a mass balance of Na was done and the calculations indicate that a large pool of available Na exists in the created upland. This pool, which through groundwater flow is directed to the peatland, exceeds the adsorption capacity of the peat. If the outflow of Na in surface runoff from the fen is limited, as is expected, Na is likely to accumulate in the fen over the short- and medium-term, with implications for vegetation succession.

Abstract ID: 34585

Final Number: H14A-0186

Title: A Comparison of Soil Nitrogen Availability Between a Post Mined Reclaimed Wetland and Two Natural Wetlands in Fort McMurray, Alberta.

Presenter/First Author: Chelsea Thorne, McMaster University, Hamilton, ON

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Abstract Body: In situ measurement of soil nitrogen dynamics is a potential method for evaluating the health of constructed wetlands following oil sands mining. The objective of this study is to measure and compare the soil nitrogen availability of a reclaimed fen (Sandhill fen) with a nutrient-rich reference fen (Poplar fen) and a nutrient-poor reference fen (Pauciflora fen) in the Athabasca oil sands region of Northern Alberta. TIN, NO_3^-, and NH_4^+ supply rates were determined along hillslope-wetland transects using Western Ag Innovations Plant Root Simulator (PRS) probes at all three sites in 2014. Net N mineralization was determined simultaneously using the buried polyethylene bag approach. Overall, TIN supply rates were greatest at the poor fen and least at the constructed Sandhill fen. In contrast, net mineralization was greatest at the rich fen but again least at the Sandhill fen. Relatively low N supply rates and net mineralization at the Sandhill fen were likely due to lower soil organic matter content and limiting soil moisture in these newly constructed substrates. Spatial differences along the hillslopes also varied among sites. The Sandhill fen had higher TIN supply rates upslope but no differences in net N mineralization rates. The rich fen also had higher TIN supply rates upslope but greatest net mineralization rates downslope. Furthermore, the nutrient rich site exhibited a strong negative correlation between NO_3^- supply and net N mineralization, which contrast the measurement approaches. These results highlight the importance of N storage and transport processes and offer insight into the N processes of a constructed fen.

Abstract ID: 34577

Final Number: H14A-0187

Title: Understanding Flow Pathways, Major Chemical Transformations and Water Sources Using Hydrochemical and Hydrometric Data in a Constructed Fen, Fort McMurray Alberta

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Abstract Body: Bitumen extraction in the Athabasca oil-sands from open-pit mining creates significant landscape disturbance of wetland and forest ecosystems that must be returned to pre-equivalent capability, as required by Albert legislation. To date, reclamation activity has focused on upland ecosystems with more limited efforts on wetland and peatland ecosystems. Syncrude Canada Ltd. has constructed a 52 hectare upland-wetland system, the Sandhill Fen Watershed (SFW), to advance understanding on wetland reclamation strategies. The objective of this research is to identify and understand the sources, flow pathways and major chemical transformations of water as it moves throughout SFW. Surface and pore water samples from >20 well locations within SFW were analyzed for major chemical ions and oxygen and hydrogen stable isotopes. In addition, high frequency measurements of specific conductivity were recorded at 10 well locations to map salinity variability and how the SFW responsds to environmental changes. Stable isotopes have identified the source waters in SFW based on the dinstict signatures of input waters and the local meteoric water line. Major ion data has categorized the hydrochemical facies existing in the surface and subsurface waters of SFW and thus classifying areas with similar water composition. In addition, sodium adsorption ratios were evaluated to highlight areas where there is cation exchange between calcium and sodium, which is critical information for the success of vegetation. Major ion concentrations vary throughout SFW with values ranging from 100-500 mg/L and 50-650 mg/L for Ca and Na, respectively. Specific conductivity is also highly variable between the uplands and lowlands with values ranging from 1500-4000 µS/cm and 1000-2500 µS/cm. Collectively, the data provides insight to water sources, flow pathways and chemical changes within SFW, and provides insight into future evolution of the watershed.

Abstract ID: 35523

Final Number: H14A-0188

Title: Microfossil Biomonitors of Reclamation Success

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Published Material: GAC 2014 Fredericton abstract, but more data now available.

Abstract Body: Microfossils record various types of anthropogenic impact, from siltation and eutrophication associated with indigenous people to the increase in toxic chemicals associated with urbanization and industrialization. In addition to documenting anthropogenic impact, microfossils can be used to assess the success of mitigation and reclamation studies. The fossil remains of organic-walled algae (e.g., dinoflagellate cysts and desmids) record much more hospitable conditions in a Sustainable Lake South (Pond 15 in the Suncor Experimental Wetlands) than in the adjacent Sustainable Lake North (Pond 14). Similarly, the testate amoeba (thecamoebian) fauna in Pond 15 is more diverse, whereas Pond 14 contains almost exclusively hardy centropyxid taxa. This is attributed to the amendment of Pond 15 by nutrients, notably phosphorus, which appears to have speeded up the reclamation process. Microfossils are thus useful biomonitors of reclamation success, and based on the more diverse algal and protozoan communities in the pond that received phosphorous over a several year period, this appears to be a useful reclamation strategy.

Abstract ID: 33121

Final Number: H14A-0190

Title: Introduction to Soil Bioengineering Applications for Mining Reclamation of Re-Constructed Waterways within Alberta Oil Sands Overburden Mine Dumps

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Abstract Body: In 2003 a waterway swale was retrofitted into an Alberta oil sands overburden dump. The swale has an average gradient of 4 degrees and is approximately 600 m long and 30 m wide from ridge to ridge with a depth ranging from 2 to 4 m. It is composed of two lateral swales connecting onto the main swale and has a catchment basin of approximately 32 ha. The substrate consists of muskeg placed over clay capping and oil sands tailings.

In spring 2004 an erosion control prescription using a soil bioengineering approach was implemented. It consisted of the following: brush sills installed across the swale, smaller diameter cuttings installed in the middle of each sill to improve water dispersion and the planting of live stakes. Contour fascines were also installed across the swale, in two locations above the brush sills, as a trial. After 5 years the findings of this trial site were reviewed and the soil bioengineering design was adjusted and applied to the implementation of two additional swales in 2010.

Lessons Learned

Brush sills result in channel erosion. When combined with accumulated organic debris this results in falling water or a hydraulic jump and the creation of splash erosion. The use of contour fascines, without brush sills, appears to be diffusing water instead of creating channels and splash erosion. Wetland species were established as a result of seeds germinating from within the seed bank of the applied muskeg and a wetland was created. This approach allowed for the establishment of riparian herbaceous, shrub and tree species, recreating habitat on disturbed land.

Based on these findings, trial sites using large diameter (30 cm) contour fascines were established in the spring of 2010 over two newly constructed swales within an overburden mine dump. These trial sites were monitored until the fall of 2014 and assessed as excellent. This approach is now being considered for use as a template for mine closure on reconstructed waterways of mine dumps.

Abstract ID: 36502

Final Number: H14B-0192

Title: Quantifying the Link Between Hydrological Connectivity and Taxa Requirements in the Development of a Sustainable Environmental Flows Strategy for the Grand Lake Meadows Wetland, New Brunswick, Canad

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Abstract Body: Understanding the physical and biological mechanisms that contribute to flow-ecology relationships is a critical goal in the development of environmental flows frameworks. As one of the largest freshwater wetlands in Atlantic Canada, the Grand Lake Meadows (GLM) wetland (~116,000 ha) is a significant ecological and cultural habitat between Grand Lake and the mainstem Saint John River (SJR). However, the flow of the SJR is highly regulated with over 200 flow control structures along both the tributaries and mainstem leading to varying temporal and spatial lateral connectivity. The nearest flow impediment on the mainstem upstream of the GLM is Mactaquac Dam (MD), which is also one of the largest flow-regulating structures in the SJR system. Changes to the structure or operation of MD have the potential to modify both aquatic and terrestrial habitats upstream and downstream and significantly affect the hydrological connectivity with the GLM. Here we present a preliminary data analysis exploring the relationship between the ecological community and the hydrological connectivity between the mainstem and wetland habitat using statistical-, GIS- and literature review-based information. In addition, we combine water level data and GIS information to illustrate a case study focusing on dragonfly species-at-risk, which require both the riverine and wetland habitat to complete their life cycle. These data provide the base for the preliminary environmental flows framework for the wetland highlighting the importance of a critical and quantified evaluation of the habitat suitability and connectivity requirements for the aquatic community.

Abstract ID: 33242

Final Number: H14B-0193

Title: Groundwater Exploration in the Pru District of Ghana using1D and 2D Electrical Resistivity Methods

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Published Material: The paper was presented at African Geoscience Students Conference 2014 at Kwame Nkrumah University of Science and Technology, Kumasi - Ghana. The paper has not yet been published, I am now looking for a geoscience journal to send for review.

Abstract Body: Integrated geophysical techniques involving 2D electrical resistivity tomography (ERT) and vertical electrical sounding (VES) were used to delineate groundwater potential zones for borehole siting in the Pru District of the Brong-Ahafo Region of Ghana. The ABEM Terrameter LS was employed in the survey. A total of fifteen (15) 400m-ERT profiles and thirty-one (31) VES points were investigated using the Schlumberger protocol. The Res1DINV and Res2DINV inversion software were used for the data analysis. The results of the VES generally revealed either three or four subsurface geological layers at the selected points. The second and third layers were found to possess relatively low-to-moderate resistivity values indicative of potential aquifer zones. The resistivity of the fourth layer indicated the presence of slightly-fractured to fresh bedrock. The fractured zones at the selected points are expected to be intercepted from within 20 to 80 m depth to yield water during borehole drilling.

Abstract ID: 33120

Final Number: H14B-0195

Title: Changing Climate and Altering Hydrological Regime - A Case from Karnali River Basin of Nepal Himalaya

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Abstract Body: Global climate change has local implications. Focusing on datasets from the Karnali river basin in western Nepal of Himalayan region, this research provides an overview of hydro-climatic changes that have been observed during 1981-2012. The spatial and temporal trends of temperature and precipitation from 32 meteorological stations distributed in the basin were analyzed. River discharge and precipitation observation are studied to understand the rainfall-runoff relationship. The non-parametric Mann-Kendall test and Sen's methods were used to study trend in climate data. Results show that the average precipitation in the basin is decreasing by 4.36 mm/year. However, the precipitation trend in monsoon season over mountain region is increasing significantly. Increasing trends were observed for both minimum and maximum temperature. The peak discharge (August) is found to be a month later than the peak precipitation (July) over the basin. Annual precipitation amount is decreasing but the river discharge is found to be significantly increasing.

Abstract ID: 34176

Final Number: H14B-0196

Title: Plant Enhanced Bioremediation Of BTEX Contaminated Groundwater Using *Canna Generalis*

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Abstract Body: Occurrence of groundwater contamination by BTEX (Benzene, Toluene, Ethyl benzene and Xylene) arises from leaking underground storage tanks and accidental spills.These compounds can be a long term source of pollution to down gradient receptors.The most suited environmentally benign option to remove these contaminants from soil-water systems is bioremediation. These contaminants get biodegraded by indigeneous microorganisms but the process of natural bioremediation is quite slow.Constructed wetlands which have been used widely for secondary treatment of wastewater containing organic pollutants could enhance the rate of bioremediation of BTEX. This study utilizes the plant *Canna Generalis* grown hydroponically in pot-scale gravel beds to investigate its potential for enhanced bioremediation of groundwater contaminated with toluene.Preliminary batch experiments were used for quantifying the biodegradation rate of toluene in contaminated groundwater. Toluene uptake was quantified experimentally and numerically under controlled conditions using wetlands with and without shoot biomass, along with unplanted gravel bed. The residual toluene concentration in the wetlands was measured for one week using gas chromatography.Daily evaporation and evapotranspiration was also measured in the wetlands.The difference in the mass balance calculations was accounted for contaminant loss due to plant uptake, biodegradation and evapotranspiration processes. The total time required for biodegradation of toluene was found to be lowest in the wetland with shoot biomass followed by wetland without shoot biomass and unplanted gravel bed. The cumulative uptake of toluene in the shoots was observed to rise rapidly before it reached a peak value. Continuity equation integrated with active plant uptake kinetics was used for simulating the residual concentration of toluene in the wetlands. The simulated results were compared quite well with the observed data for the entire period of the experiment. Sensitivity analysis suggested that the residual toluene concentration was more sensitive to biodegradation rate constant (K_1) as compared to diffusion rate constant (D_r) for both the wetland cases. These results can be used to frame in-situ plant-assisted bioremediation techniques for BTEX contaminated sites.

Abstract ID: 36743

Final Number: H14B-0197

Title: The Geochemical Responses Of Small Tundra Lake Catchments To Landscape Perturbation, Upland Region North-East of Inuvik, Northwest Territories

Presenter/First Author: Erika C Hille, University of Victoria, Victoria, BC

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Published Material: The results presented in this poster were used in my MSc thesis. Preliminary results from this study were also presented at the ArcticNet ASM (2010, 2013) and the IPY Arctic Change Conference (2012).

Abstract Body: The overall goal of this study was to examine the geochemical linkages between the contributing catchment and lakes affected by shoreline retrogressive thaw slumping (SRTS) in Northwestern Canada. Detailed geochemical data was obtained from a pair of representative small tundra lake catchments (Control vs Affected by SRTS), supplemented with less detailed data obtained from 10 regional small tundra lake catchments. The concentration of major ions and nutrients in the study lakes exhibited strong seasonal variability. The concentration of major ions and nutrients increased over the winter months due to the processes associated with ice formation, then decreased at the onset of spring snow and ice melt in response to melt water inputs and dilution. Notably, the concentration of nutrients increased at the beginning of spring melt, which was attributed to the mobilization of surficial organic materials by runoff, but then decreased as the spring months progressed and runoff to the lake became more diluted. With the exception of rainfall events, the concentration of major ions and nutrients in the lakes increased over the open water period due to the addition of relatively ion-rich runoff and concentration via evaporation. In the control lakes, the concentration of most major ions and nutrients decreased during heavy rainfall events in response to the addition of relatively dilute landscape runoff. Notably, the concentration of major ions in SRTS-impacted lakes increased during summer rainfall events. In addition to landscape-level hydrological processes, the concentration of major ions in the study lakes was driven by SRTS. The concentration of major ions was significantly higher in the SRTS-affected study lakes than in the unaffected study lakes due to the addition of relatively ion-rich runoff from SRTS-affected terrain during the spring and summer months. Interestingly, SRTS had no significant effect on the concentration of nutrients in the study lakes.

Abstract ID: 33149

Final Number: H14B-0198

Title: Analysis of Extreme Climate Events in the Volta River Basin

Presenter/First Author: Fati Aziz, Department of� Disaster Prevention and Mitigation, Takoradi,

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Co-authors: Emmanuel Obuobie, CSIR Water Research Institute, Accra, Ghana

Abstract Body: Countries which share the Volta River Basin in West Africa recorded significant impacts arising from extreme events especially in the late 20th century. This study analyzed changes in temperature and precipitation extremes over the Volta River Basin using the RClimdex software. The data used included observed daily records of precipitation and maximum and minimum temperatures for the period 1981-2010 derived from meteorological stations located within the basin. Indices relevant for the region were selected out of the 27 key indices for Climate Change detection settled on by the Expert Team on Climate Change Detection and Indices (ETCCDI) and used for our analysis. Results obtained from such simple analysis provide a basic and first step to understanding how climatic extremes have been changing in the Volta Basin region. It also serves as a basis for further detailed analysis to help in the development and adoption of management practices for the sustainable development of water resources in the Volta Basin under changing conditions.

Abstract ID: 33348

Final Number: H14B-0199

Title: Examination of Field Scale Hydrological Processes Under Three Different Tillage Methods in Southern Ontario: Conventional Till (CT); Modified Till (MT); and No Till (NT)

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Abstract Body: In the wake of the severe algal blooms of 2011 and 2013 in the Great Lakes, international governing bodies such as the United Nations, are advocating for increased studies on nutrient dynamics within agricultural systems. Understanding farm contributions to nutrient loads entering the Great Lakes involves quantifying nutrient export from different tillage practices common in the Great Lakes basin, which include no-till (NT), conventional till (CT) and modified tillage (MT). Understanding differences in nutrient export from different tillage practices may well be related to structural differences in the upper portion of the vadose zone which impact infiltration, soil moisture and overall effectiveness of artificially draining cultivated fields by tiles and exporting nutrients to surface water bodies. Added to the importance of understanding how different tillage practices impact hydrology and the efficiency of exporting of nutrients to surface water bodies is how present increased year-to-year climatic variability and future climate/hydrological change will impact these systems. This study examines the hydrological balances within three ~.6 ha tiled plots each with different (NT, CT, MT) tillage practices but common soil type, nutrient application, cultivated crop, and precipitation patterns.

Abstract ID: 33714

Final Number: H14B-0200

Title: Advancements in Tracer Dilution Gauging: Quantifying Uncertainties in Streamflow Data

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Abstract Body: In the last decade, there has been increasing attention within both the operational and research communities to quantify the uncertainties in streamflow data. Dilution gauging via stream tracers (dominantly salt or Rhodamine dye) can be a powerful tool for measuring stream discharge or exploring solute dynamics, especially in steep, rough streams that cannot be gauged using the area-velocity method. However, many questions involved in the technique remain unresolved despite decades of usage in research and industry: (1) for salt dilution gauging via injection of dry salt, what is the most accurate and robust approach to calibrating the relation between salt concentration and electrical conductivity, (2) to what extent does the calibration factor vary with background water chemistry, (3) for gauging with Rhodamine WT, what is the effect of sorption to suspended sediment, (4) can mixing lengths be predicted from geomorphic properties of the stream channel, and (5) how sensitive is the integral of the salt breakthrough curve to location along or across the channel? These questions were addressed through a combination of field work conducted at mountain streams in southwest British Columbia and controlled laboratory studies. Based on the results, recommendations are made for best practices to ensure accuracy and robustness of streamflow measurements.

Abstract ID: 33717

Final Number: H14B-0201

Title: Understanding the Spatial anisotropy of Daily Rainfall using Radar Information

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Abstract Body: Spatial variability of rainfall has been recognised as an important factor controlling the hydrologic response of catchments. However, gauged daily rainfall data are often available at scattered locations over the catchments. The current research is looking into how to capitalise on the spatial structure of radar rainfall data for improving Kriging interpolation of the limited gauge data over catchments at 1 km^2 grid scale. 114 gauged stations within a 128km x 128km region of Brisbane (Mt Stapylton), Australia, radar field were used for the case study. Correlograms, the backbone of Kriging interpolation methods, were developed using a Fast Fourier Transform method on the Gaussianised radar and gauged data. It is observed that the correlograms vary from day to day and display significant anisotropy. For the radar data, locally varying anisotropy (LVA) was examined by developing the correlogram centred on each pixel and for different radial distances. Leave one out cross validation was carried out using the empirical correlogram tables as well as different fitting strategies of a two-dimensional exponential distribution for both the gauged and the radar data at the gauged locations. Results indicate that the correlograms based on the radar data outperforms the gauged ones as judged by statistics including mean-square-error, mean-bias, mean-absolute-bias and mean-standard-deviation. While the radar data display significant LVA, it was observed that LVA did not significantly improve the estimates compared with the global anisotropy. Ongoing research is generating large ensembles over the 128km x 128km region to be used for evaluation of the different correlograms where LVA is expected to outperform the global one.

Abstract ID: 35274

Final Number: H14B-0202

Title: Hydraulic behavior of a fractured massif

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Abstract Body: A set of hydraulic test were performed along "La Linea Tunnel" in Los Andes Mountain (Colombia), in order to establish the changes in the interaction among groundwater, surface water and civil work. This research is focused on the analysis of the hydraulic tests performed in 20 boreholes between 9 and 10 m length with dip among 10° and 50° were drilled in the massif. The latter is composed by two main geological groups of rocks. The first one is igneous and the second one is metamorphic. Whole massif is highly fractured and was traversed by means of a tunnel of 8200 m length with a variable depth between 100 and 800 m from surface. Nine fault zones are traversed; most of them are related with some creek in surface whose flows have diminished since the tunnel was built.

Fractured-rocks have spatially and temporally variability in the hydraulic parameters. This is generally attributed to fracture intensity and connectivity. In consequence, boreholes were located closed to fracture zones. 16 hydraulic tests were performed to characterize hydrogeological parameters. Well-tests were analyzed via diagnostic plots of both, drawdown and its derivate versus time using AQTSOLVE.

Most of the tests show combined effects. For early times a double porosity effect is shown followed by a constant drawdown which derivate declines to zero. This response appears to be due to dewatering of the fracture.

However, diagnostic plot for two tests indicate a vertical fracture of infinite conductivity. This is consistent with their location, where the highest part of the mountain crossed by the tunnel is found. The tests show that of fractures define the hydraulic behavior of the massif. Additionally, this test let us know the dimension of the flow. In this case, the flow is quasi-2D (almost radial).

In contrast, other tests (where top of the mountain is near) achieve steady state in late time. It means that the massif is dewatered but those tests do not allow to estimate the flow dimension.

Abstract ID: 34336

Final Number: H14B-0203

Title: Paleoflood History of an Oxbow Lake in the Désert River Catchment Area, Southwestern Québec, Canada

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Co-authors: Andre E Viau, University of Ottawa, Ottawa, ON, Canada; Jean Bjornson, , ,

Abstract Body: Most paleoflood reconstructions come from the arid dry climate of southwestern USA and in Europe with few studies being conducted in temperate climates of North America. In this study we show that oxbow lakes can be used to reconstruct past flood events in temperate regions. Sediment cores extracted from an oxbow lake along the Désert River in southwestern Québec, Canada were analyzed for magnetic susceptibility, loss-on-ignition and grain-size. Results show a strong relationship between past flood events and known climate variability on multi-decadal to centennial timescales over the past 1650 years. Higher frequencies of floods were observed during the Little Ice Age (LIA; 1450-1850 AD) and the Dark Ages Cold Period (DACP; 300-800 AD) known to have been more humid than the Medieval Warm Period (MWP; 900-1200 AD). This study provides evidence to support the use of oxbow lakes in temperate regions as a proxy of past hydroclimatic changes on regional scales, thus leading to a better understanding for future floods under a changing climate.

Abstract ID: 34608

Final Number: H14B-0204

Title: Climatic Controls of Low Water Levels on the Mackenzie River Mainstem, Summer and Autumn, 2014.

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Abstract Body: The Mackenzie River serves an important transportation role for communities along its valley and in the western Canadian Arctic. Annual transportation by barge represents the only way to get large and heavy items to many northern coastal communities. In the case of one of the major tug and barge operators in Northwest Territories, freight is trucked to Hay River and then barged from Great Slave Lake to the Beaufort Sea. In some years water levels along the river are low, which can present navigational problems. Operators often insert their own routing marks and water level gauges along the river using charts and experience accumulated over many years. In most cases, however, because the river bed morphometry can change relatively rapidly, charts do not necessarily keep pace, which leaves operators relying on their own skill and experience. Water levels on the river are controlled by a combination of: direct runoff from snowmelt and rainfall events within its watershed, stored runoff accumulated in the large lakes, and water released from regulated watersheds (ie Peace River headwaters) that feed the Mackenzie. When viewed as a function of seasonal atmospheric forcing, weather events or non-events, such as lack of precipitation, can occur in different areas within the Mackenzie's large collection area and exert an impact on navigable water levels, and it is likely that all three elements of water level control must be in phase for a large water level anomaly to result. The 2014 season was of particular note; operators on the Mackenzie River mainstem indicated that summer water levels were some of the lowest they had observed in many years. This in turn resulted in serious delivery difficulties for communities and shippers in the Beaufort Sea region, including lost perishable supplies when a shipment had to be dropped at the shore 100 km away from the town it was destined for, and increased numbers of trips required, forced by lower cargo capacities resulting from reduced potential barge draft. This paper will present a preliminary overview of climatic and hydrological drivers for the observed 2014 low water levels along the Mackenzie River using the framework of the control mechanisms identified above. Focus will center on the Mackenzie River mainstem from Great Slave Lake to the Delta.

Abstract ID: 34755

Final Number: H14B-0205

Title: Dynamic Fractional Wettability During Infiltration of Water, Ethanol, and Aqueous-ethanol Solutions in Post Wildfire Soils.

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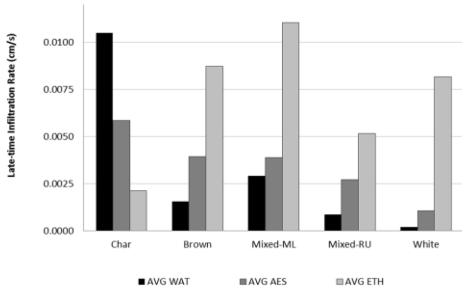
Published Material: Some data and findings were reported in a Journal of Hydrology paper, in 2014, accepted. Beatty, SM and Smith, JE (2014). Infiltration of water and ethanol solutions in water repellent post wildfire soils. Journal of Hydrology, 514, 233-248.

Abstract Body: Soil hydrophobicity or soil water repellency is an emerging area of interest across a wide scope of research disciplines that includes hydrology, soil physics, wildfire, agriculture, geochemistry and geomorphology. Often treated as a near-surface phenomenon, reduced wettability soils can generate substantial impacts on soil hydraulic properties and infiltration behaviours, and have larger scale implications on groundwater fluxes and overland flow. There is growing consensus that many soils exhibit complex wettabilities, with soil matrices being comprised of particle fractions that exhibit a range of contact angles which can change over time. To help develop mechanistic insight in such systems, this work presents a combination of *in situ* field (3D) and laboratory (1D) experimental data collected in naturally repellent post wildfire soils using tension infiltrometers (4.4cm and 8cm, respectively) and different infiltrating fluids. Forty nine infiltration tests were conducted in the field, and 20 column experiments were conducted in the lab using water, ethanol, and Molarity of Ethanol Drop (MED)-derived aqueous-ethanol solutions. By experimentally eliminating positive pore-water pressures through tension infiltration, observations of infiltration initiated by capillary pull were more readily observable. Early- and late-time infiltration rates were analysed in-combination and showed clear relationships in within-material variability, differences in infiltration fluids, and site specific differences in infiltration. These relationships generated more information than traditional analysis approaches. Analytical approaches based on idealized wettable-system principles yielded suspect results in the form of negative Ksat and Sorptivity values. This also introduced uncertainty into positive values of Ksat and Sorptivity. Results of this kind challenge our ability to rely on traditional approaches for analyzing infiltration data and drawing meaningful conclusions in non-wetting / fractionally wettable / dynamic systems. There is great opportunity to develop new approaches for developing mechanistic insight into these systems, particularly over

times scales of infiltration and groundwater recharge.



Abstract ID: 34781

Final Number: H14B-0206

Title: Debye decomposition of complex electrical conductivity spectra of contaminated sediments

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Abstract Body: The relevance of geophysical investigation to hydrogeology problems have been extensively reported in the literature. Electrical methods have shown to be successful in characterizing and monitoring groundwater flow and contamination plumes in the subsurface. The spectral induced polarization (SIP) geophysical method has been considered a promising tool in environmental and hydrogeophysical studies. Induced polarization (IP) is a phenomenon associated with energy storage in a medium, stimulated by an induced electrical current. The SIP method records the complex, frequency dependent, expression of the IP phenomenon. SIP data are frequently interpreted with the use of phenomenological models that describe relaxation processes, such as the Debye relaxation model. One common procedure, known as Debye Decomposition (DD), is to fit SIP data using several distinct Debye relaxation models. The objective of our work is to interpret the relaxation time distribution obtained with DD for SIP data from an experiment with sand-clay mixtures contaminated by toluene. We apply an alternative formulation for DD, where a different set of parameters are recast, with a close relationship to the continuous formulation for the complex conductivity method. The procedure determines frequency-independent parameters that modulate SIP spectra and the range spanned by the conductivity spectra between low and high frequency limits. Using these two parameters, the complex conductivity can be normalized and decomposed into smaller contributions. Each contribution can then be associated with specific relaxation processes that are characterized in terms of distinct parameters, such as electrochemical or interfacial, derived from inverted parameters obtained. Our discrete version of the continuous DD yields a distribution of relaxation times with associated gate probabilities and two frequency-independent parameters that allow for interpretation in terms of petrophysical parameters from mechanistic models. The relaxation time distribution obtained for the toluene contaminated samples identified two main polarization processes related to different polarization mechanisms (electrochemical and Maxwell-Wagner) that were not clearly distinguishable in complex conductivity spectra.

Abstract ID: 35770

Final Number: H14B-0207

Title: Downscaling Daily Precipitation with the Climate Forecast System Reanalysis across Canada

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Abstract Body: One of the most important challenge in assessing historical precipitation across Canada is related to the low station density, especially up north the 50°N of latitude. The reanalysis datasets are now an attractive alternative that reconstructs the past state of the atmosphere using Numerical Weather Prediction methods assimilating past observations, to generate spatially and temporally continuous meteorological fields. The objective of this study is to access to what extent the Climate Forecast System Reanalysis (CFSR) reproduces precipitations for potential application in hydrology.

CFSR, produced by the National Centers for Environmental Prediction (NCEP), covers the period from 1979 to 2010 and includes daily precipitation series at 38 km resolution. Two important issues are addressed: 1) to what extent the CFSR reproduces the observed precipitation at stations for different time scales? 2) Do physically and statistically-based post-treatments of CFSR precipitations permit to match recorded ones? The first issue is examined through bias, correlation and variability estimates when CFSR and station series are compared at different time scales. The second issue is addressed with Stochastic Model Output Statistical (SMOS) approach which proceeds in two steps: first precipitation occurrence is determined and, if precipitation occurs, then precipitation intensity is estimated.

Results showed satisfactory performances according to bias and correlation on series in eastern and western parts of the country, especially during winter and fall for correlation and summer for bias. Precipitations in the Rockies were not accurately represented by CFSR (e.g. rain-shadow effect). Preliminaries SMOS results are promising and suggested this method could be used to downscale grid-cell CFSR precipitation to specific sites. The next steps are to relate spatially and seasonally SMOS parameters to be able to assess statistics on precipitation in regions where no stations are available.

Abstract ID: 35935

Final Number: H14B-0208

Title: Differentiation between anthropogenic and natural contamination of stream water by heavy metals: a case study in the Cordillera Blanca, Peru

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Abstract Body: Predicting the impact of the glaciers retreat on water quality for the downstream populations is an objective that requires a good understanding of the contamination and transport mechanisms of pollutant. Where contaminants are heavy metals, identifying the origins of the contamination and differentiating between the anthropogenic and natural contamination origins in particular is a required step. In Northern Peru, the Rio Santa dry season discharge is projected to decline with the ongoing Cordillera Blanca glaciers retreat making the identification of the heavy metal contamination sources a priority. The scale of the watershed, more than 13,000 km^2 combined with the high density of mines of different size makes the anthropogenic contamination non-point of source like. In those conditions, differentiating between the natural and anthropogenic contamination origins requires identifying their distinct hydrochemical signatures.

In order to identify hydrochemical contaminant origin dependant signatures in the Rio Santa watershed, 5 areas of known contamination origins were sampled during the summer 2014. Samples of surface water and groundwater, suspended and riverbed sediments have been collected at each site. Each sample was analyzed for trace metals using an ICP-MS or an ICP EOS, depending on the concentration of metals. Preliminary results show that natural contamination is characterized by low levels of arsenic and calcium and high level of sulfates and fluorine compared with mine drainage. The possibility to use those characteristics to trace contamination origins is investigated and options are being proposed.

Abstract ID: 36147

Final Number: H14B-0209

Title: Mapping the depth of a small lake using ground-penetrating radar

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Abstract Body: A geophysical study was designed to determine if ground-penetrating radar is a feasible means of mapping small bodies of water where sonar cannot be deployed. We collected ground-penetrating radar data by canoe on a small (250 x 100 m) lake near Deep River, approximately 250 km NW of Ottawa in Ontario. This lake is situated between a glacial-fluvial sand aquifer and a wetland just South of the Ottawa River and formed because of the construction of the Trans-Canada Highway. The radargrams were collected with a 400 MHz antenna and exhibit sharp reflections off the bottom of the lake, as well as a lower interface (between the mud and till). GPS was used to record the Easting and Northing coordinates at both the starting and ending locations for all twenty survey lines. Picking the two-way-time arrivals, converting these to depth, and placing them into the UTM coordinate system allowed us to create a bathymetric contour map of the lake bottom which we can compare to measurements done with a plumb line. The results show water depths of up to 3 m and generally a steeper drop on the East side of the lake. Our survey exemplifies the feasibility and applicability of using GPR on small bodies of water.

Abstract ID: 36247

Final Number: H14B-0210

Title: Arctic Tundra Lakes in a Region Impacted by Permafrost Disturbance – Application of Isotope Signatures for Enhanced Hydrological Understanding

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Abstract Body: A projected "hot spot" of climate warming and development is the Mackenzie River Delta region, Northwest Territories, Canada. The upland tundra areas within the Mackenzie Gas Project development area north of Inuvik contain thousands of small lakes with poorly defined ephemeral drainage that are underlain by permafrost and ice-rich sediments for which the basic water balance controls are not fully understood. Natural retrogressive thaw slumps are common along lakeshores and the rapid drainage of ice-rich permafrost-dammed lakes has been occurring. Oil/gas exploration activities and infrastructure construction may result in terrain disturbance and localized degradation of permafrost, while climate change may increase the magnitude and frequency of thermokarst processes. These disturbed lakes are believed to act as historical analogues for the future effects of climate change on the hydrology, geochemistry, and aquatic ecology of tundra lake catchments in the continuous permafrost zone of northwestern Canada. Environment Canada initiated an integrated research program in 2005 with the overall goal of improving our understanding of lake hydroecological impacts associated with shoreline slumping. Limited catchment studies have examined water-balance parameters (precipitation, evaporation, and surface flows) for tundra lakes in the development area. Comparisons of naturally-occurring water isotopes (^{18}O and ^{2}H) are useful indicators of water balance variations among lakes in remote permafrost regions where hydroclimatic information is very limited. In particular, information on evaporation-to-inflow ratios and residence times would provide useful information for estimating appropriate water withdrawals from lakes within the proposed development area and provide a temporal perspective on geochemical impacts due to slumping. Another key objective is identifying whether permafrost slumping impacts the hydrology of tundra lakes via catchment area enlargement and/or enhanced snow accumulation. Here, we present preliminary isotope hydrology findings from i) 7 years of seasonal surveys in a pair of representative lake catchments and ii) annual synoptic surveys in up to 60 lakes, including those with and without shoreline slumping, located along the proposed Mackenzie Valley Gas Pipeline.

Abstract ID: 36408

Final Number: H14B-0211

Title: Hydro-Climatic Variability and Runoff Response in Glacial River Basin: A Case from Langtang River Basin of Nepal Himalaya

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Abstract Body: The Himalayas display great climatic variability. The variability in climatic parameters has greatly affected the water resource availability due to the occurrence of frequent and uneven extreme events. Climate change is expected to contribute to increased variability of river runoff due to changes in the other climatic variables as well as the melting of snow glaciers. Therefore, it is essential to understand the underpinnings of hydro-climatic variability in order to assess the effects of climate changes and effectively meet future water supply challenges. This paper therefore provides the analysis of observed variability and change in temperature, precipitation, snow cover and its response to streamflow of Langtang River Basin of Nepal. Langtang River basin which lies in Langtang Valley of Rasuwa district is glacier-fed and provides sustained flow during dry seasons to fulfill the water requirements for downstream.

The observed hydro-meteorological data for the period 1988 to 2009 obtained from Department of Hydrology and Meteorology, Government of Nepal was used for this study. Trend analysis of temperature data using non parametric Mann-Kendall test revealed that there is increasing trend of temperature and was more pronounced in winter season (December, January, February) and both are statistically significant at the 95% confidence level. Also observation shows that the total number of days per year below $0^{o}C$ has been decreasing. Similarly, total annual precipitation showed increasing trend but have large interannual variation. Pre monsoon, post monsoon and winter precipitation also showed significant increasing trend whereas the monsoon precipitation was observed to have significant decreasing trend. Monsoon precipitation in the region amounts 84.78% of total annual precipitation. Snow cover area (2002-2014) examined using the data acquired from MODIS snow data showed decreasing trend of snow cover area in Langtang river basin. The annual stream flow showed decreasing trend. The streamflow at monsoon and post monsoon seasons were found to be decreasing and winter and pre monsoon streanflow showed increasing trend. The streamflow was observed to start increasing in June and reach peak in July and August. In the post-monsoon period and winter, snowmelt contribution to the total discharge is large.

Abstract ID: 36741

Final Number: H14B-0212

Title: Hydrological forecasting events in the context of global warming using Fokker-Plank-Kolmogorov's equation

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Abstract Body: In the last decade, stochastic and deterministic approaches were widely used in hydrological analyses to predict events with reliable results. However, scientists are still looking for the best solution and the most efficient forecasting method to evaluate a future hydrologic event that could help to prevent damage of infrastructures.

This paper is proposing a method based on application of Fokker-Plank-Kolmogorov's equation in hydrological modeling in the context of climate change. The method provides a new insight in ongoing hydrological processes to forecast and define action priorities. The model is based on stochastic analysis and consists in determining and optimizing numerical approximates of sensitive parameters in hydrological processes. The application of FPK was used to establish the water level of a dam in different scenarios with the goal of preventing the floods.

In this paper, the strategy is to focus on the optimization of sensitive parameters in hydrological processes. Hence, at each stage of an identified hydrological process, a probabilistic density function (PDF) is determined enabling the optimization of decision-making in stochastic modeling. The objective was to simulate hydrological scenarios that could take place in the case of a long storm on a studied watershed. The novel approach significantly reduced uncertainties in hydrological modeling and forecasting. It was also possible to manage white noise processes and their intensities with acceptable accuracy. The approach yielded more accurate forecast and was used to manage the adjustment of the water level of a dam subject to instability and efficiency. Results of simulations were in good agreement with recorded data. The approach enabled different scenarios of storms and analyzes their impact on a dam and the surroundings of the studied area. The methodology and benefits are presented in this paper.

Abstract ID: 36772

Final Number: H14B-0213

Title: A Study on Debris(floating waste) Flow Simulation in Hantangang dam Using the EFDC Model.

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Co-authors: Ji Hwan Oh, , , ; Su Hee Han, , ,

Abstract Body: Dam and reservoir are very important facilities to prevent flood and also using water resources. Hantangang dam designed only for the purpose of flood control whose bottom outlets are specially designed at the original river bed level and can pass through inflow sediments almost naturally during flood periods are often planned for the new flood control.(Tetsuya Sumi, 2008).

Hantangangdam in Hantan river, length is 690.0 meter, height is 83.5 meter and flood control capacity is 2.7 hundred million tons. Generally, Flood Control dam is large of water level changes. And floodplain is exposed in the dry season because it does not store water. Therefore, Maintenance method is different other multipurpose dam. Also, Width and depth of Mainstream in Hantanriver is very irregular and meandering characteristrics. It was difficult to determine the distribution of floating waste.

In this study, GIS analysis was conducted for basin topography for actual basin to estimate predict space and flow analysis were simulated through the EFDC model considering water level, flood condition of frequency. Find the inflow route and delay zone of floating waste in hantan river. After that, I try to present the effective debris collection method. Analysis were reviewed along 6 cases–Small sized flood(2yr, 5yr frequency), medium sized flood(25yr, 50yr frequency), large sized flood(100yr, 200yr frequency).

The result of small sized flood, debris is incapacitated under the influence of river curvature, it was simulated to be partially accumulated in a specific area. In particular, floating waste is expanding the width of the flow rate while at the confluences can not go downstream. The result of medium sized flood, floodwave is overflow the mainstream that flood in ploodplains with wide area. The result of large sized flood, dam site area is analyzed Under the influence of the above largest dam drainage, and water depth is deeper flow both mainstream and tributaries of the most delayed in the region to be a large amount of debris distribution. Also wide floodplain to flooding scope is rapidly increasing and thus the area that can be distributed floating garbage were analyzed to rise significantly.

keyword : Hantangang dam, EFDC model, Debris, Floodplain

Abstract ID: 35179

Final Number: H14D-0215

Title: Comparing catchment mean transit times and landscape characteristics for mesoscale catchments in northeastern Ontario

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Abstract Body: Improved accessibility to stable water isotope (SWI) analyses has highlighted SWI-based evaluation of streamflow partitioning and mean transit times (MTT) as powerful ways to generate new information on water cycling for large scale catchments. Located in northeastern Ontario, Lake Nipissing is part of an important headwater tributary to the Great Lakes. In 2012, we initiated a stable water isotope (SWI) study of the Sturgeon River-Lake Nipissing-French River (SNF) basin, to examine how landscape characteristics influence streamflow generation at scales where both natural landscape variation (e.g. surface reservoirs, clay belt soils, forested headwaters) and anthropogenic influence (power generation, urbanization, agriculture) are anticipated to influence water quantity and quality. Catchments range in size from 35 to 6,875 km^2, with a median size of 146 km^2 and mean catchment slopes from 1 to 8%. Landcover includes considerable agricultural (0-18%) and/or urban (0-47%) area. Lakes and wetlands together cover 10-25% of catchment area, with large individual lakes (e.g. Lake Temagami) acting as important reservoir storage for hydropower generation. In this poster, we present a comparative analysis of MTT estimates generated using periodic regression analysis of 1-2 years of biweekly to monthly streamflow and precipitation observations. MTT estimates are longest for the smallest catchments (<1000 km^2) but have high variability (472 – 722 days); the largest catchments (2400-6800 km^2) exhibit much more uniform but shorter MTT (386-430 days). There are negative correlations between MTT and mean catchment slope (R^2=0.71, p<0.01), and MTT and total % area of lakes and wetlands (R^2=0.33, p<0.05). Comparison of MTT estimates across two major forks of the Sturgeon River with substantial differences in flow manipulation show similar MTT estimates (~390 days) suggesting that similarities in % lake/wetland and mean catchment slope may be more influential in these instances.

Abstract ID: 35582

Final Number: H14D-0216

Title: High frequency monitoring of lake and weather conditions in Lake Nipissing, Ontario: Exploring the 2014 hydrographical dataset

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Abstract Body: In 2014, high frequency monitoring of water and weather conditions was undertaken in three bays (Cache, Callander and West Bay) on Lake Nipissing, a large (822 km^2), relatively shallow lake located in northeastern Ontario. Lake Nipissing is part of an important headwater tributary to the Great Lakes. Eight of the 12 major river inflows to Lake Nipissing have been evaluated as either impaired or marginal in water quality, and historical data shows total phosphorus (TP) levels exceeding provincial water quality objectives and evidence of eutrophic conditions in bays with upstream agricultural activity (Callander and Cache). Lake Nipissing's walleye population has been reported as highly stressed with ecosystem change listed as one potential cause of the unexplained decline in adult walleye abundance. High frequency monitoring of lake and weather conditions was initiated in a 2013 pilot project in Callander Bay and extended to the three bays in 2014. In each bay, a data buoy was deployed, instrumented with thermistors and light sensors at 1 m intervals through the water column. At two locations, an EXO2 water quality sonde recorded continuous measurements of pH, conductivity, turbidity, chlorophyll, and total algae at a 1 m depth and *in situ* meteorological data. Data were collected on a 10 minute interval. Regular profile surveys (conductivity, temperature, DO) were performed at each buoy using a YSI multi-parameter probe. In this poster, we present the 2014 dataset collected from the three bays, with specific examination of seasonal and event-based trends and influence of meteorological conditions on thermal structure. We explore the development and use of custom data visualization and analysis tools as well as those available through the Global Lake Ecological Observatory Network (GLEON) for generation of lake hydrographical metrics (e.g. Schmidt stability, epilimnion depth, anoxic lake volume and sediment area, thermocline, mixed layer depth, Lake Number).

Abstract ID: 33112

Final Number: H14E-0217

Title: Application of SWAT model to quantify blue and green water resources in Alberta

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Co-authors: Karim Abbaspour, EAWAG Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, Switzerland; Greg Goss, , ,

Published Material: This is a three years research project, funded by Alberta Innovates Energy and Environment Solutions on 2014. It is started since March 2014 and the results have been recently submitted for publication in an ISI Journal. The status of the manuscript is "under review". General objectives of the project have been reported in local and regional media. We have also discussed our results with the scientists and local experts trough personal meetings.

Abstract Body: Dynamic nature of water resources, both spatially and temporally, present a significant challenge to sustaining economic developments, ensuring food security, and implementing other development plans in Alberta and elsewhere in the world. A sound knowledge of internal renewable water resources availability and reliability is needed to lay a strong basis for a long-term planning and management. In this study we used the program Soil and Water Assessment Tool (SWAT), in combination with the Sequential Uncertainty Fitting program (SUFI-2), to calibrate and validate a hydrologic model of Alberta. Monthly data from 135 hydrometric stations and wheat yield was used to calibrate the model. This dual-objective calibration increased reliability in the prediction of soil water balance components. The study period was 1993-2007 for calibration and 1983-1993 for validation. The heterogeneous hydro-

climatic conditions and the diverse management practices in combination with the scarcity of data in the remote areas and mountainous regions made hydrological modeling challenging. A data discrimination procedure was developed to represent most of the natural and anthropogenic processes in the watersheds. The calibrated model was further used to quantify water resources including blue water flow (river discharge plus deep aquifer recharge), green water flow (evapotranspiration), green water storage (soil moisture), and aquifer recharge at the subbasin spatial and monthly temporal scale. Uncertainty analyses were also performed to predict the errors related to the input data, model structure, and management measures. The results of this study will be integrated with other dynamic predictive models (e.g., climate change, water demand, economic evaluation) to enable analysis of alternative management options in the future.

Abstract ID: 35383

Final Number: H14E-0219

Title: Modeling the Partitioning of Precipitation over the Almadinah Watershed, Saudi Arabia: An Integrated Approach

Presenter/First Author: Talal Alharbi, King Saud University, Riyadh,

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Co-authors: Mohamed Sultan, Western Michigan Univ, Kalamazoo, MI; Mohamed Ahmed, Western Michigan University, Kalamazoo, MI

Abstract Body: Assessment and development of freshwater resources remain the main and the only key to sustain the Kingdom of Saudi Arabia growing population and increasing water consumption. An integrated (remote sensing, GIS, and modeling) approach was applied to spatially delineate the recharge areas of, and model the precipitation of precipitation over, the Almadinah watershed, the largest (area: ~108,000 km2) watershed in the Kingdome of Saudi Arabia, during the past three decades. The Soil Water Assessment Tool (SWAT) was used to estimate the partitioning of precipitation into runoff, recharge, and evaporation. SWAT model inputs were generated as follows: (1) daily rainfall data extracted from the Tropical Rainfall Measuring Mission (TRMM) data which is calibrated against rain gauges measurements; (2) soil data were extracted from the geologic maps generated by Saudi Geological Survey; (3) land use maps extracted from the U.S. Geological Survey (USGS) 1-km global Land Use and Land Cover database; (4) topography data were generated from a mosaic of Shuttle Radar Topography Mission (SRTM; 90 m spatial resolution) data; and (5) other climatic parameters including solar radiation, wind speed, air temperature, and relative humidity were obtained from the Climate Forecast System Reanalysis (CFSR) database. SWAT model was calibrated against the discharge data extracted from the archival runoff datasets. The average annual modeling results over the Almadinah watershed through the period from 1980 to 2010 revealed: (1) rainfall was estimated at 58 mm; (2) stream flow were estimated at 19.1 mm (33% of the rainfall); (3) the potential recharge was estimated at 7.2 mm (12.5% of the rainfall); and (4) initial losses is estimated at 31.3 mm (54% of the rainfall). Our results invite the deployment of technical projects such as dam construction and wells installation for groundwater extraction within the Almadinah watershed.

Abstract ID: 35090

Final Number: H14E-0220

Title: Hydrological Modeling of the Niger River (West Africa) for Flow Prediction in Ungauged Basins.

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Abstract Body: In West Africa, many drainage basins are ungauged or poorly gauged, and in some cases existing measurement networks are declining. Prediction of discharge and other hydrological characteristics of ungauged basins is therefore an important priority for water resources planning and management and for ecological studies. The ultimate goal of our study is flow estimation in ungauged catchments of the Niger basin through hydrological modeling of the Bani River using SWAT and its parameters transfer to the upper Niger. The calibration task presented in this article, is the foundation for regionalization of model parameters, which will be addressed in the companion paper. In the present article the modelling framework: model description, study area and data, calibration strategy and results are presented. The Bani is located in the upper part of the Niger River and drains an area of about 101, 000 km^2 at the outlet of Douna. The climate is tropical, humid to semi-arid from the South to the North with an average annual rainfall of 1050 mm. Global datasets used are from USGS hydrosheds DEM, USGS LCI GlobCov2009 and the FAO Digital Soil Map of the World. Daily measured rainfall from nine rain gauges and maximum and minimum temperature from five weather stations covering the period 1981-1997 were used for model setup. Sensitivity analysis, calibration and validation were performed within SWATCUP using GLUE procedure at the catchment's outlet (Douna) and at two additional internal stations (Pankourou and Bougouni). Model parameters were calibrated at daily time step on ten years (1983-1992) then validated on 5 years (1993-1997). A warm-up period of two years (1981-1982) was considered. Calibration and validation results are good at the catchment's outlet (Nash and R^2 equal to 0.76 and 0.79 for calibration, 0.84 and 0.87 for validation). Model performance was slightly lower for the additional gauging stations (Nash equal to 0.73 and 0.58) but again always higher for the validation period (0.77 and 0.65). These statistics suggest that the model performance can be judged as satisfactory, especially considering limited data condition and a high climatic gradient characterizing the Bani catchment.

Abstract ID: 34359

Final Number: H14F-0221

Title: Radiogenic and Stable Strontium Isotope Variation in Rivers Draining the Canadian Precambrian Shield

Presenter/First Author: Ross Stevenson, Universite du Quebec a Montreal, Montreal, QC

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Abstract Body: We present new radiogenic (87Sr/86Sr) and stable (δ88Sr/86Sr) strontium isotope data from four rivers of the Canadian Precambrian Shield. Radiogenic Sr isotope ratios reflect the contributions of different crustal sources, while the stable strontium isotope ratios can be used to calculate weathering rates. All four rivers flow into Hudson Bay or Hudson Strait. Three rivers drain the Precambrian Shield of Northern Quebec (The Koksoak, Great Whale and La Grande Rivers). The fourth one, the Nelson River, drains the Precambrian Shield of Northern Manitoba and Phanerozoic sedimentary deposits, through supplies from Lake Winnipeg and the North and South Saskatchewan Rivers. The Nelson, La Grande and Koksoak have one or more hydroelectric dams, while the Great Whale River remains free of hydroelectric development. Radiogenic strontium isotopes provide constraints on the geology of the terrain underlying the drainage basin whereas stable strontium isotopes fractionate in response to precipitation and dissolution reactions. Combining these radiogenic and stable isotope systems leads to a better understanding of the weathering of the Canadian Shield. Preliminary data reveals that the difference in the

geology of the drainage basin of the Nelson River is evident from lower 87Sr/86Sr ratios (0.713) compared to the other three rivers (0.728-0.735). Seasonal variations in the 87Sr/86Sr ratios are evident in some of the rivers and absent in others. Preliminary stable strontium isotope data (δ88Sr/86Sr) exhibits variations between 0.25 and 0.35 per mil, values that are consistent with those measured in rivers from elsewhere in the world.

Abstract ID: 35728

Final Number: H21A-01

Title: Progress in modeling high latitude land surface hydrological processes

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Abstract Body: High latitude environments pose special challenges to land surface models. In addition to the need to represent land-atmosphere energy and moisture fluxes in a consistent manner, phase change is a dominant process, prevalent both in the need to represent snow and snow free hydrological processes, but also frozen soils which may be permanent aside from seasonal surface thawing (permafrost) or seasonally ephemeral. Land surface models represent these processes with varying degrees of fidelity, although many modeling groups have given them increased attention over the last decade or so. I review some of the key issues, and progress in modeling from the perspective of community modeling efforts, including the US DOE-funded Regional Arctic System Model (RASM), field experiments past and planned, and high resolution process models, and the extent to which they have affected the evolution of macroscale land surface schemes in coupled land-atmosphere models.

Abstract ID: 33721

Final Number: H21A-02

Title: Changing Climate and Streamflow in the Western Canadian Arctic

Presenter/First Author: Philip Marsh, Wilfrid Laurier University, Waterloo, ON

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Published Material: Previous work has described changes in streamflow for one watershed. This paper will expand this work to six watersheds crossing the treeline and diagnose the observed changes.

Abstract Body: The climate, landcover and permafrost are changing across the Western Canadian Arctic, with resulting changes in streamflow. Observed changes include warming air temperatures, decreasing precipitation, earlier onset of spring snowmelt, warming and deepening active layer, and north of the treeline expansion of shrubs. For one watershed north of the treeline, decreases in total, and peak, spring melt streamflow and delayed timing of melt runoff have been described. This paper will consider changes in spring melt streamflow for 6 watersheds along a 200 km transect crossing the arctic treeline in the vicinity of Inuvik, NWT, Canada, and will diagnose the integrated impact of changes in climate, landcover and permafrost, on the spring melt hydrology of these watersheds.

Abstract ID: 33966

Final Number: H21A-03

Title: Polar amplification and elevation-dependence in trends of Northern Hemisphere snow cover extent, 1971-2014

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Abstract Body: Recent years have exhibited large declines in snow cover extent (SCE) in the Northern Hemisphere (NH), marked by earlier snowmelt in the springtime. In northern latitudes, the snow-albedo feedback (SAF) is most pronounced in the spring and may be contributing to these decreasing trends in SCE. Rising surface air temperatures and changes in precipitation patterns could also vary the declining trends in SCE depending on latitude and elevation. Previous trend analyses of NH SCE are extended here to cover the period 1 October 1971 to 30 September 2014 using observed data from the National Oceanic and Atmospheric Administration snow chart climate data record. Trends in snow coverage (significant when $p < 0.05$) with latitude and elevation are investigated using the Mann-Kendall test. Over the 43-year period, strong polar amplification of negative trends in snow cover are observed. The majority of statistically-significant negative trends are found in the mid- to high-latitudes, reaching a maximum reduction at 75.5°N. There is also elevation dependence of SCE over time as statistically-significant negative trends occur at most elevations, with a minimum reached at 3950 m a.s.l. These strong negative trends exhibited in the mid- to high-latitudes and mid- to high-elevations provide evidence of polar amplification and elevation dependence of trends in snow cover in a warming climate, suggesting a leading role of the SAF on the recent retreat of NH snow cover.

Abstract ID: 35850

Final Number: H21A-04

Title: Examining the influences of changes in snowpack structure on the declining Bathurst caribou herd in the Northwest Territories.

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Abstract Body: Over the past 15 years the Bathurst Caribou herd in the Northwest Territories has undergone a dramatic 96% decrease in population. The objective of this research is to determine if snowpack conditions in the winter foraging grounds of the Bathurst herd have changed over long periods of time in response to a warming climate and, in response to this, if the frequency of ice lens formation in the snowpack has changed over the past 20 years. Changes in snowpack characteristics such as dpeth, and increases in ice lenses may provide physiological challenges to caribou as for 6-7 months of the year their primary food source –lichen- lays at the base of the annual snowpack. To explore this idea remote sensing tools are employed. The Globsnow database is utilized to quantify changes in snowpack water equivalent (SWE) and assess the probability of ice lens formation especially during the fall and spring of sequential years between the late 1990's to present time. The snowpack water equivalent data is derived from a combination of SSM/I satellite data (passive microwave emissions at 37 GHz and 19 GHz) and local weather station data. Over the past several years the Environment and Natural Resources

Ministry (Wildlife Division) of the Government of the Northwest Territories has monitored the movement of approximately 20 caribou of the Bathurst herd outfitted with satellite collars. Assuming the movement of these individuals is representative of the pattern of movement of the non-collared herd it is possible to relate caribou spatial movement with respect to snowpack conditions on a daily basis. To assess whether snowpack conditions impact the distribution of the collared caribou specific pixels within the fall to early spring foraging habitat have been selected for long term evaluation and compared to caribou occurrence. Areas previously burned by forest fires are included in the data evaluation.

Abstract ID: 33006

Final Number: H21A-05

Title: The Impacts of Thermal Perturbation and Permafrost Disturbances on Runoff Pathways and Stream Water Quality, Cape Bounty, Melville Island, Nunavut

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Published Material: Some results from this study will be presented at the Arctic Change 2014 conference (December 8 to 13) in poster form. We hope to present our full research as an oral presentation at the Joint Assembly where we can discuss results in greater detail.

Abstract Body: The Intergovernmental Panel on Climate Change (IPCC 2013) has projected that continued warming of the Arctic will substantially impact hydrological processes. However, there is limited research examining how runoff dynamics will respond to deepening active layers and permafrost disturbances, specifically active layer detachments (ALDs). Our research addresses this knowledge gap through research carried out at the Cape Bounty Arctic Watershed Observatory (CBAWO) in the Canadian Arctic, where significant localized ALDs occurred in 2007. We used major ion concentrations and stable isotope values (D, 18O and d-excess) as hydrological tracers to determine the relative contribution of different water sources (snowmelt, rainfall, soil water) to hillslope runoff in an undisturbed catchment (Goose) during summer 2012, a season characterized by high air surface temperatures, deep active layer thaw and above normal rainfall. We also investigated the same tracers at this undisturbed catchment and at a recently disturbed catchment (Ptarmigan) at CBAWO from 2006 to 2014 to identify possible longer terms changes in water sources and/or pathway that may have occurred in response to disturbance or interannual variability in climate.

Results indicate that deep active layer thaw increases the storage capacity of for summer rainfall and displaces stored soil water, which affects stream water chemistry as solute-rich waters are moved to the stream. Soil water with the highest solute concentrations are found progressively deeper in the soil profile and at the maximum active layer depth. Hence, the deeper the active layer thaw proceeds, the more likely this water can be moved to the surface following displacement by rainfall. ALDs create new channels for surface flow where meteoric water interacts with exposed solute-rich ground ice. This routing of water through new exposed permafrost soil directly impacts the variability and composition of ion concentrations in stream water. Hydrochemical variability (i.e. greater variations in ion concentrations) appears to increase over time from the onset of the disturbance. Consistent δD and δ18O in stream waters suggest that differences in water pathways, not water sources, may be the dominant control in stream water ion concentration between undisturbed and disturbed catchments.

Abstract ID: 35338

Final Number: H21A-06

Title: Hungry ponds in a thawing world: Variations in subarctic pond runoff quality and quantity depend on peatland moisture and frost conditions

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Abstract Body: In subarctic permafrost environments, ecological productivity is often nutrient-limited, both in terrestrial and aquatic vegetation. The subarctic is experiencing significant climatic change, including rapid warming and changing precipitation patterns, which may result in changes in nutrient dynamics within terrestrial and aquatic systems and hydrologic transport between them. A change in nutrient dynamics may result in changes to vegetation growth, pond ecology, and food web stability in the North. The objective of this research was to characterize changes in runoff quantity and quality between peatlands and ponds over the snow-free summer seasons. Twenty-two ponds and five transects of piezometer nests along moisture gradients were instrumented to measure changes in hydrologic storage, frost table position, and water quality over two snow-free seasons (May to October) in Churchill, Manitoba, within the Hudson Bay Lowlands. Differences in antecedent moisture conditions across landscape units, combined with frost table position (inhibiting infiltration and storage) produced non-linear, threshold responses in runoff generation. Greater inputs were required to exceed storage ('fill and spill') when a lower frost table permitted deeper infiltration. Seasonal variations in groundwater chemistry were reflective of different layers of peat and mineral soil accessed at different times throughout the season, governed by frost table and water table positions. Varying thaw rates across landscape units (controlled by moisture and vegetation) resulted in changing groundwater pathways throughout the season. Changing hydrologic pathways combined with precipitation events throughout the season resulted in temporally variable nutrient concentrations in runoff and ponds. This work has implications for how nutrient dynamics and exchange between terrestrial and aquatic systems in cold regions may evolve under a changing climate.

Abstract ID: 35398

Final Number: H21A-07

Title: Hydrologic Response of a Bog Cascade with a Dynamic Contributing Area in Discontinuous Permafrost

Presenter: William L Quinton, Wilfrid Laurier University, Waterloo, ON

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Abstract Body: Flows from river basins in the lower Liard River valley in northwestern Canada have been rising in the last two decades as a result of climate warming. Changes in precipitation account for only about 30% of this increase. In the wetland-dominated basins that characterise the southern margin of permafrost, permafrost thaw and disappearance, and resulting land-cover change, is occurring at an unprecedented rate. Permafrost thaw has the potential to fundamentally alter the processes giving rise to streamflow in this region by altering the type and relative proportions of biophysical terrains. Field studies were conducted at the Scotty Creek Research Basin, a 152 km^2 watershed, located about 50 km south of Fort Simpson, NT. Scotty Creek is typical of other basins in the region and is underlain by discontinuous permafrost. There are three major land-cover types in the basin, each exhibiting a distinct hydrological function. Channel fens convey water to the basin outlet, while permafrost plateaus are runoff generators. Flat bogs have been shown to be primarily storage features, however ephemeral channels have been observed to cut through permafrost plateaus and allow for hydrologic interaction between bogs. These channels create series of bog cascades that drain adjacent peat plateaus and ultimately flow into the channel fen. It is shown that the transmission of water through bogs and into the fen is a mechanism that changes the effective contributing area based on antecedent moisture conditions. The dynamic contributing areas are shown to be controlled by storage thresholds. Field data indicates that transmission of water through bogs is dependent on storage levels. Sharp crested v-notch weirs and flume boxes were installed in the channels to create a continuous stage-discharge relationship to gauge runoff entering the channel fen through the bog cascades. In this study we attempt to quantify the amount of runoff produced from bog cascades and determine how the contributing area varies in time and space. The hydrological model Raven will be used to simulate this system and explore how the contributing area changes in response to storms of varying magnitudes.

Abstract ID: 35295

Final Number: H21A-08

Title: Root Network Impact on Soil Thermal Conductivity and Active Layer Thaw

Presenter/First Author: Stacey Van Opstal, Wilfrid Laurier University, Acton,

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Co-authors: William L Quinton, Wilfrid Laurier University, Waterloo, ON, Canada

Abstract Body: A large portion of Canada's land surface is underlain by permafrost ranging from continuous to isolated and sporadic. Future increases in regional air temperatures are expected to lead to widespread degradation of permafrost, particularly in the zone of discontinuous permafrost where ground temperatures are close to the freezing point. This study examines the impact of black spruce root networks on the thermal conductivity of northern peatland soils and their resultant impact on active layer thaw. Measurements were taken in the Scotty Creek research basin, a wetland dominated area in the zone of discontinuous permafrost located near Fort Simpson, Northwest Territories. Thermal conductivities for black spruce roots and peat soils of various moisture contents were determined and used to model the relative importance the thermal conduction from each material has on the thawing of the active layer. As soil thawing progresses, the frost table and the thawed saturated zone above it descend through the wetted soil profile while the saturated horizontal hydraulic conductivity of peat decreases with depth. The influence of vegetation on soil moisture is an important aspect to consider when understanding permafrost thaw due to the relationship of thermal conductivity of soils and moisture content. Root systems of plants are known to extend vertically into the soil profile for considerable depths and can tap water and nutrients from both deep and shallow layers, black spruce roots reach only approximately 30 cm below ground. The movement of moisture by plant roots is an important component of below ground hydrological processes and is therefore also important in understanding heat movement within soils through 1) the effect of soil moisture on heat conduction, and 2) coupled heat and mass transfer processes. In the context of a peat plateau complex understanding the process of hydraulic redistribution is important because the root networks are an important mechanism of soil moisture movement and as a result the relation between the soil thermal conductivity and moisture content.

Abstract ID: 34085

Final Number: H21B-01

Title: Groundwater Development In Semi-Arid South India: Trends and Status

Presenter/First Author: Rajendra Prasad Sishodia, ICRISAT, Patancheru,

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Co-authors: Sanjay Shukla, University of Florida, Ft Walton Beach, FL

Published Material: The manuscript is currently under final stage of preparation and it would be submitted for publication in February.

Abstract Body: Growing number of studies have indicated declining groundwater levels in the semi-arid southern region of India, however the statistical significance of the change in the level has not been analyzed. This study attempts to determine whether the semi-arid southern India is experiencing significant decline by analyzing the long term (1990-2012) groundwater levels data for three districts (administrative division in a state) with diverse land uses. Based on the length of the record, data from monitoring wells were divided into three time periods: 1990-2012 (group A), 1990-2005 (group B) and 1997-2012 (group C). Nonparametric trend tests showed that 21% of the wells in group A, 36% wells in group B and 25% of the wells in group C had a statistically significant ($p < 0.05$) declining trend in the mean annual groundwater levels. Trend tests for rainfall and rainfall adjusted groundwater levels (locally weighted regression residuals) showed that rainfall variability could not fully explain the declining trends. Increase in numbers of irrigation wells (shallow and deep), as well as the irrigated area, were the main factors causing the decline in groundwater levels. The number of closed drilled wells increased from 61,236 in 1994 to 297,601 in 2007, an increase of almost 400%. The growth in number of tube wells has caused abandonment of many traditional open (dug) wells and reduced the productivity (area irrigated per well) of drilled wells. Continued increase in groundwater-based irrigated areas is likely to increase the groundwater level declines and well drying occurrences in the future. Supply and demand management of groundwater along with a transition to resource efficient techniques such as drip irrigation could reverse this decline and increase the water availability in the region. Low specific yield and low storage capacity of these shallow weathered fractured aquifers would continue to play an increasingly important role in planning, design and management of groundwater resources of the region.

Abstract ID: 33198

Final Number: H21B-03

Title: Effective management of brackish irrigation water for a network of farms along a river by considering soil-water-plant feedback mechanisms: a conceptual framework development

Presenter/First Author: Syed Hamid Hussain Shah, Organization Not Listed, Faisalabad,

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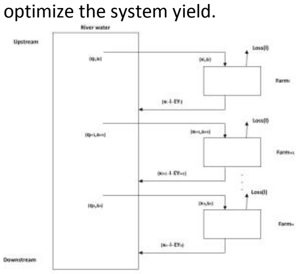
Abstract Body: In semi-arid regions, irrigation water to compensate the deficit of precipitation is compulsory for crop production. The demand for quantity of water used for agricultural production is greater than the required water for domestic utilization and production factories. With increase in population, the demand for good quality water increases. The cost to purify the brackish water also increases to fulfill the demand of agriculture. Therefore, the use of marginal water quality is increasing day by day. In order to reduce the effects of salinity on crop yield, irrigation water must contain additional water for leaching. This additional water becomes part of the surface and subsurface water resources and increases the leaching requirements due to increase in salinity level for next water user.

A conceptual framework developed by Ben Gal et al., (2013) has been applied and validated for optimal management of scarce and brackish irrigation water. The conceptual model is applied to the irrigation of *Zea mays L. c*v. Jubilee on Millville Silt Loam. In this model, it is shown that how water application should be distributed between upstream and downstream plots or farms. We show the scenarios where water is traded from upstream to downstream farms keeping in view that upstream farm holds the water rights.

The conceptual ANSWER model of irrigation containing conjunctive use of fresh and waste water predicts crop yields and water consumption and tracks the water flow and level of salinity along a river dependent on irrigation management decisions. The model considers a coupled agro-physical model, in which plant response to soil and climate parameters in addition to feedback is predicted. Furthermore, the model evaluates the impact of water shortage, salinity, and unproductive application on yield for exact crop, soil and climate conditions. We find that as salinity level and inefficiency increase, the upstream user must use less water and downstream user as a result uses better quantity and quality water to optimize the system yield.



Abstract ID: 36650

Final Number: H21B-04

Title: Submarine Groundwater Discharge of Artificial Releases? Using a Hydrodynamic Model to Assess the Origin of ^{222}Rn Activities in a Coastal Lagoon Connected to a Highly Anthropized Aquifer (Mar Menor, SE Spain).

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Published Material: A worked called "ESTIMATION OF SUBMARINE GROUNDWATER DISCHARGES USING RADON AND RADIUM ISOTOPES IN THE MAR MENOR LAGOON (SPAIN) AND THE PORT-MIOU CALANQUE (FRANCE)" was presented at Rapp. Comm. int. Mer Médit. in 2013. A paper has been sent to Journal of Hydrology and is under review.

Abstract Body: In highly anthropized watersheds, surface water tributaries may carry unexpectedly high quantities of radon (^{222}Rn) to surface water masses. Assessing the impact of these additional sources of radionuclides on the spatial repartition of radionuclides is a hard task for submarine groundwater discharge (SGD) investigations. A methodology was tested to the Campo de Cartagena aquifer - Mar Menor lagoon hydrosystem in SE Spain. In this area, intensive irrigation and subsequent recharge caused a severe water table rise, from which groundwater started to discharge to the main surface water stream. In addition, the uncontrolled release of brines from private groundwater desalination potentially induced artificial surface water discharges through the main stream or directly to the Mar Menor lagoon. In order to decipher the influence of the different water sources on the spatial repartition of radionuclides and to strengthen the quantification of submarine groundwater discharge fluxes, we combined a ^{222}Rn survey with the hydrodynamic modeling of the Mar Menor lagoon. Once demonstrated that reverse osmosis desalination does not affect significantly ^{222}Rn activities, it was shown that brine discharge exerted a main control on the total radionuclide discharge of the surface stream. Hydrodynamic modeling then demonstrated that high values measured along the discharge coastline were, unexpectedly, not indicators of localized SGD fluxes. Indeed, the observed high values were rather explained by the propagation of the river plume (central area), by artificial releases to the lagoon (northern area) and by agricultural groundwater drainage (southern area). These findings helped quantifying the impact of artificial releases and by then, strengthened the SGD quantification.

Abstract ID: 34983

Final Number: H21B-05

Title: Spatially distributed recharge modelling with commonly available data - Application to the Centre-du-Québec region of southern Quebec (Canada)

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Abstract Body: The estimation of mean groundwater recharge over a watershed is a relatively simple task when using a global water balance. However, such a simple recharge estimate often hides local variations of recharge that depend on geological, topographical or land use heterogeneity within the watershed. There is clearly a need to develop and use recharge models aimed at calculating spatially distributed recharge rates for regional scale hydrogeological studies. The objective of this work

was to develop an approach to quantify spatially distributed recharge rates based on commonly available data. The *HydroBilan* model was developed to estimates surface infiltration by calculating a spatial water balance with a 500 m x 500 m grid resolution. The model uses the temporally variable runoff estimate from the Runoff Curve Number (RCN) method adapted for southern Quebec, as well as the daily vertical inflows generated by the Centre d'expertise hydrique du Québec and the daily air temperature. Slope, land use and soil type data are extracted from a database typical of those generally available. A limited number of parameters, including soil freezing, moisture conditions and percentage of water that effectively infiltrates daily into the soil, require calibration. The model was calibrated with a 21-year time series on a 1550 km² sub-watershed to minimize the error between calculated runoff, evapotranspiration and seasonal evolution of the infiltration. The calibration was performed to reproduce the total runoff/recharge ratios simulated with the MOHYSE hydrological model as well as those from base flow separation data. The calibrated parameters were then used on the Nicolet and the lower Saint-François watersheds in the Centre-du-Québec region of southern Quebec (Canada; 18 300 cells over 4500 km²). The model estimates an average recharge of 152 mm/year for the study area and a preferential recharge zone over the Appalachian Mountains and a low recharge zone over the sedimentary plains. The *HydroBilan* model reaches its full potential in the Appalachian Piedmont where it allows the identification of sparsely distributed recharge areas. Potential recharge, evapotranspiration and runoff respectively represent 14%, 42% and 44% of the total water budget.

Abstract ID: 35444

Final Number: H21B-06

Title: Application of the Pressure-State-Response Framework for Measuring Groundwater Sustainability. Case Study: Campo de Cartagena (SE Spain)

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Abstract Body: In arid and semi-arid areas in which irrigated agriculture prevails, a sustainable management is difficult to achieve. The Campo de Cartagena area in the Murcia region (SE Spain) is an emblematic case of the hydrological and environmental changes caused by the intensive use of groundwater for agriculture in Mediterranean areas. It is a 1440 km² coastal plain where the climate is semiarid with an average temperature of 18˚C and an average rainfall of about 300 mm per year. The economy of the area relies on the agro-industrial sector with crops covering 1/3 of the total surface. Due to the low precipitation rate and a lack of permanent surface water, intensive irrigated agriculture has been historically and mainly supported by groundwater extraction from the aquifer system.

Since the introduction of the concept of sustainable development in the Brundtland report in the late last century, many scientists have recently turned to work on the objective measurement of sustainability through indexes. Applying these indices to the water resources management, it could be assessed the current state of them and they serve as an aid to decision-making by the competent authorities. Several issues impact the groundwater sustainability of an aquifer, such as hydrogeological, socioeconomical and environmental aspects. However, they are often treated separately, and not as an integrated process. The aim of this study is to integrate these issues and develop an index in order to assess the groundwater sustainability in a pressure-state-response framework. The proposed methodology could be extrapolated to many semi-arid basins with hydrological, environmental, social and political conditions similar to the case study.

Abstract ID: 34931

Final Number: H21B-07

Title: Simulating the Effects of Groundwater Dynamics on Aquifer Vulnerability

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Abstract Body: Groundwater vulnerability mapping is extensively used as an analytical tool for groundwater resource protection and land use management. Vulnerability mapping can however bring some limitation, as the most widely used methods (i.e. DRASTIC, GOD, SINTACS, etc.) are based on semi-objective weighted parameters. The majority of these methods do not take into account groundwater flow and solute transport. The objective of this study was to use numerical modeling to quantitatively identify the hydrogeological parameters which significantly influence contaminant transport and therefore aquifer vulnerability. A synthetic 3D model using MODFLOW and MT3D was built to represent the main characteristics (e.g. watershed scale, hydraulic gradient, recharge rate) of the Becancour watershed (2 900 km²) located in southern Québec (Canada). Diffuses sources of contamination were simulated as contaminant influx with the recharge and computed concentrations in groundwater were interpreted as a proxy of vulnerability. The numerical experiments show that maximum contaminant concentrations in groundwater are more largely influenced by hydrogeological parameters than by the size and density of the contaminant sources. At the regional scale, the simulated concentrations in groundwater are mostly sensitive to recharge rates and to the dilution potential with regional flow. At the local scale, river drainage coefficients and hydraulic gradients are the most influential parameters. As expected, these results suggest that the most vulnerable areas can be found where recharge rates are high and where the contaminant dilution potential is low. In the simulated model, the majority of contaminant input is exported out of the aquifer through the rivers. The modelling also suggests that deep bedrock aquifers could become vulnerable to anthropogenic pollution (e.g. nitrates) in the long-term, as nitrates originating from the beginning of intensive agriculture in the 70-80's may not yet have reached aquifers deeper than 75 m.

Abstract ID: 34957

Final Number: H21B-08

Title: The Impacts of Change in Rainfall and Groundwater Withdrawal on Groundwater Resources of Raya Valley, Northern Ethiopia.

Presenter/First Author: Merhawi GebreEgziabher GebreMichael, Addis Ababa University, Addis Ababa,

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Abstract Body: Climate change and anthropogenic factors have direct impact on the availability of subsurface water. Groundwater potential is governed by its quality and the quantity. The groundwater quantity is interconnected with the hydrological cycle and its components. Change in climate condition will have impact on the hydrological cycle leading variability on the groundwater resource by affecting the groundwater recharge. In contrary, human impact like excessive pumping exacerbate the depletion of the groundwater potential. In this study, we give more emphasis to change in rainfall and human induced groundwater discharge, on the available groundwater resource.

We have conducted hydrological and hydrogeological study to see the impacts of change in precipitation and groundwater withdrawal using groundwater flow modeling in Raya Valley, Northern Ethiopia. Raya valley, is characterized by humid to semiarid climate condition, where surface water is limited. The hydrogeological studies had proven the groundwater is accessible along two major aquifers, these are fractured volcanic and alluvial aquifers. Geomorphological setup shows, the volcanic aquifer is situated in the humid highland area and the alluvial aquifer is found in the lowland, where the climate condition is semiarid. The major sources of water are groundwater and seasonal flooding water.

A comprehensive conceptual modeling of the basin has been carried out using hydrochemistry, isotope hydrology, and hydrogeological studies. Then we conducted the flow modeling using Modflow Pro. The model was calibrated with the actual hydrogeological condition. The model result depicted that change in rainfall have a general declining trend in water level, this is as a result of reducing groundwater recharge. Under this scenario, lowering lake level and drying up of swampy areas is observed. The simulation of increasing groundwater pumping from the aquifers have been done to predict future water use and its impact. The model results shows that, a dramatic groundwater fall up to 20 meters as a result pumping ten times the current groundwater withdrawal. Therefore, the groundwater potential of the basin can be affected under high pumping conditions and the adjacent wetlands will dry up, as a result of pumping the groundwater dependent ecosystem will be in danger.

Abstract ID: 33332

Final Number: H22A-01

Title: A Unified Approach for Process-based Hydrologic Modeling

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Published Material: Some material presented at AGU; papers under review in WRR.

Abstract Body: This work advances a unified approach to process-based hydrologic modeling to enable controlled and systematic evaluation of multiple model representations (hypotheses) of hydrologic processes and scaling behavior. Our approach, which we term the Structure for Unifying Multiple Modeling Alternatives (SUMMA), formulates a general set of governing model equations and spatial approximations, providing the flexibility to experiment with different spatial representations, different flux parameterizations, different model parameter values, and different time stepping schemes. In this paper we introduce the general approach used in SUMMA, detailing the spatial organization and model simplifications, and how different representations of multiple physical processes can be combined within a single modeling framework. We discuss how SUMMA can be used to systematically pursue the method of multiple working hypotheses in hydrology. In particular, we discuss how SUMMA can help tackle major hydrologic modeling challenges, including defining the appropriate complexity of a model, selecting among competing flux parameterizations, representing spatial variability across a hierarchy of scales, identifying potential improvements in computational efficiency and numerical accuracy as part of the numerical solver, and improving understanding of the various sources of model uncertainty.

Abstract ID: 33330

Final Number: H22A-02

Title: Simulated thaw development of a peat plateau-bog complex in a discontinuous permafrost region, Northwest Territories

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Abstract Body: Air temperatures at high latitudes have increased at rates that exceed globally averaged trends, and this warming has produced rapid permafrost degradation in many areas. In discontinuous permafrost regions of the Taiga Plains of northwestern Canada, past climate warming has created a complex landscape mosaic of thawed bogs/fens and remnant peat plateaus underlain by thin permafrost. The thawing of peat plateaus can alter the landscape hydrologic connectivity by creating pathways to efficiently convey water from bogs to nearby rivers and lakes. Extensive monitoring of the thermal regime of a peat plateau-bog complex in the Scotty Creek watershed (61.3˚ N, 121.3˚W), Northwest Territories has identified rapid permafrost degradation in the past decade. In addition, satellite images indicate major landscape evolution due to permafrost thaw since 1970, and these changes have resulted in increased discharge at the watershed outlet. These long term comprehensive data facilitate the numerical modeling of idealized permafrost environments based on observed data. The objective of this project is to elucidate processes that contribute to multi-dimensional permafrost thaw and associated hydrological changes in discontinuous permafrost regions.

The thaw evolution in this peat plateau-bog complex is simulated using SUTRA, a numerical groundwater flow and heat transport model that has been modified to include freeze-thaw processes. To accommodate complex surface processes, measured climate data from 1900-2010 are used to drive a separate soil-vegetation-atmosphere-transfer model. Near-surface temperatures produced by the vertical transfer model for the peat plateau and bog are applied as the upper thermal boundary conditions for the multi-dimensional subsurface heat transport simulations. The simulated thaw development of this peat plateau will be compared to satellite imagery to assess the ability of this sequential modeling approach to reproduce observed permafrost degradation.

Abstract ID: 34621

Final Number: H22A-03

Title: Implications of Galling Herbivory on Ground Thaw Through Shrub-Soil Heat Transfers Within Canada's Northern Boreal Forest

Presenter/First Author: Allison McManus, Wilfrid Laurier University, Waterloo, ON

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Co-authors: Jennifer Lynn Baltzer, Wilfrid Laurier University, Waterloo, ON, Canada; William L Quinton, Wilfrid Laurier University, Waterloo, ON, Canada

Published Material: Poster presentation of preliminary findings at the 2nd Annual General Meeting of the Changing Cold Regions Network, October 19-22, 2014. Research is not currently under review or recently accepted by a scientific journal.

Abstract Body: The significant climate warming faced by Canada's northern boreal forest has the potential to affect forest dynamics by altering the dispersion and abundance of resident natural enemies. Warmer air temperatures can impact the distribution and overwinter survival rate of these arthropods. Thus, the impacts of arthropod pests on

their host plants require better understanding. Gall-inducing mites are a resident natural enemy in high latitude forests and have been shown to drive dramatic reductions in photosynthetic carbon uptake and transpiration rates of infested plants with the potential to alter shrub-energy balance. In this study we examine the impacts the gall-inducing eriophyoid mite, *Vasates oldfieldi*, has on *Betula* shrub energy inputs to the underlying ground surface. Two hypotheses will be tested: 1) a positive feedback to permafrost thaw through a reduction in evaporative cooling on the leaf surface increasing the canopy temperature of the *Betula* shrubs. The increase in the incident longwave radiation to the ground surface leads to an increase in the active layer thickness. 2) a negative feedback on permafrost thaw through a compensatory response in the shrub leading to an increase in leaf area index (LAI) to offset the loss of photosynthetic function. This reduces the amount of incident solar radiation at the ground surface resulting in a shallower active layer. To test these hypotheses, we measured soil moisture and surface temperature, leaf temperature, active layer thickness, shortwave radiation, transpiration and LAI. Our initial findings have shown an increase in active layer thickness and soil temperature under ungalled shrubs compared to galled shrubs of similar size for both the 2013 and 2014 field seasons. The results from this experiment are of great significance as the potential for a positive feedback of warming at a very local scale can potentially influence ground thaw in the northern boreal forest.

Abstract ID: 35167

Final Number: H22A-04

Title: Robustness in the spring surface energy balance in a mountain basin

Presenter/First Author: Chris Marsh, Global Institute for Water Security (GIWS), University of Saskatchewan, Saskatoon, SK

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Co-authors: John W Pomeroy, University of Saskatchewan, Canmore, AB, Canada; Howard S. Wheater, University of Saskatchewan, Saskatoon, SK, Canada; Raymond J Spiteri, , ,

Abstract Body: Complex dynamical systems, such as hydrological systems, exhibit system-wide behaviours that are due to the interaction of numerous processes and may result in system robustness. Such robustness is characterized by persistent behaviours despite system perturbations. In process-based hydrological models, inter-process interactions are typically included to increase physical realism, often at the cost of increased complexity. Model robustness is characterized by a persistence of model behaviours to perturbations in initial/boundary conditions, system parameters, and underlying model assumptions. This model robustness may reproduce system robustness and allow up-scaled and possibly falsified model representations of the system to be successful. Model robustness is distinguished from model stability by considering not just the persistence of behaviours but by also considering the interplay between model dynamics, model structure, and model assumptions that leads to this persistence. Quantifying the details of why, and under what conditions, system and model robustness occurs is critically important to deciding how to design robust hydrological models of sufficient complexity that can perform well when faced with uncertainty in parameters and forcing data.
In this work, we explore model robustness through the use of point-scale, physically based, energy-budget snowmelt models of varying degrees of physical realism and model complexity. We consider snowmelt model robustness as a possible surrogate for snowmelt system robustness over complex mountain topography. These models are driven by data from a mountain research watershed to examine the effects of surface characteristics, perturbations to meteorological forcing, and level of process representation on robustness. The results have implications for the estimation of uncertainty in the representation of complex mountain terrain and snow processes in up-scaled hydrological models and land surface schemes.

Abstract ID: 35614

Final Number: H22A-05

Title: Sensitivity of Snow-Vegetation Interactions and Streamflow Regimes to Climate Change in Mountain Basins

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Abstract Body: Understanding the interactions amongst snow processes, vegetation and runoff in mountains is crucial for climate change impact studies. In this research, a sensitivity analysis is carried out based on regional climate model scenarios, field measurements, and factors that control vegetation growth. The objectives are to investigate the interaction of concomitant vegetation and snow changes and to simulate transient changes in hydrological processes under climate change. Land cover changes alter the evapotranspiration, sublimation, snow redistribution, infiltration and runoff mechanisms which are responsible for the variability of subsurface storage, soil moisture, active layer thickness, and vegetation growth. The Cold Regions Hydrological Modelling platform (CRHM) is applied for modelling these mechanisms based on transient changes in vegetation. The model is tested in two well instrumented mountain headwater basins: Wolf Creek Research Basin, WCRB, with a very cold climate and discontinuous permafrost in the Canadian subarctic and Reynold Mountain East catchment, RME, in the Reynolds Creek Experimental Watershed with a moderate climate in Idaho, USA. The results showed that the hydrological impacts of warming decreased snowmelt runoff substantially in both basins. In WCRB warming increased the active layer depth, leading to conditions suitable for the growth of shrub tundra and conversion of some shrub tundra to forest and short vegetation to shrubs. In contrast, the hydrological response to warming in RME led to smaller snow drifts, which led to conversion of forests that were dependent on meltwater from snowdrifts to sagebrush and grass. The increase in forest area and expansion of shrubs in WCRB further decreased runoff generation at lower and middle elevations and moderated decreased runoff at higher elevations; the suppression of snow redistribution by wind shortened the melt season. The loss of forests from RME accelerated melt rates of the remaining snowpack and reduced evapotranspiration losses, slightly dampening the reduction in streamflow from the reduced snowmelt due to warming.

Abstract ID: 34722

Final Number: H22A-06

Title: Effects of Roads and Linear Forest Disturbances on the Snow Mass and Energy Balance

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Abstract Body: Linear disturbances for infrastructure such as roads, power transmission and pipelines are commonplace and rapidly expanding across the seasonally snow-covered needle-leaf forest zone in North America. Compared to other disturbance practices (e.g., clearings for timber harvest), the relatively narrow extent and permanence of linear

disturbances uniquely modifies surface-atmosphere exchanges, largely due to changes to longwave and shortwave radiation and greatly reduced snow interception capacity due to the reduction in needleleaf canopy. The sign and magnitude of these modifications are determined by how hydrometeorological processes such as snow interception, wind redistribution, radiation transfer and turbulent transfer of heat and water vapour are controlled by climate, forest structure, and slope-aspect. Results are presented from a modelling study of snow mass and energy balance dynamics in and around conceptual linear forest clearings. A solar ray trace model developed and tested against extensive measurements made at the Marmot Creek Research Basin is coupled to a snow energy and mass balance calculation scheme and applied to a range of latitude, slope-aspect, and disturbance and forest characteristics. The results are shown to resolve shading effects necessary to simulate the fine-scale variability in the snow surface energy balance that characterize these environments. A comparison of simulation results from a sensitivity experiment showed that the orientation of the disturbances (i.e., N-S vs. E-W), the latitude, and the width-to-tree-height ratio were three dominant factors determining the net impact of the linear disturbances on the timing and duration of snowmelt. The disparity in energy and mass balance over short distances highlights the importance of understanding the variability of hydrological inputs over forested regions that are fragmented by linear disturbances.

Abstract ID: 35551

Final Number: H22A-07

Title: Measuring and Modelling a Major Winter Precipitation Event in the Canadian Rockies

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Abstract Body: Mountains present extraordinary challenges to both snow measurement and modelling. The seasonal snowpack in the Canadian Rockies is strongly influenced by accumulation and redistribution during and after snowstorms. Often just a few large storm events determine the main characteristics of the seasonal mountain snowpack. Quantifying the temporal and spatial distribution of mountain snowpacks due to individual storms is therefore of great interest for water supply prediction from mountains. In order to assess the variability and uncertainty in accumulation and ablation associated with a major snow storm, precipitation, snow accumulation and snow depth measurements were made in the Canadian Rockies during and after a major storm event in November 2014. The storm was characterised by strong winds and rapidly decreasing air temperatures as a cold front advanced from the north. Measurements suggest that snowfall of up to 90 mm SWE over two days was caused by uplifting of a warm, relatively moist, air mass as the cold front advanced. Blowing snow, and potentially preferential deposition, contributed to the highly variable post-storm snow accumulation. To assess the relative contributions to variable snow accumulation, snowfall gauge undercatch corrections were applied to sites with different wind exposures but identical precipitation gauge types and compared to results from automatic and manual snow accumulation and snow depth measurements in sheltered and open sites. A blowing snow model was then run to estimate blowing snow redistribution. The results suggest that there is great uncertainty in estimating snowfall in this environments because gauge-undercatch corrections established at flat test sites do not produce credible values in complex terrain and because snowfall gauges bridge with large snowfall amounts. The relative impacts of measurement errors, preferential deposition and blowing snow redistribution are discussed.

Abstract ID: 34927

Final Number: H22A-08

Title: The Influence of Site Conditions and Surface Vegetation on Snow Accumulation and Ablation in the Elk Valley, British Columbia, Canada

Presenter/First Author: David Aaron Bezeau, McMaster University, Hamilton,

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Abstract Body: Surface mining of coal in the Elk Valley, British Columbia involves the blasting of overburden rock to access the underlying coal formations. Waste rock is placed in adjacent valleys, which influences the timing and magnitude of hydrological fluxes within the watershed. As part of a multi-year R&D program examining the influence of surface mining on watershed hydrology in the Elk Valley, British Columbia, this study investigates how: 1) site conditions and surface vegetation atop waste rock influences snow accumulation and ablation, and 2) the ability of a physically based model to simulate these processes. During the 2014 melt season, meteorological observations, turbulent fluxes determined via eddy covariance, and snow conditions were measured at three sites: 1) a bare waste-rock surface, 2) a waste-rock surface covered with agronomic grass species, and 3) a mixed pine stand on waste-rock. Elevation was the dominant control of snow accumulation, with the upper elevation site recording a maximum snow water equivalent of 670 mm, that compared to the lower elevation site with a maximum snow water equivalent of 170 mm. Ablation was driven largely by incoming short-wave radiation, which at the bare waste-rock and grass covered waste rock sites was greater than at the forested site. Melt occurred at the forest site several weeks in advance of the bare and grass covered sites. Turbulent flux contributions to snow ablation were limited at the forested site relative to the bare waste-rock and grass covered waste rock sites. The physically based Cold Regions Hydrological Model (CRHM) was able to simulate the influence of surface vegetation on the accumulation and melt dynamics. Model results were sensitive to parameters quantifying vegetation cover and blowing snow. Results of this study assist our understanding of how surface vegetation on waste rock and site conditions can influence the timing and magnitude of melt and infiltration, and subsequent freshet response.

Abstract ID: 33375

Final Number: H22B-01

Title: An Overview of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing

Presenter: Thomas Darrah, Ohio State University Main Campus, Columbus, OH

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Published Material: This is an overview presentation based on several scientific publications on the environmental effects of shale gas exploration.

Abstract Body: The rise of unconventional shale gas development through horizontal drilling and high volume hydraulic fracturing has expanded oil and gas exploration in the USA. The rapid rate of shale gas exploration has triggered an intense public debate regarding the potential environmental and human health effects. Active research by the Duke team in different parts of the USA (Pennsylvania, West Virginia, New York, Arkansas, North Carolina, Texas) has identified four potential risks for impacts on water resources: (1) stray gas contamination of shallow aquifers near shale gas sites resulted in elevated methane levels in some drinking water wells located < 1 km from shale gas wells ; (2) contamination of surface water and shallow groundwater from spills, leaks, and disposal of inadequately treated oil and gas wastewater resulted in elevated levels of halides, ammonium, barium, radium among other contaminants in downstream waterways ; (3) accumulation of toxic and radioactive residues in soil and stream sediments near disposal or spill sites; and (4) over-extraction of water resources for drilling and hydraulic fracturing that could induce water shortages and conflicts with other water users, particularly in water-scarce areas. New state-of-the-art geochemical and isotopic techniques have been developed for delineating the origin of gases and contaminants in water resources. In particular, multiple geochemical and isotopic (carbon isotopes in hydrocarbons, noble gas, strontium, boron, lithium, radium isotopes) tracers have been utilized to distinguish (1) fugitive gas induced from leaking of shale gas wells relative to background naturally occurring methane flux in the subsurface; and (2) contamination from hydraulic fracturing fluids relative to produced water from conventional oil and gas wells and/or naturally occurring salinization. Overall, the environmental effects of unconventional shale gas exploration and hydraulic fracturing can be mitigated by improving the wells integrity and preventing leaking of stray gas, treating or preventing the release of flowback and produced waters to the environment, and using alternative water resources instead of fresh water for hydraulic fracturing.

Abstract ID: 35043

Final Number: H22B-02

Title: Gas Emissions from Energy Wells and the Groundwater Monitoring Problem

Presenter/First Author: Richard Ervin Jackson, Geofirma Engineering Ltd, Heidelberg, ON

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Co-authors: Dru Heagle, , ,

Abstract Body: There is accumulating evidence from the drilling and completion of some energy wells of free-phase gas emissions migrating considerable distances away from such wells (500 m or more) in structurally complex terrain. This information was obtained by regulatory agencies and geological surveys in structurally complex regions such as the Appalachian belt of eastern North American. Such migration distances pose real problems with respect to the monitoring of gas emissions that may affect shallow potable groundwaters. Information on wellbore leakage is only recently appearing in the technical literature reflecting what industry has long acknowledged, i.e., the difficulty of wellbore sealing with cement slurries when numerous strata contain hydrocarbon and hydrogen sulfide gases under varying in-situ pressures. Given (i) the transient nature of natural gas emissions from energy wells, (ii) the spatial and temporal variability of groundwater quality and (iii) the uncertain integrity of landowner wells, there is clearly a burden of proof on those sampling landowner wells to demonstrate that the 'pre-drill' data collected are robust and provide reliable information for use in dispute resolution. Not only can we expect gas emissions to be pulses, but we must anticipate that the discharge area, in which such gas 'daylights', might be distant from the energy well pad and its location therefore uncertain. For these reasons there is a clear need to link research concerning wellbore integrity with gas migration through fractured-rock networks. Similarly, groundwater monitoring has to be focused on potential gas-discharge areas that contain public groundwater supply wells. Such research and monitoring requires recognition from research-funding institutions, regulatory agencies and geological surveys.

Abstract ID: 35798

Final Number: H22B-03

Title: Paleozoic Brine and Gas Seeps on Anticosti Island: Impacts for Developing Unconventional Hydrocarbon Resources

Presenter/First Author: Ian Douglas Clark, University of Ottawa, Ottawa, ON

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Abstract Body: The Upper Ordovician Macasty shale on Anticosti Island hosts hydrocarbon potential currently being evaluated for non-conventional extraction. This study focuses on groundwaters in the region for evidence of deep groundwater discharge to shallow aquifers and at surface. Of particular interest is the high salinity spring, Source-de-Saumure-de-la-Chaloupe, situated near the Chaloupe River on Anticosti Island. At this spring, water is discharging at about 0.05 L s^{-1} with salinity of 3x seawater and accompanying gas ebullition at a rate of roughly 10 cc s^{-1}. The water precipitates calcite, forming a mound measuring about 1 m in height and 30 m in diameter around the main vent. Stable isotopes and geochemistry of the waters indicate them to be a mixture between shallow, meteoric waters and basin brines of evaporated seawater origin. The gas is dominated by methane with $\delta^{13}C$ values from –57.7‰ (June 2014) to –44.3‰ (July 2013) that suggests a mixture between biogenic and thermocatalytic methane. The dissolved inorganic carbon has an enriched $\delta^{13}C$ signature (+9.2‰) indicating that the DIC is affected by biogenic methanogenesis. Preliminary DNA sequencing results of biofilms growing in the brine suggest that bacteria and archaea likely play a role in carbon cycling. Our current hypothesis in this evolving study holds that shallowly circulating, methanogenic groundwater in the karstic aquifers of Anticosti Island acquires contributions of basin brine with thermocatalytic methane from the deep Paleozoic strata via a system of fracture permeability associated with the adjacent Jupiter fault. Ongoing research focuses on noble gases and ^{14}C with stable isotopes of the carbon pool to resolve the origins of the mixing fractions.

Abstract ID: 33575

Final Number: H22B-04

Title: Numerical investigation of methane and formation fluid leakage along the casing of a decommissioned shale-gas well: Application to the St. Lawrence Lowlands Basin

Presenter/First Author: Jean-Michel Lemieux, SNC-Lavalin Environment, Montreal, QC

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Co-authors: Ali Nowamooz, Universite Laval, Quebec, QC, Canada; John W H Molson, Laval University, Quebec City, QC, Canada; Rene Therrien, Universite Laval, Quebec, QC, Canada

Published Material: This material has been presented at the IAH conference in Marrakech (fall 2014) and at the GSA annual meeting in Vancouver (fall 2014). It is also in submission to WRR (revisions pending).

Abstract Body: Numerical simulations are used to understand the role of the well casing annulus cementation and formation hydrodynamic properties on the migration of methane gas and formation fluids in the context of environmental risks related to shale gas development.

A conceptual model of a vertical decommissioned shale gas well is developed based on a geological sequence in the St. Lawrence Lowlands Basin (Quebec, Canada) containing from bottom to top, 200 m of Utica shale overlain by 750 m of low-permeable caprock (Lorraine Group), which is in turn overlain by a 50 m thick surficial unconsolidated sand aquifer. The geological sequence is intersected by a borehole with an external diameter of 200 mm and a cemented casing annulus thickness of 50 mm. A parametric study of leakage scenarios is then conducted, assuming isothermal multi-phase, multi-component flow. The model is not calibrated, but the simulations are used to identify the possible range of leakage rates and the time scale for gas and contaminant migration along the casing annulus. Although observed properties of the geological formations of the St. Lawrence Lowlands Basin are used, the results presented here have broad outreach due to the similarity of hydrodynamic properties of other shale formations.

The numerical results show that an adequately cemented borehole (with a casing annulus permeability $k_c \leq 1$ mD) can prevent methane and brine leakage over a time scale of up to 100 years. However, a poorly cemented borehole ($k_c \geq 10$ mD) can yield methane leakage rates ranging from 0.08 m^3/day to more than 100 m^3/day, depending on the hydrodynamic properties of the target formation and the quantity of mobile gas after abandonment. These leakage rates are consistent with Surface Casing Vent Flows (SCVF) reported for shale gas wells in Québec and Alberta. Simulated long-term brine leakage rates after 100 years for poorly cemented boreholes ($k_c \geq 10$ mD) are on the order of 10^{-4} m^3/day (0.1 l/day). Based on scoping calculations with a well-mixed aquifer model, these rates are unlikely to have a major impact on groundwater quality in a confined aquifer since they would only increase chloride concentrations by about 1 mg/l above background, a negligible increase relative to the commonly recommended aesthetic objective of 250 mg/l for chloride.

Abstract ID: 34469

Final Number: H22B-05

Title: Numerical Modelling of Methane Gas Migration from Decommissioned Shale Gas Wells into Shallow Aquifers

Presenter/First Author: Nicolas Roy, Laval University, Québec,

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Co-authors: John W H Molson, Laval University, Quebec City, QC, Canada; Jean-Michel Lemieux, SNC-Lavalin Environment, Montreal, QC, Canada; Dale Van Stempvoort, , , ; Ali Nowamooz, Universite Laval, Quebec, QC, Canada

Abstract Body: The behavior and fate of methane gas leaking from decommissioned shale gas wells into shallow aquifers is simulated in three dimensions. The main objective is to assess the efficiency of natural bacterially-driven processes to mitigate methane concentrations in both confined and unconfined aquifers. The conceptual model includes a shallow sandy aquifer pierced by a vertical well which is leaking gas-phase and dissolved-phase methane from a faulty cement seal within the underlying rock. The modelling approach couples the DuMux multi-phase simulator with the BIONAPL/3D flow and transport code for reactive transport and degradation of dissolved methane under oxygen and/or sulfate-reducing conditions. Methane behavior in the aquifer is evaluated for different leakage rates, background geochemistry and hydraulic gradients. In confined aquifers, methane will tend to persist longer than in unconfined aquifers from which the buoyant gas phase will more readily escape. Aquifers with a naturally high background sulfate concentration can significantly attenuate methane migration. Moreover, dissolved oxygen inflow through groundwater recharge in unconfined aquifers can also enhance methane oxidation. By-products of methane degradation reactions can also affect the groundwater geochemistry. The modelling approach can be extended to other contaminants emerging from deep decommissioned or abandoned wells or from natural faults and fractures such as brines, fracking fluids or hydrocarbons.

Abstract ID: 34900

Final Number: H23A-02

Title: A New User-Friendly Tool to Estimate Groundwater Recharge from Daily Weather Data and Well Hydrographs

Presenter/First Author: Jean-Sébastien Gosselin, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec,

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Co-authors: Christine Rivard, Natural Resources Canada, , ON, Canada; Richard Martel, INRS-Eau Terre Environnement, Quebec, QC, Canada; Rene Lefebvre, INRS-ETE, Quebec, QC, Canada

Abstract Body: The estimation of groundwater recharge from well hydrographs is commonly done in groundwater resource assessment projects. However, this task can be cumbersome and time consuming, especially if there are several wells in the study area with many years of data. To address this issue, the open-source user-friendly application named WHAT (Well Hydrograph Analysis Toolbox) was developed. WHAT estimates groundwater recharge at the local scale using a method combining daily weather data and a well hydrograph. First, the application prepares a complete daily weather time-series representative of the well location. For this purpose, data from the Government of Canada website can be downloaded and automatically formatted. Furthermore, missing data can be filled with data from selected neighboring weather stations using a multiple linear regression model. Groundwater recharge is then estimated as the residual of a daily soil moisture balance (DSMB). In a second step, the daily recharge fluxes are substituted into a mathematical model of the aquifer groundwater balance to produce a synthetic well hydrograph. The third and final step of the method consists in the calibration of the DSMB model parameters, based on the comparison of synthetic and observed well hydrographs. WHAT offers several advantages: 1) gap-free weather datasets can be quickly and conveniently set up; 2) recharge is estimated with a rarely used approach combining well hydrographs and weather data; 3) groundwater levels and aquifer recharge can be calculated for the entire period covered by weather records; and 4) it includes a variety of functionalities useful for the interpretation of water level measurements, such as the plotting of air temperature, precipitation and water-level time series on the same graph. The software is available for download free of charge on GitHub (www.github.com/jnsebgosselin/WHAT).

Abstract ID: 33433

Final Number: H23A-03

Title: Rapid Recharge in a Shallow Bedrock Aquifer Having Minimal Overburden

Presenter/First Author: Kent S Novakowski, Queen's University, Kingston, ON

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Co-authors: Owen Miles, , ,

Abstract Body: Rapid recharge events which occur as significant increases in hydraulic head following rainfall have been observed widely in fractured

bedrock aquifers. The response in hydraulic head often exceeds what would be observed in a porous aquifer by more than a factor of ten. These responses have been variously attributed to air entrapment, mechanical loading due to the rainfall, or due to the low specific yield of bedrock aquifers. In this study, a detailed investigation was conducted at a well-characterized field site in eastern Canada, to resolve the possible mechanisms. The bedrock is composed of gneiss covered by a thin veneer of drift materials having variable thickness (0-4 m). During an intensive monitoring period of approximately six months, a multi-level piezometer located on a bedrock outcrop which responded rapidly and in large magnitude to rainfall (> 1 m rise in hydraulic head to less than 20 mm of rainfall) was identified and used as a focus for numerical simulations. Contiguous measurements of transmissivity with depth (total depth equal to 15 m) were collected and a survey of fracture features was obtained via borehole camera, prior to completion as a multi-level piezometer. To determine the thickness of the drift materials in the vicinity of the outcrop, a GPR survey was conducted over a 40×40 m area. A total of eight infiltration experiments were also conducted over the same area using a novel infiltration system which covers an area of 10×10 m. Three-dimensional numerical simulations were conducted using HydroGeoSphere to reproduce the response in the piezometer for both the natural and simulated infiltration events over short (24 hour) and long (one month) timescales. The numerical simulations were used to evaluate the parameters most likely to impart rapid response and recharge. Based on this study it was concluded that the large magnitude head rises recorded in this piezometer are a result of recharge to steeply inclined fractures exposed on or immediately adjacent to the outcrop. The hydraulic head responds rapidly because of the low specific yield of the rock to which the transmissive features are connected. The modeling and infiltration experiments also showed that as little as 0.4 m of drift material can completely eliminate response in the well especially during times when evapotranspiration is high.

Abstract ID: 33127

Final Number: H23A-05

Title: Impacts of Snow Cover and Frozen Soil on Groundwater Recharge

Presenter/First Author: Sophie Guillon, GEOTOP-UQAM, Montréal,

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Co-authors: Florent Barbecot, UQAM, , QC, Canada; Marie Larocque, Univ du Quebec - Montreal, Dorval, QC, Canada; Daniele Luigi Pinti, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Eric Pili, CEA/DAM-ILE DE FRANCE, Arpajon, France

Abstract Body: In many Northern Hemisphere locations, groundwater recharge mainly occurs during the spring snowmelt and as a result of fall rain. In these cold environments, smaller recharge events also occur during the winter due to melting at the snow-soil interface and infiltration into frozen or thawed soil. But soil water dynamics and water infiltration before the onset of spring snowmelt are neither well studied nor constrained. The intensity and duration of these winter recharge events appear to be controlled by the thickness and permeability of frozen soil and its frozen water content. We present a case study based on the monitoring of water fluxes during the winter season at an instrumented site located on a sand deposit (esker), southwest of Montreal (Canada). Water content and temperature are measured in the first meters of soil and in the snowpack during winter season. Tracing experiments using D_2O-enriched water are performed to identify water infiltration, fluid velocity and transport mechanisms. Heat and hydraulic parameters are determined for the frozen soil and the snow cover. These data are used to validate and calibrate a numerical scheme to quantify water and heat budgets as well as water recharge fluxes. This work focuses on the availability of liquid water at the soil surface and on the influence of soil freeze/thaw events on the possibility and extent of winter infiltration as opposed to surface runoff.

Abstract ID: 36062

Final Number: H23A-06

Title: Drip flow and gravity driven simulations of water transfer in vadose dolomite karst

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Abstract Body: Recharge processes in a Mediterranean dolomite karst are studied on the basis of simulations and field measurements. Located 10 meters beneath the surface of a karst plateau, the Canalette's cave (Larzac, South France) offers a window on the karst vadose zone. To appreciate the various recharge processes, models are constrained with hydro-meteorological and gravity data, which are sensitive to the underground mass variation. The high weathering of the dolomite karst allows assuming that the vadose zone has a continuous porosity and permeability. Numerical simulations accounting for Richard's equations are performed; then, the influence of i) the matrix rock/cave interface and of ii) hysteresis and on the drip discharge and on the water content distribution within the vadose zone is assessed. The major water storage variations are clearly evidenced within the first 5 meters. A saturated zone is observed above the matrix rock/cave interface, which locally enhances permeability and generates downward flush mechanism. Finally, the recharge processes and the role of hysteresis evidenced from the local study are discussed at the basin scale to understand the dolomite karst singular recharge dynamic.

Abstract ID: 36816

Final Number: H23A-07

Title: Assessment of recharge to the coastal Bou-Areg aquifer (Morocco) using environmental tracers.

Presenter/First Author: Paul Baudron, Polytechnique Montreal, Montreal, QC

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Abstract Body: Located in NE Morroco, the coastal Bou-Areg aquifer provides an illustration of hydrogeological consequences of the rapid development of irrigated agriculture in semi arid mediterranean areas. The main features are a saline water intrusion in the coastal zone, and elevated nitrate concentrations in agricultural areas, as a consequence of excessive withdrawals and increased recharge through irrigation return flow, respectively. While, the aquifer is expected to receive fresh water from

lateral recharge, the dissolution of messinian evaporites may provide another source for salinity. Here, more than elsewhere understanding the origin of groundwater and the global recharge pattern is a fundamental step for a sustainable groundwater management. To this end, eleven samples were collected in September 2014 for young-aged radiogenic (^{3}H), old-aged radiogenic (^{14}C) and stable (^{13}C, ^{2}H, ^{18}O) isotopes combined with additional young-age (SF_6, CFCs) tracers and noble gases (Xe, Ar, Kr, Ne). Preliminary results allow to distinguish between at least two groundwater masses, to estimate recharge rates in the plain and to provide insights on lateral groundwater inputs from the surrounding mountainous areas.

Abstract ID: 35057

Final Number: H23B-01

Title: Improvement of Land Surface Schemes for Cold Region Processes: Recent Results from the Changing Cold Regions Network in Western Canada

Presenter/First Author: Howard S. Wheater, University of Saskatchewan, Saskatoon, SK

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Published Material: Findings have been previously reported in the following two publications: (1) Chun, K.P., Wheater, H.S. and Barr, A.G. 2014. A multivariate comparison of the BERMS flux tower observations and Canadian Coupled Global Climate Model (CGCM3) outputs. Journal of Hydrology, 519 Part B, 1537-1550, doi:10.1016/j.jhydrol.2014.08.059.(2) Khaliq, M.N., Sushama, L., MOnette, A. and Wheater H.S. 2014. Seasonal and extreme precipitation characteristics for the watersheds of the Canadian Prairie Provinces as simulated by teh NARCCAP multi-RCM ensemble. *Climate Dynamics,* doi:10.1007/s00382-014-2235-0.

Abstract Body: Recent North American Regional Climate Change Assessment Program (NARCAAP) Regional Climate Model ensemble results for Western Canada shows reasonable inter-model consistency for future precipitation change, but analysis of historical performance shows large (positive and negative) biases. Clearly there is need to understand and overcome model limitations to improve model performance. The Changing Cold Regions Network is maintaining a set of observatories across Western Canada, focussed on the Saskatchewan and Mackenzie River Basins, which provides a basis for model performance analysis and the development of improved land surface schemes. Results from a set of boreal forest flux towers are used to illustrate systemic differences between the inter-variable dependencies of observed and GCM simulations which show new insights into potential model limitations. The paper will also review results of ongoing comparisons between ground-based observation and land surface scheme performance over the CCRN network, and hence discuss the prioritisation of improvements in representation of cold region processes.

Abstract ID: 35234

Final Number: H23B-02

Title: Representation of high-latitude hydrology in climate models

Presenter/First Author: Laxmi Sushama, University of Quebec at Montreal UQAM, Montreal, QC

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Abstract Body: High-resolution regional climate model outputs, including surface hydrologic variables such as streamflows, are increasingly being used directly in many impact and adaptation studies. The realism of these RCM simulated surface variables for the high-latitude regions is dependent to a large extent on the representation of surface types and processes important for these regions and their atmosphere interactions. This will be demonstrated by comparing simulations performed with the fifth generation of the Canadian Regional Climate Model (CRCM5), with and without organic soil, near-surface permafrost, lakes and interactive phenology, for the Canadian high-latitude and Arctic regions. The comparison of simulations with and without organic soil, for example, indicates significant differences in the energy and water partitioning at the surface, leading to differences in both the regional climate and hydrology. The runoff and therefore streamflows are higher for the summer and fall seasons in the simulation with organic soil compared to the one without organic soil, while the inverse is noted for the spring season. The relatively higher value of runoff in summer and fall in the simulation with organic soil is mostly due to increased drainage contribution. Similarly, the differences in the surface climate, particularly the 2-m minimum temperatures, lead to differences in the hot spell characteristics in the two simulations. This talk will discuss the mechanisms leading to these differences as well as the comparisons between the other simulations performed to identify the impact of lakes and interactive vegetation on the surface hydrology/climate. Projected changes to selected hydrometeorological variables over Canada from the improved model simulations will also be presented.

Abstract ID: 34490

Final Number: H23B-03

Title: Toward a Better Understanding of Hydrological Impacts of Climate Change: Lessons Learned from Ouranos Hydroclimatic Studies Based on Regional Climate Model Simulations

Presenter/First Author: Biljana Music, Ouranos, Montreal, QC

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Abstract Body: Global warming is expected to alter the water cycle across the planet in multiple ways. Many studies indicate that hydrological regimes and extremes across different regions of the world will be affected differently bringing about various unfamiliar environmental risks. Understanding regional hydrological cycles and their variability and potential changes under an evolving climate requires the development and implementation of sophisticated modeling and data analysis tools. Numerical climate change experiments based on Regional Climate Model (RCMs) have proven to be powerful tools in assessing hydrological impacts of climate change over a region of interest. Constantly refining spatial resolution of RCMs promises better representation of small-scale processes and more reliable description of the interactions between the land-surface and the atmosphere, which have significant effects on the hydrological cycle. In the past years, the Ouranos Climate Simulation and Analysis team has produced a large number of regional climate simulations using the Canadian RCM (CRCM) at a spatial resolution of 45 km. Data from this vast databank has been very useful for hydrological impact and adaptation studies. Moreover, RCM simulations generated in the framework of several international collaborative RCM projects, such as NARCCAP, in which Ouranos made significant contributions, allowed construction of multi-model ensembles that are essential for analysis and quantification of various sources of uncertainties. Quantifying uncertainty associated with RCM simulations is an important part of hydrological projections and will be discussed in the first part of the presentation. Thereupon, several results where RCM hydrological outputs are used to assess impact of climate change on the probability of extreme events of the hydrological regime will be presented. Special focus will be given to projects aiming to assess Great Lakes Net Basin Supplies under a changing climate.

Abstract ID: 34862

Final Number: H23B-04

Title: Assessing Extreme Rainfall Characteristics in Future Climate for Canada

Presenter/First Author: Alain Mailhot, Institut National de la Recherche Scientifique, Québec, QC

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Co-authors: Karine Guinard, , , ; Gérémy Panthou, LTHE (UMR 5564), Saint Martin d'Hères, France

Published Material: I was invited to this session and I decide to present some of our recent works on extreme precipitation. These have been published in the following papers:Guinard K., Mailhot A., Caya D. (2014). Projected changes in characteristics of precipitation spatial structures over North America. Available on line, *Int. J. Climatol*. DOI: 10.1002/joc.4006.Panthou G., Mailhot A., Laurence E., Talbot G. (2014). Relationship between surface temperature and rainfall intensities - A multi-timescale and event-based analysis. *J. Hydrometeorology*, 15(5):1999-2011. DOI: 10.1175/JHM-D-14-0020.1Mailhot A., Beauregard I., Talbot G., Caya D., Biner S. (2012). Future changes in intense precipitation over Canada assessed from multi-model NARCCAP ensemble simulations, *Int. J. Climat*., 32:1151-1163. DOI:10.1002/joc.2343.

Abstract Body: Hazards associated to extreme rainfalls can cause important damages to infrastructures. In order to correctly designed water infrastructures, it is therefore important to correctly assess extreme rainfall frequency and intensity in historical and future climates. Considering the vastness of the Canadian territory, characterizing extreme rainfalls has also been a challenged due to the low density of stations especially in the northern regions. Assessing extreme rainfall statistics is even complicated by the fact available rainfall series are relatively short and that some applications (e.g. in urban hydrology) require sub-daily rainfall series for which available series are even more rare. Available projections from regional climate models suggest that extreme rainfalls will be more frequent and intense in future climate. Even if these conclusions seem robust, large uncertainties remain because of the (still) coarse resolution of climate model and the impact of unresolved convection processes. This presentation will discuss of: 1) projected changes on Intensity-Duration-Frequency curves for extreme rainfalls over Canada based on simulations from the *North American Regional Climate Change Assessment Program* (NARCCAP); 2) projected changes in characteristics of precipitation spatial structures (defined as a contiguous area of precipitation above a given threshold) over North America; 3) relationships between surface temperature and extreme rainfalls. Forthcoming challenges related to the simulation of extreme rainfalls in future climate will be finally addressed.

Abstract ID: 36747

Final Number: H23B-05

Title: Near-term projections of hydro-meteorological extremes over the United States

Presenter/First Author: Moetasim Ashfaq, Oak Ridge National Laboratory, Oak Ridge, TN

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Co-authors: Deeksha Rastogi, Oak Ridge National Lab, Oak Ridge, TN; Rui Mei, Oak Ridge National Lab, Oak Ridge, TN; Shih-Chieh Kao, Oak Ridge National Laboratory, Oak Ridge, TN; Bibi S Naz, Oak Ridge National Lab, Oak Ridge, TN; Sudershan Gangrade, Oak Ridge National Laboratory, Oak Ridge, TN

Published Material: This work will be submitted for review in a few weeks.

Abstract Body: We present near-term projections of hydro-meteorological extremes over the U.S. from a hierarchical high-resolution regional modeling framework that consists of the dynamical downscaling of 12 Global Climate Models (CCSM4, ACCESS1-0, NorESM1-M, MRI-CGCM3, GFDL-ESM2M, FGOALS-g2, bcc-csm1-1, MIROC5, CanESM2, MPI-ESM-MR, IPSL-ESM-MR, CMCC-CM5) from the 5th phase of Coupled Model Inter-comparison Project at 4km horizontal grid spacing. Our modeling framework uses a combination of a regional climate model (RegCM4) and a hydrological model (VIC). All models' integrations consist of 41-years in the historic period (1965-2005) and 41-years in the near-term future period (2010-2050) under the RCP 8.5. RegCM4 domain covers the continental U.S., and the parts of Canada and Mexico at 18km horizontal grid spacing whereas VIC domain covers the continental U.S. at 4km horizontal grid spacing. We apply SOM cluster analysis technique to identify the atmospheric patterns associated with the hydro-meteorological extremes and effect of their future variations on the frequency and intensity of climatic extremes in the coming decades. The high-resolution ensemble shows substantially better skill in the simulation of hydro-meteorological extremes and associated atmospheric patterns in the historical period. Further, we find that while extreme heat waves show a significant increase in their occurrence in the coming decades, extreme cold waves are not projected to significantly decrease even when mean daily minimum temperatures are increasing. We also find an overall increase (decrease) in the inflows to the flood-controlling (hydroelectric) reservoirs across the United States. Such changes in the hydro-meteorological extremes could have substantial impacts on natural and human systems across the U.S.

Abstract ID: 35446

Final Number: H23B-06

Title: Projecting the Impact of Climate Change on Extreme Runoff in the Pacific Northwest

Presenter/First Author: Mohammad Reza Najafi, University of Victoria, Victoria, BC

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Co-authors: Hamid Moradkhani, Portland State University, Portland, OR

Published Material: Part of this study is recently published in the journal of Hydrologic Processes however additional assessments will be included (covering basins in Canada) which are not published or presented previously.

Abstract Body: Changes in snowpack and snowmelt characteristics caused by warming temperature trends and the increased probability of extreme rainfall, due to climate change, will alter the frequency and intensity of extreme runoff. Understanding these changes is necessary before taking any adaptation plan. In this study the changes in extreme runoff over the Pacific Northwest (PNW) region are assessed based on suite of regional climate model simulations provided by North American Regional Climate Change Assessment Program (NARCCAP). Considering the limited number of available extreme events (30 years of historical/future simulations) the spatial hierarchical modeling framework is used to combine data from different locations to provide a more reliable assessment compared with single point analysis. Seasonal variations are investigated to detect possible shifts in extreme events. RCM output variables including precipitation, maximum and minimum temperature and wind speed are downscaled to 1/8° resolution for the regional assessment. Hydrologic modeling is performed using the Variable Infiltration Capacity (VIC) model and the results of these assessments are then merged using the Bayesian Model Averaging approach. Overall the results show increase in the

extreme runoff in the future for most seasons particularly during winter and over the high elevation areas. North of Rockies in particular experiences increase during spring. The reduction of extreme events in most dry areas in summer is also evident. Based on these results substantial shift in the seasonality of peak streamflow is expected from summer to spring in many regions of the PNW.

Abstract ID: 33512

Final Number: H23C-01

Title: The strengths and weaknesses of using hydrological connectivity to interpret stream biogeochemistry

Presenter/First Author: Christopher Spence, Environment Canada Saskatoon, Saskatoon, SK

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Co-authors: Rosa Brannen, University of Saskatchewan, Saskatoon, SK, Canada; Newell Hedstrom, , , ; Steven V Kokelj, Northwest Territories Geoscience Office, Yellowknife, NT, Canada; Shawne Kokelj, , , ; Meg McCluskie, , , ; Cherie Westbrook, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: Some of the results used in this review presentation were presented at the CGU annual general meeting in 2013.

Abstract Body: The concept of hydrological connectivity emerged with the broad acceptance that the non-linear streamflow response to precipitation or snowmelt inputs is partially due to heterogeneous landscape storage capacities, thresholds, and runoff pathways across a range of scales. Because hydrological connectivity is defined as the ability of water to transfer across the landscape, its nature could have implications for biogeochemical regimes. This presentation will discuss the advantages and disadvantages of using hydrological connectivity in the interpretation of biogeochemical connectivity with two examples from Canadian watersheds. It will be shown that peak hydrological connectivity is not necessarily synonymous with peak biogeochemical connectivity. Secondly, connectivity can be simultaneous, but not common to all constituents. These examples demonstrate that 1) the definition of metrics of both the connection presence and strength are crucial for integrated analysis of biogeochemical and hydrological connectivity; 2) the interplay of sources, sinks and pathways of water and constituents influences observed patterns; and 3) biogeochemical cycles are at least as important as hydrological connectivity to defining stream biogeochemical responses and regimes.

Abstract ID: 33959

Final Number: H23C-02

Title: Predicting seasonal stream chemistry from catchment topography: the importance of the near-stream zone.

Presenter/First Author: Nora J Casson, University of Winnipeg, Winnipeg, MB

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Co-authors: Catherine Eimers, Trent University, Peterborough, ON, Canada; S.a. Watmough, Trent University, Peterborough, ON, Canada; Murray C Richardson, Carleton University, Ottawa, ON, Canada

Abstract Body: Catchment topography influences stream nutrient export through regulation of such factors as hydrological flow paths and distribution of organic soils, and by determining connections between sources of nutrients across the landscape and the stream. Recent work has demonstrated that biogeochemical processes occurring in the near-stream zone exert a stronger influence on stream chemistry compared with catchment-averaged processes. This may be particularly true in dry seasons when there is less hydrological connectivity between upland source areas and the stream channel. In this study, we tested the hypothesis that near-stream topography is a better predictor of seasonal stream chemistry compared with whole-catchment averages. We evaluated relationships between catchment topography and 20-year average seasonal concentrations of nutrients at 10 forested catchments in south-central Ontario. 1 m resolution LiDAR derived digital elevation models were used to calculate average topographic metrics within 20m, 50m and 100m of the stream, as well as for the entire catchment. Dissolved organic carbon and nitrogen were strongly related to wetland coverage averaged across the entire catchment and these models were not improved by considering only the near-stream zone, perhaps because wetlands in these catchments are generally associated with the stream channel. Regression models predicting sulphate and nitrate concentrations using catchment slope and wetness indices were often improved by considering only the area within 50 m or 100 m of the stream network, particularly during the summer. This was in contrast to wetter seasons (e.g. spring and winter), when larger proportions of the catchment contributed to stream chemistry. In these forested headwater catchments, variable hydrologic connectivity of source areas to streams alters the role of the near-stream zone environment in regulating sulphate and nitrate concentrations in streamwater. During dry periods, the near-stream-zone catchment morphology should be included in landscape models to improve predictions of streamwater sulphate and nitrate concentrations.

Abstract ID: 34397

Final Number: H23C-03

Title: Using Streamflow Recession Analysis to Understand Variations in Hydrologic Connectivity During Baseflow

Presenter/First Author: Stephen B Shaw, SUNY College of Environmental Science and Forestry, Ithaca, NY

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Co-authors: Nicole Ng, , ,

Published Material: Some of this work is currently in a manuscript under revision in the journal Hydrological Processes. This presentation will incorporate new field work from 2014 that was not included in the manuscript.

Abstract Body: The concept that runoff generation occurs from temporally varying source areas in watersheds with steep terrain and shallow soils has been well established for decades. However, this same concept of time-varying source areas is often not considered for baseflow; in many cases baseflow is presumed to originate uniformly across a catchment's area from groundwater contributions. In this work, we use detailed observations of changes in the active channel network of head water streams in conjunction with recession analysis of aggregate flow at the catchment outlet to investigate seasonal changes in baseflow source areas. By linking discharge recession analysis to field observations, we suggest that insights into the degree of spatial variation in hydrologic activity during baseflow can potentially be inferred from stream discharge and does not necessarily require extensive field work. We present data from two watersheds in New York State as well as analysis of recession data from multiple sites with long-term discharge records. Besides providing insights into seasonal changes in hydrologic connectivity during baseflow, this work also supports new interpretations of stream flow recession analysis.

Abstract ID: 36702

Final Number: H23C-04

Title: Modelling the impacts of fine-scale spatial configuration and connectivity of soil and land use on water, sediment and nutrient flows

Presenter/First Author: Bethanna M Jackson, Victoria University of Wellington, Wellington,

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Abstract Body: The delivery of water, sediment and chemicals across landscapes and to water bodies is a function of both the biophysical properties of individual landscape elements and their configuration. However, due to computational constraints, fine-scale landscape configuration has generally been neglected or grossly simplified in hydrological modelling. In this talk, we demonstrate a new approach designed to be fast-running while maintaining physical consistency and fine spatial detail. Hydrology, sediment and chemical routing algorithms are based on physical principles of hillslope flow, taking information on the storage and permeability capacity of elements within the landscape from soil and land use data and honoring physical thresholds, mass and energy balance constraints. Hydrological response units are delineated within the landscape according to similarity of their hydraulic properties, and spatially explicit topographical routing is preserved. Landscape response is then evaluated under different meteorological or climatic events (e.g. flood return periods, rainfall events, droughts), cascading water through the hydrological response units using a “fill and spill” approach. The computational efficiency of the approach combined with its focus on spatial detail allows the impacts of landscape connectivity from subfield level scale to national scale to be analysed simultaneously, and communicates the spatial patterns of mass flow within the landscape at detailed resolutions. Case studies from Wales and New Zealand will be presented in this talk, with a focus on how water, sediment and macronutrient delivery to water bodies is impacted by soil and land use configuration.

Abstract ID: 36313

Final Number: H23C-05

Title: The re-eutrophication of the Laurentian Great Lakes and the potential influence of changes in agricultural land use, climate, and transport pathways

Presenter/First Author: Mohamed Mohamed, Ontario Ministry of the Environment, Toronto,

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Abstract Body: Agricultural land use has a variety of effects on material and energy flow of receiving waters, some of which can be highly local, while others may be far reaching, with cumulative impacts extending to large, distant receiving waters such as oceans or large lakes. The impacts of land use, including agriculture, on the Laurentian Great Lakes (LGL) became a topic of intense study during the eutrophication of the lower LGL that occurred in the late 1960s and early 1970s. The Pollution from Land Use Reference Group (PLUARG) was formed to examine the relationships between land use and their impacts on the LGL, then to develop recommendations for changes in these practices to reduce impacts on the LGL. The agricultural studies of the PLUARG examined the interaction between types of agricultural land use and the sensitivity of those landscapes to lose nutrients and other materials to the streams that drain them, as well as to develop recommendations to mitigate these losses. In the ensuing years, water quality in the LGL improved dramatically, driven primarily by improvements in sewage treatment. More recently, there has been a resurgence of eutrophication in the western basin of Lake Erie, as well as widespread nearshore algal fouling occurring in all of the lower LGL. The mechanisms causing the re-eutrophication of the LGL are not yet quantified. However, it is known that a major driver is a shift in the food webs of the LGL, while changes in climate and tributary loading may also be important. On the agricultural landscape, several changes such as artificial drainage, climate change, and other land use practices have occurred that may influence not only the magnitude, but also the nature and timing of nutrient loss to watersheds. In this work, we provide an overview of the PLUARG approaches to examining the connection between agricultural land use and their impacts on the LGL as well as possible changes in the magnitude, timing, and hydrological connectivity that have happened since those studies. We will also describe a new study that will revisit many of the goals of the PLUARG agricultural studies to examine how these changes may be influencing the re-eutrophication of the LGL.

Abstract ID: 36811

Final Number: H23C-06

Title: Natural and anthropogenically-induced hydrological connectivity produces methylmercury hotspots in the Hudson Bay Lowlands, Canada

Presenter/First Author: Brian A Branfireun, Western University, London, ON

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Abstract Body: The Hudson Bay Lowlands is the second largest contiguous peatland complex in the world, and is a critical source of water and solutes to the James and Hudson Bays. Water quality in this extensive, low-gradient catchment is strongly influenced by the saturated organic matter that comprises ~ the top 2 m extensive surficial deposits. The fish supported by this freshwater system are critical to human residents who rely on it in whole or in part for their subsistence, however it has been known since the 1970s that fish of edible size frequently exceed consumption guidelines for tissue methylmercury (MeHg) concentrations. In the absence of point sources in this remote landscape, the sources of Hg are entirely atmospheric.

We hypothesized that the source of MeHg was *in situ* methylation of atmospherically-deposited inorganic Hg in the extensive peatlands; a well-documented occurrence in more southern latitudes. Extensive sampling within both bog and fen peatland types in the Attawapiskat River catchment in the central James Bay Lowlands revealed that MeHg concentrations were vanishingly low in the peatlands, despite at least superficial similarity to strong methylating environments in other geographic regions. Instead, extremely localized zones of elevated MeHg concentrations were found in near-stream pore waters and surface pools associated with surface water-ground water convergence. These hotspots appear to play an important role in the flux of MeHg to streams, and food web exposure. Similar biogeochemical hotspots for Hg methylation were produced in both an operational and an experimentally-manipulated wastewater treatment wetland, with elevated sulphate and labile carbon generated localized MeHg concentrations 3 orders of magnitude higher than background. Hydrological connectivity supporting methylation is much more localized in this vast landscape than previously thought. Knowledge of relatively fine-scale hydrological processes is required to predict biogeochemical hot spots and understand the implications of future changes in hydrology due to land-use or climate change.

Abstract ID: 36714

Final Number: H23C-07

Title: Hydrochemical and isotopic end member mixing analysis to quantify snowmelt contributions to streamflow and lakes during arctic spring: application to hydrologic and mercury mass balance modelling

Presenter/First Author: Murray Richardson, Carleton University, Ottawa, ON

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Co-authors: Jamal Shirley, , ,

Abstract Body: Spring snowmelt is the most important hydrologic event of the year in arctic landscapes. During this relatively short period if time, fluxes of water and waterborne contaminants such as mercury to surface waters can far exceed those occurring during the remainder of the water year. Several important studies have reported relatively little mixing of snowmelt runoff with lake water over the melt period. However, on an annual basis, the extent to which catchment runoff mixes with lake water is believed to depend on the relative fractions of rainfall vs. snowfall throughout the year, and the fraction of annual runoff that occurs during the open-water season. This implies that seasonal and inter-annual differences in terrestrial-aquatic interactions may influence the "source-strength" of hydrological and biogeochemical source areas in relation to downstream water bodies.

As part of a broader study focused on these aspects of terrestrial-aquatic connectivity during spring runoff in arctic lake basins, we used hydrochemical and isotopic end member mixing analysis (EMMA) to help quantify the extent of mixing of snowmelt runoff within an 8 ha lake near Iqaluit, NU. Specifically, two and three-component hydrochemical and isotopic EMMA models were developed to calculate volumetric fractions of source waters in inflowing and outflowing streams of the lake over a 2 month period from early June to late July, 2014. Source water composition of inflowing streams ranged from 80% to 0% snowmelt-derived throughout the melt period, with concomitant changes in both mercury and dissolved organic carbon concentrations. Outflowing lake water largely tracked the hydrochemical and isotopic signature of the inflowing streams throughout the entire melt period, and according to EMMA, was dominated by this source water component (~50%). Contributions from melting lake ice and pre-melt lake water also comprised substantial fractions of the remaining 50% of the lake outflow, in approximately equal proportions. Overall, EMMA was found to be a useful tool for inferring interactions between snowmelt runoff, groundwater and lake water in an arctic lake basin, and for studying the mechanisms by which snowpack accumulation and melt serve to couple atmospheric sources of contaminants to arctic freshwaters.

Abstract ID: 34569

Final Number: H23C-08

Title: Physical, Chemical, and Biological Connectivity of Water Bodies in a Watershed Context – Lessons from Naked Watersheds

Presenter/First Author: Michael N Gooseff, Colorado State University Fort Collins, Fort Collins, CO

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Published Material: Less than 50% was presented at the JASM meeting last year in Portland Oregon. We have evolved this work since then.

Abstract Body: The connectivity of water bodies (streams, wetlands, lakes, etc.) is an important underpinning of terrestrial/aquatic ecosystem processes as well as water quality dynamics in space and time. In temperate watersheds, the study of the hydrologic, chemical, and biological connectivity of water bodies can be significantly complicated by land cover, complex hydrogeology, and management practices. Here we use a hydrologically-based framework to characterize the connectivity of water bodies through quantification of the frequency, magnitude, and duration of measured connections in a watershed with no vegetation cover and very little groundwater – the McMurdo Dry Valleys, Antarctica. The frequency, magnitude, and duration of connections of glaciers to lakes, via meltwater streams are well-quantified over this period, from an extensive stream gauging network. The connectivity and disconnectivity (periods of no flow) have significant influences on stream diatom and algal communities. In the past decade, we have observed increased connectivity of glaciers to soils and lakes outside of stream channels as new parts of the landscape are melting and thawing and providing new water that flows toward valley-bottom lakes.

Abstract ID: 33109

Final Number: H24A-0223

Title: Geostatistical extrapolation of area-density relations of water bodies from local to regional scale

Presenter/First Author: Saskia L Noorduijn, University of Calgary, Calgary, AB

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Co-authors: Masaki Hayashi, University of Calgary, Calgary, AB, Canada; Laurence R Bentley, University of Calgary, Calgary, AB, Canada

Abstract Body: The northern prairie landscape in North America is typified by topographic depressions which vary from small ephemeral ponds to large permanent lakes. These features are hydrologically and ecologically important because they providing habitats for migratory birds as well as focusing recharge to underlying aquifers. Quantifying the contribution of ephemeral ponds to groundwater recharge for large areas has proven challenging due to the difficulty in delineating the presence of topographic depressions within the landscape at a high enough resolution. Previous work has identified a power law relationship between the surface area of water bodies in depressions and their spatial density (i.e., number of water bodies per area). This power law relationship is influenced by landscape characteristics, in particular landform type (e.g., hummocky terrain). High-resolution (0.3 m) digital images were used to delineate water bodies in a 250-km^2 watershed of West Nose Creek (WNC) near Calgary, Canada. This dataset contains two well-defined power law relationships, one for hummocky and one for undulating terrains, which collectively comprise 75% of the watershed. Training images, based on the hummocky and undulating landform types within the WNC watershed were used to produce power law statistics for each of the landform types. The power law statistics were used to generate stochastic realizations of depression patterns which conform to the power law relationship determined from the WNC watershed. The stochastic images can then be used to generate distributions of the small ephemeral water bodies for larger areas with these landform types in order to investigate the spatial distribution of groundwater recharge.

Abstract ID: 35531

Final Number: H24A-0224

Title: Isotopic and chemical investigations of a small river to constrain groundwater recharge quantity and quality

Presenter/First Author: Karine Lefebvre, University of Paris South, Orsay,

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- Montreal, Dorval, QC, Canada; Marina Gillon, 1114 UAPV-INRA EMMAH, University of Avignon, Avignon, France; François Hardy, , ,

Abstract Body: Groundwater recharge is largely known to be spatially heterogeneous especially on watersheds impacted by human activities (drained surfaces, urban areas, release of effluents of waste water treatment plant, etc.). Depending on land uses occurring in recharge areas, the quality of the groundwater can undergo a marked deterioration, inducing the degradation of related aquatic ecosystems in groundwater discharge areas. Both the location of recharge areas and the quantification of the recharge rates are then crucial for the management of watersheds and the preservation of the ecosystems. The objective of this work was to use isotopic and geochemical tools to locate recharge of the Fontainebleau Sands aquifer in the small watershed of the Rhodon stream (26 km²) southwest of the Paris Basin (France). In this region, groundwater recharge is often impacted by agricultural practices with high nitrates concentrations.

A water and mass balance model was developed to quantify groundwater inflows and mass fluxes to the river, based on the spatial evolution of the river chemistry (^{222}Rn, $\delta^{13}C_{TDIC}$, $\delta^{18}O_{water}$, $\delta^{2}H_{water}$ and major ions). Along the course of the stream (10.5 km), two important groundwater contribution areas were identified between 2 and 5.5 km and after 8 km from the spring. In sub-watersheds corresponding to drained surfaces discharging in the stream at each sampling point of the stream, the mean quality of the regional groundwater and the calculated quality of groundwater inflow to the river with mass balance approach have been compared. Despite mass fluxes strongly balanced for conservative tracers (Cl^-, K^+, Mg^{2+}), there are some significant differences for the non-conversative elements (NO_3^-, SO_4^{2-}). These differences were compared to land uses to constrain the most important areas of groundwater recharge. This approach allowed the estimation of recharge rates and quality for each area to determine the quality of the groundwater discharge.

Abstract ID: 35604

Final Number: H24A-0225

Title: Recharge processes in karst at different time scales

Presenter: Xavier Durepaire, HydroSciences Montpellier, Montpellier,

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First Author Student?: No

Co-authors: Jean-Luc Seidel, , , ; Christelle Batiot, , ,

Abstract Body: In karst, the heterogeneity of the transfer processes within the different compartments (soil, epikarst, unsaturated zone, saturated zone) control the recharge-discharge relationship. The MEDYCYSS observatory (www.medycyss.org), an observation site of the KARST (www.sokarst.org) and RBV (http://portailrbv.sedoo.fr/) multi-disciplinary research networks, has been set up to better understand these transfers in a Mediterranean climatic context. Within the Lez karst catchment (South of France), part of the MEDYCYSS observatory, a 333m deep borehole has been equipped with the PMPS Multi-level monitoring system (SolExperts). This borehole is located 100 m from an intermittent river and 500 m from the aquifer main outlet (Lez Spring) where intermittent pumping is performed. Continuous pressure and temperature monitoring is realized at 5 levels isolated by packers where discrete water sampling can also be achieved. The main objective of this karst monitoring, realized in the framework of the CRITEX project, is to assess the different mechanisms of the recharge at various time scales. The collected data will implement the existing spatial monitoring of the hydrodynamic and geochemical variations followed in bore-holes, karst features (cave and estavelles), perennial and temporal springs of the karst aquifer. In this study we aim at specifying the contribution of the different karst compartments, from the recharge zone towards the main outlets. The preliminary results obtained during a flash flood event show a contrasted hydrodynamic response for each compartment in agreement with the karst functioning assessed from the analysis of the chemical variations. These data are essential to better assess the recharge processes and specify the role of the vadose zone in the flow organization at short and long timescale.

Abstract ID: 35849

Final Number: H24A-0226

Title: Are kettle lakes good objects to observe groundwater recharge?

Presenter/First Author: Marie Arnoux, GEOTOP-UQAM, Montréal,

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Co-authors: Florent Barbecot, UQAM, , QC, Canada; Elisabeth Gibert-Brunet, GEOPS-UMR 8148, Orsay, France

Abstract Body: It is known that the mean total annual volume of lacustrine groundwater discharge is closed to the mean total annual groundwater recharge in the whole catchment. All of hydrological interactions are not linear but the signal observed in lakes can be linked to recharge if lakes connections to groundwater are clearly determined. In Canada, the fractionated melting of the Laurentide ice sheet allowed the formation of kettle lakes. These lakes can be either (i) completely disconnected from groundwater, behaving like large rain gauges, or (ii) in direct connection with the underlying aquifer, being thus a opened window on groundwater. Twenty kettle lakes distributed in South Quebec were sampled in June-July and October-November 2014, and their water balances determined by using geochemical tracers. Those balances in conjunction with stable isotope signatures of system end-members allow the determination of the sensibility of lake water budgets regarding all components and thus groundwater discharge. It appears that some lakes can be very sensitive to change in groundwater-lake interactions. The seasonal response of water balance was also analysed to discuss groundwater-lake interaction dynamics and links between recharge dynamics. From these results a sensitive analyse of water budget parameters allow to discuss if kettle lakes may be sensitive systems to monitor recharge changes at the catchment scale.

Abstract ID: 33806

Final Number: H24A-0227

Title: Recent advances in the on-site analysis and process-based interpretation of dissolved noble gases and biogeochemically active species in water bodies

Presenter/First Author: Matthias Stefan Brennwald, Swiss Federal Institute for Environmental Science and Technology (EAWAG), Duebendorf,

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Co-authors: Rolf Kipfer, EAWAG Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, Switzerland

Abstract Body: The gas concentrations in water bodies are controlled by air/water exchange, sources/sinks in the water, and mixing of different fluids. Atmospheric gases originate from air/water partitioning at the water surface and (partial) dissolution of air bubbles entrained/entrapped in the water (excess air). This excess air component is commonly substantial in groundwaters. The noble gas concentrations in water allow quantification of excess air, which provides a robust basis for quantitative interpretation of reactive gases.

We developed a membrane-inlet mass spectrometer[1] for quasi-continuous on-site gas analysis in the field (He, Ar, Kr, N_2, O_2, CO_2, CH_4, etc). Most recently, we miniaturized this instrument and reduced power consumption to allow battery operation in the field. This instrument yields gas concentration time series, which provide the data basis for robust interpretation and quantification of gas dynamics in terms of physical *and* biogeochemical processes (e.g., respiration/O_2 or denitrification/N_2).

Currently available software tools for physical interpretation of noble gas data are, however, not adequate to interpret data sets containing both noble and chemically active gases. These tools are furthermore restricted to a limited and hard-wired set of physical gas-exchange processes. We therefore developed a new and flexible tool[2] (NOBLEFIT) for quantitative interpretation of dissolved gas data in terms of system-specific environmental processes and variables. NOBLEFIT covers the functionality of previous tools, but is designed to allow user-defined process models (e.g., physical conditions during atmosphere/water exchange, bubble/water interaction, strength and kinetics of internal gas sources and sinks, etc.).

Both on-site gas analysis and system-specific model fitting reflect significant improvements relative to currently available techniques. Moreover, the combination of both tools offers new avenues to study the interaction of physical and biogeochemical processes in water bodies.

1 Mächler et al 2012, ES&T, 10.1021/es3004409

2 Free software, http://sourceforge.net/projects/noblefit

Abstract ID: 33912

Final Number: H24A-0228

Title: Geochemistry of sediment moisture in the Badain Jaran desert in Northwest China: Insights into groundwater recharge and past environmental changes

Presenter/First Author: Li Jin, SUNY College at Cortland, Cortland, NY

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Published Material: Some preliminary results from this study have first been presented at AGU in December 2012.

Abstract Body: Unsaturated zone pore water has the potential to record history of recharge and retain information related to environmental changes. In this study, two 6-meter cores from the Badain Jaran desert (Northwest China) were collected to explore this potential using directly extracted moisture. Pore waters in low moisture sediments (1-5%) were directly extracted using immiscible liquid displacement and then analyzed for major anions, cations and trace elements. The pore water chemistry was used to illustrate the recharge history, natural geochemical processes and anthropogenic influence. The calculated recharge rates at two sites from the conservative tracer Cl^- were low, 1.5-3.0 mm/year. Major cations in two profiles showed relative low concentrations in the unsaturated zone and high concentrations in the capillary fringe and into the water table. High nitrate and low iron concentrations indicate the overall oxidizing environment, which allows the mobility of oxy-anions, such as uranium, arsenic and chromium. The modern rainfall infiltration signature contrasts with that of the underlying groundwater body, which has a distant, regional recharge signature. In addition, ratios of SO_4^{2-} over Cl^- in two profiles showed increasing trends since 1990s, which might suggest higher industrial activity and sulfur emissions. This reconnaissance study demonstrates the potential for a new geochemical approach to studying geochemical processes in the unsaturated sediments in semi-arid environments due to both natural and human influences. The direct use of pore water improves the understanding of hydrological and geochemical processes as water moves from the surface to the capillary fringe zone and to groundwater.

Abstract ID: 34865

Final Number: H24A-0229

Title: Developing Novel Techniques for In Situ Nitrate Sampling, Vertical Profiling, and Real-time Remote Groundwater Quality Monitoring

Presenter/First Author: Graeme MacDonald, University of Guelph, Guelph,

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Co-authors: Jana Levison, University of Guelph, Guelph, ON, Canada

Abstract Body: Certain hydrogeological settings in southern Ontario are particularly vulnerable to nitrate contamination of groundwater. Nitrate can leach into aquifers during recharge events, where it is subject to transport under spatially and temporally variable ambient flow conditions. Advancements in monitoring and data collection capabilities can improve understanding of these transport processes. Groundwater quality measurements are traditionally obtained by purging wells and analyzing samples ex situ. This “snapshot” data can disrupt the natural subsurface flow system and is not always detailed enough to determine critical water quality conditions. This research involved the application of innovative sensors to develop alternative groundwater sampling methods. Three unique methods were developed: flow cell spot sampling, depth-discrete downhole geochemical profiling and real time remote groundwater quality monitoring. While nitrate was the contaminant of focus, field parameters including temperature, DO, ORP, EC, and turbidity were also monitored. Research sites ranged from supply wells located in shallow overburden aquifers to deep fractured bedrock boreholes. Flow cell spot sampling results were compared to traditional sampling methods and were very strongly correlated ($R^2 = 0.99$). Depth-discrete profiling was used to identify groundwater quality zones corresponding to different formations. Real time remote monitoring methods were conducted by deploying sensor equipment downhole. Groundwater quality parameters were obtained every 15 minutes for several months, greatly improving the temporal resolution compared to traditional sampling. Data was transmitted in real time over the HSPA network, which allowed for remote monitoring, effectively reducing labour associated with traditional methods. The detailed datasets obtained will support future nitrate transport modelling initiatives and complement field projects in which in situ, detailed nitrate measurements are desired.

Abstract ID: 35989

Final Number: H24A-0230

Title: *Pinus banksiana* growth responses to a soil water recharge controlled by the Lichen organic layer.

Presenter/First Author: Benjamin Gadet, Organization Not Listed, Québec,

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Co-authors: David Paré, Natural Resources Canada - Canadian Forest Service, Québec City, QC, Canada; Yves Bergeron, Industrial Chair CRSNG-UQAT-UQAM in sustainable forest management, Rouyn-Noranda, QC, Canada

Abstract Body: The forest industry must continually improve the environmental performance of its activities while preserving the environment and the sustainability of its ecosystem so that the forest remains an asset for future generations. In the boreal forest, soils have widely developed on coarse textured deposits. Following natural or anthropogenic disturbance, this type of substrate provides a capacity of resilience of the ecosystem which strongly varies in time and space. At the level of the station, we often observe a bimodal distribution in productivity between patches of dense populations and unproductive land forests covered with Lichens. Such a parcelling out of these stands conveys a strong possible occurence of their change into an unproductive alternative stable state. As far as the Boreal shield is concerned, some recent studies have confirmed the expanding of this opening phenomenon of the canopy. Once set up, the opened Lichens woodlands are considered as being relatively stable. The origin of positive feedbacks supposed to enhance the irreversibility of this unproductive state was the subject of many studies but has not succeed in reaching meaningful conclusions permitting to guide future strategies. The forest industry has therefore become very vulnerable in front of the evolution of these ecosystems. The present work is part of a project which aims at bringing elements of understanding necessary to develop tools for predicting and maintaining the productivity of Pinus Banksiana stands. We postulate that the organic layer originating from Lichens contributes to maintaining unproductive stands by limiting plant available water recharge. Hydrodynamic properties of organic and underlying layered mineral soil horizons would induce capillary barrier effects. These effects could significantly decrease available water holding capacity and consequently forest productivity. Preliminary results show that low-productivity stands are characterized by high hydraulic conductivity of the organic layer with respect to the underlying mineral horizons. When the infiltration is not restricted by the organic layer, gradation and layering of different soil textures can significantly enhance the tree growth.

Abstract ID: 35693

Final Number: H24A-0231

Title: Water and contaminant travel time through the unsaturated zone under an agricultural field in Prince Edward Island, Canada

Presenter/First Author: Serban Danielescu, Environment Canada Toronto, Fredericton,

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Co-authors: Karl E. Butler, University of New Brunswick, Fredericton, NB, Canada; Shuang Wang, , , ; Mark Grimmett, Crops and Livestock Research Centre, Charlottetown, PE, Canada; Kerry T B MacQuarrie, University of New Brunswick, Fredericton, NB, Canada; Bernie Zebarth, , ,

Abstract Body: Knowledge of the travel time of water and contaminants through the unsaturated zone in intensive agricultural areas such as Prince Edward Island (PEI) is of crucial importance when assessing the impacts of Beneficial Management Practices (BMPs) on the quality of drinking water and of down-gradient aquatic ecosystems. This study was done at the Agriculture and Agri-Food Canada (AAFC) Research Farm in Harrington, PEI, in a field that has been under a potato production system since 2007. The unsaturated zone comprises a relatively thin soil layer (~1 m), underlain by a thick (~ 8 m) glacial till consisting of weathered local parent material (i.e., sandstone) and a 10-12 m thick layer of fractured sandstone. The estimated average downward velocities through the matrix of both till and bedrock has an upper limit of 12 m/year, however the estimated velocity of flow through the fractures can reach 280 m/year. In 2014, three boreholes disposed in an equilateral triangle (with 9 m long sides) were drilled and each equipped with an array of 11 Decagon 5TE sensors measuring temperature, moisture and electrical conductivity and 24 electrodes measuring resistivity to provide real-time vertical profiling of downward movement of water and solutes. A simplified flow and transport model has been developed in Finite Element Flow (FEFLOW) and the model will be refined using data resulting from a tracer test that is planned in the summer of 2015 as well as from the logging of the rock cores and overburden samples collected during the drilling of the three boreholes. The use of field data in combination with unsaturated flow and transport modelling as well as cross-hole three dimensional Electrical Resistivity Tomography (3D ERT) will provide insight into the travel times of water and solutes through the unsaturated zone as well as into the partitioning between fracture and matrix flow and the effects of heterogeneity in hydraulic conductivity of both till and bedrock materials.

Abstract ID: 35542

Final Number: H24A-0232

Title: Recharge controls in arid and hyperarid piedmont - Example of the Pampa del Tamarugal basin, Northern Chile.

Presenter/First Author: Benoit Viguier, HydroSciences Montpellier, Montpellier,

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Co-authors: Hervé Jourde, CNRS HydroSciences Montpellier, Montpellier Cedex 5, France; Véronique Leonardi, Université Montpellier II - HydroSciences Montpellier, UMR5569, Montpellier, France; Elisabeth Lictevout, ciderh-Universidad Arturo Prat, Iquique, Chile

Abstract Body: The dryland areas cover 47.2% of the continents surface, whereas the pediments (or piedmont) are present on all the continents. In this study, we attempt to better understand the hydrogeological functioning and recharge processes in such areas.

The endorheic Pampa del Tamarugal basin (Northern Chile) is shaped in by a Central Depression (Northern extension of Atacama Desert). This depression contains the Pampa del Tamarugal lowland (1000 m a.s.l) and the Andean Piedmont, limited on his eastern side by the Precordillera mountain range (5000 m a.s.l). This area is one of the most arid areas of the world. The climatic context is arid and hyperarid, with an annual average precipitation close to 250 $mm.y^{-1}$ in the Precordillera and no precipitations in the lowland. This lowland contains the Pampa del Tamarugal regional aquifer, which is a strategic groundwater resource for the Northern Chile as a whole.

The study of water transfers from the Precordillera to the downstream aquifer highlights several geomorphological and geological controls on the recharge. This recharge also depends on climatic control such as El Nino/La Nina Southern Oscillations.

The geological and geomorphological settings of the piedmont area, such as the spatial distribution of aquifer geological layers and the outcropping of bedrock (acting as impermeable barriers), control the groundwater circulations and suggest preferential recharge locations in the piedmont. On this basis, it is shown that most of the potential recharge should occur during flooding, when high altitude precipitations generate surface runoff that reaches the downstream aquifer recharge zone. Based on the estimation of the flooded area surface, we attempt quantifying the recharge of aquifer in lowland area when flashflood occurs. Numerical modelling accounting for pedotransfer functions (based on in situ sampling) with Hydrus-1D is performed to quantify this transient recharge as a function of various flooding duration.

Abstract ID: 33737

Final Number: H24B-0236

Title: The Effect of Inter-Basin Water Transfer on the Water Resources of Betwa Basin, India

Presenter/First Author: Shakti Suryavanshi, University in Allahabad, Allahabad,

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Abstract Body: This investigation has been carried out to analyse the effect of inter-basin water transfer on the water balance of the Betwa basin (43500 km²), India. The Providing Regional Climates for Impacts Studies - Regional Climate Model (PRECIS-RCM) data in conjunction with the Soil and Water Assessment Tool (SWAT) model (Semi distributed model) has been employed to examine the long term effects of inter-basin water transfer on the basin water resources. Analysis of water balance was carried out dividing the whole Betwa Basin into three parts. The upper basin was considered as rainfed and this area is denoted by "Area-A". In lower part of the basin, the existing major irrigation projects fulfilling irrigation and municipal/industrial needs are considered and this area is denoted by "Area-B". The third "Area-C" represents the Dhasan catchment irrigated also through small irrigation schemes. Assuming that the present situation of irrigation in the Betwa basin shall prevail till 2035 and Ken-Betwa Link Plan (KBLP) will establish afterwards, this study considers two scenarios: Long Term Part-I (LTP-I) for year 1976-2035 and Long Term Part-II (LTP-II) for year 2036-2095. Water resources of LTP-I (1976-2035) and LTP-II (2036-2095) scenarios were compared for all sub-areas, viz., Areas-A to C. Precipitation and evapotranspiration has been increased in all areas. Change in these parameters influences all the other water balancing parameters of the basin. The effect of implementation of the KBLP on different components of water balance during 2036-2095 was also evaluated considering that no man-made changes would occur in the basin. Results reveals that there will be a considerable decrease in surface runoff, transmission losses, and total water yield in Area-A (upper basin), largely because of trapping of water in upper basin through different (but likely) irrigation schemes. In addition, lateral flow, groundwater contribution and percolation will increase significantly. The water balance is almost similar for Areas-B and C in both scenarios. Thus, this study in different scenarios indicates significant effect of the KBLP in upper basin, but without affecting previous commitments of the water withdrawals from the lower basin.

Abstract ID: 34399

Final Number: H24B-0237

Title: Hydrological impacts of the changes in simulated rainfall fields on the Nakanbe basin in Burkina Faso

Presenter/First Author: Boubacar Ibrahim, WASCAL West African Science Service Center on Climate Change and Adopted Land Use, Ouagadougou,

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Abstract Body: Changes in rainfall regime during the last five decades over West African Sahel have significantly modified the hydrological regime of many rivers with a significant impact on water resources. In this study, the main hydrological processes on Nakanbe watershed in Burkina Faso are described with two hydrological models: GR2M (lumped and monthly model) and ORCHIDEE (distributed and half hourly model). The two models were calibrated on the watershed from the observed runoff at the outlet of Wayen (an area of about 22 000 km²) over the 1978-1999 period with a Nash-Sutcliffe efficiency criterion of more than 62%. The mean annual hydrological balance on the watershed over 1978-1999 period is composed from both models with 4% of runoff, 10% of groundwater recharge and 86% of actual evapotranspiration. The validated model of ORCHIDEE was then used to assess the hydrological impacts of the changes in the rainfall regime simulated by five regional climate models (CCLM, HadRM3P, RACMO, RCA and REMO) run under the intermediate scenario of A1B. ORCHIDEE simulations show that the hydrological impacts on runoff come mainly from the changes in the rainfall field with regard to the frequency and the intensity of the rain events. The impacts of the decrease in the two characteristics reveal different magnitudes of decrease in water resources. The decrease in the intensity of rainfalls is much more (10% more important) prejudicial to runoff and to groundwater recharge (two times more important) than a decrease in the frequency of rainfalls.

Abstract ID: 36143

Final Number: H24B-0238

Title: Simulation of Hydrological cycle in Western Canadian regions using CLASS/Canadian Regional Climate Model

Presenter/First Author: Waqar Younas, University of Northern British Columbia, Prince George, BC

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Co-authors: Stephen J Dery, University of Northern British Columbia, Prince George, BC, Canada

Abstract Body: The climate of western North America, most notably British Columbia, has changed substantially over the past century and its impacts can be observed widely from its hydrological cycle. In this context, it is vital to monitor and simulate these changes and their impacts on the region's future hydrology. In this study, the Canadian Land Surface Scheme (CLASS) coupled with the Canadian Regional Climate Model (CRCM) will be implemented to simulate the snow modelling over the principal watersheds of western Canada, e.g. the Nelson, Mackenzie, Columbia and Fraser rivers basins. The emphasis will be placed on the development of a sub-grid scale snow (SSS) parameterization and its impact on representing land surface heterogeneities within the framework of CRCM version 6. The snow parameterization within CRCM will incorporate elevation bands, the consideration of slope and aspect and exposure to wind, among others. It is expected that this work will improve the depiction of snowpack evolution in western North America and will help to evaluate its impacts on regional hydrology.

This study will also focus on some other important issues related to snow modelling of above mentioned regions. For example, the impact of high resolution model integrations combined with SSS parameterizations on the simulation of snow in mountain regions will be assessed. The change in regional hydrology with multi-layer snow model together with the simulation of snow-albedo feedback in CRCM will also be addressed.

[SJD1]Do you have a title?

Abstract ID: 36798

Final Number: H24B-0240

Title: Development of a Simple Framework to Assess Hydrological Extremes using Solely Climate Data

Presenter/First Author: Etienne Foulon, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec City, QC

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Published Material: AGU fall meeting 2014, 15-19 december, poster presentation

Abstract Body: Extreme flow conditions such as droughts and floods are in general the direct consequences of short- to long-term weather/climate anomalies. For example, in southern Quebec, Canada, summer 7-day low flows are due to summer and fall precipitations. Which prompts the question: is it possible to assess future extreme flow conditions from meteorological/climate indices or should we rely on the classical approach of using outputs of climate models as input to a hydrological model? The objective of this study is to assess six hydrological indices describing extreme flows at the watershed scale (Q_{max}, $Q_{min;7d}$, $Q_{min;30d}$ for two seasons: winter and summer) using local climate indices without relying on the aforementioned classical approach.

To establish the relationship between climate and hydrological indices, daily precipitations, minimum and maximum temperatures from 89 climate projections are used as inputs to a distributed hydrological model. River flows from five hydrographic regions in Québec are separately calibrated for winter and summer seasons and the watersheds are divided into upper-, middle-, and lower-sections. This allows to better take into account the different driving mechanisms behind the generation of high and low flows, as for the snow-melt or heavy convective rainfall events induced high-flows of late winter and summer. To identify the best predictors between 1961 and 2100, hydrological indices are extracted from the flow series, and climate indices are computed for different time intervals (from a day up to four years).

Overall, preliminary findings clearly illustrate that the change in the hydrological indices can be detected through the concurrent trends in the climate indices. The use of many climate projections ensures the relationships are not simulation-dependent and shows summer events are particularly at risk with increasing high flows (60% of the variability is explained on average) and decreasing low flows.

The development of a simple predictive tool to assess the impact of climate change on flows represents one of the major spin-off benefits of this study and may proove to be useful to municipalities concerned with source water and flood management. Future work includes the use of different sets of climate indices for watersheds clustered according to their physiographic descriptors.

Abstract ID: 34859

Final Number: H24C-0241

Title: Modelling of ground subsidence in Mexico City observed by RADARSAT-2 DInSAR during October 2008-December 2010 time period

Presenter: Jose Fernandez, Complutense University of Madrid, Madrid,

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Abstract Body: Rapid population growth and overuse of groundwater contributes to severe land subsidence in Mexico City. For studying the subsidence phenomena we processed high resolution ascending and descending RADARSAT-2 images acquired during 2008/10/29-2010/12/11. The advanced analysis based on the Multidimensional Small Baseline Subset (MSBAS, Samsonov & d'Oreye, 2012) technique was applied to produce vertical and horizontal deformation time series and mean deformation rates. The vertical deformation rate reveals rapid subsidence with a rate over 30 cm/year at selected locations. The horizontal deformation with rate of up to 10 cm/year accompanies subsidence with motion directed towards subsidence center. It was observed that subsidence rate varies spatially over short distances. A few areas of steady ground are observed surrounded by fast subsidence. Such heterogeneity is likely due to the spatially varying. The nonlinear inversion methodology by Camacho et al. (2011) was used for modeling 3D pressure and mass sources with a free geometry. The geometrical description of the extended sources is developed by aggregation of point sources in a 3-D context, allowing for a very general description of the free geometry for the source bodies. For simplicity, it is assumed that anomalous pressure changes and density anomalies are nearly homogeneous within the sources. The inversion process fills cells with the prescribed pressure value (and/or density anomaly), giving rise to the aggregation structure. The nonlinear search is based on an exploratory approach. Simultaneously regional deformation patterns are obtained. Measured displacement and modeling results are described.

References

Camacho, A. G., et al., 2011, doi: 10.1029/2010JB008165.

Samsonov S. & d'Oreye N., 2012, doi: 10.1111/j.1365-246X.2012.05669.x.

Abstract ID: 33636

Final Number: H24D-0244

Title: Preventing the Next Disaster at Lake Nyos.

Presenter/First Author: Emmanual Asongacap Atemnkeng, University of Yaoundé, Kumba,

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Abstract Body: Lake Nyos is an active crater lake located in Menchum Division of the North West Region of Cameroon. This is one of only three volcanic lakes in the world (the others are Lake Monoun in Cameroon and Lake Kivu in Rwanda).

In August of 1986, there was a huge eruption at Lake Nyos that sent plums of Carbon dioxide (CO2) gas into the atmosphere killing 1700 people, livestock and practically all living things within a 15 miles radius of the lake. The explosion was the result of accumulation of a large amount of gas CO2 deep underneath the lake. It is believed that some 1.2 cubic km of gas was released to the environment in this one single event. CO2 concentrations are ok at about 3% but lethal in excess of 10%. The villagers around Lake Nyos literally suffocated under the heavy poisonous cloud of the gas. The lake was dubbed the deadliest lake by Guinness world record in 2008

Several efforts are being put in place to prevent a repeat of what happened here in 1986. Following the various scientific studies on the disaster that the lake was super-saturated and out-gassing could occur every 10-30years, there were proposals to reduce the volume of water in

the lake that could reduce pressure on the lake's CO2 and cause the gas to escape. Another research finding proposed the installation of a degassing column in the lake. To this effect, the U.S office of foreign Disaster Assistance funded a permanent installation of a degassing pipe at Lake Nyos.
On January 30th 2001, a spectacular 50 m high fountain soared above the peaceful surface of the lake.
The demonstration was a total success; a powerful soda spray jet - stable and safe - was switched on and off several times using a remote radio-controlled system. In 2011 two additional pipes were installed to assure the complete degassing of Lake Nyos.

Abstract ID: 34767

Final Number: H24D-0245

Title: Mediterranean Network of Environmental Forcing Records In Travertines _ Med-NEFRIT Project: preliminary results

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Abstract Body: While they support most of ecosystems, water resources are the first victim of climate and environmental changes. They are largely impacted over the world in terms of quantity as well as quality. Whatever are the modelling contributions, the lack of records of water resources responses to external forcing limits our understanding and capability to develop integrated management of these resources. In such a scheme, we proposed to organize a scientific network (Poland, Turkey, Spain, France) within the European Cooperation MISTRAL-ENVIMED Programme, to share and develop original approaches and enhance our knowledge of these systems.

The study of environmental changes over recent periods focuses on relationships and feedback effects between climate and human aspects, using a variety of archival sources and proxies such as ice cores, ocean sediments, tree rings or soils. However, with the development of novel proxies (physical, chemical or methodological), the calibration and validation of data have to be clearly evaluated on their own.

For developing a comprehensive overview of processes leading to reliable records of environmental parameters, we focuses our work on modern travertines that are seen as a link between hydrological balance (recharge *vs* discharge/abstraction) and climatic data (temperature, rainfall), *via* specific geochemical records.

Our research project is based on the study of recent travertine that potentially registers environmental conditions. It implies research developments to (i) accurately understand the geochemical processes between liquid-gas-solid phases (kinetic degassing, carbonate precipitation, fractionation out of equilibrium and water-rock partitioning), (ii) reconstruct hydrological fluctuations from annual to seasonal time scales during the last 100 years, and (iii) compare environmental records with recent available meteorological parameters, in relation with regional to global atmospheric trends of Mediterranean/Western Europe area.

Abstract ID: 35526

Final Number: H24D-0246

Title: Kinetic isotope fractionation during rich-CO_2 water degassing: understanding the travertine geochemical record.

Presenter/First Author: Léonora Fleurent, GEOTOP-UQAM, Montréal,

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Abstract Body: The response of continental groundwater systems to recent climate fluctuations can be reconstructed via the continuous measurement of groundwater level, spring flow and climatic chronicles. When any data exist, recent reconstructions of groundwater dynamics may be reached through various recorders of environmental and hydrological conditions such as travertine. Although the relationship between geochemical records in travertine and environmental parameters seems to be accepted, the details of processes and their respective weight in the paleo-information are not clearly established.

Rate of CO_2 degassing in CO_2-rich spring likely influences calcite precipitation rate and the related $\delta^{18}O$ and $\delta^{13}C$ composition. Isotopic equilibrium is rarely maintained during travertine deposition and the degassing rate is the main controlling factor of the disequilibrium. Due to the lack of knowledge, fractionation processes, either kinetic or equilibrium, occurring between CO_2-rich water, gas and travertine required specific pH and temperature-controlled laboratory tests. These tests were conducted on synthetic water at different pH to focus only on the degassing processes. Other tests were conducted on trace elements partitioning during calcite precipitation, to identify the origin of isotopic signature variability, and to constraint the way of recording past conditions.

All these tests confirmed that during a degassing leading to travertine precipitation, the speciation of dissolved inorganic carbon species is a major parameter to be tackled since a linear relationship between $\varepsilon_{DIC-CO2(g)}$ and pH is observed. Indeed, we highlighted that for a high degassing rate, the isotopic equilibrium is not reached because the reaction greater involves light isotopes than heavy ones. There is thus different reaction rate between the species of dissolved inorganic carbon, the reactions occurring faster in the water than the one between water and gas, the latter being controlled by diffusion.

Abstract ID: 35036

Final Number: H24E-0248

Title: Development and application of a decision support system for sustainable groundwater management: A case study of Rechna Doab basin, Pakistan.

Presenter/First Author: Azhar Inam Baig, McGill University, Sainte-Anne-De-Bellevue, QC

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Co-authors: Johannes Halbe, McGill University, Montreal, QC, Canada; Jan F Adamowski, McGill University, Montreal, QC, Canada; Shiv O Prasher, , ,

Abstract Body: Sustainable aquifer management is often regarded as a significant challenge in the developing world. Factors such as low farmer awareness levels, scarcity of irrigation water supplies, high cropping

intensities and government policies such as flat electricity rates for tube well operations often hamper the adoption of effective management solutions. Over-abstraction results in lower groundwater depth, with a concurrent decrease in aquifer water quality and increase in pumping cost; in shallow zones, on the other hand, salt accumulation in the root zone is common due to high evaporation losses.

This presentation is part of a research project conducted in the Rechna Doab Basin of Pakistan and addresses such challenges via the development of a comprehensive but simple decision support system using a participatory modeling approach. The presentation evaluates different sustainable aquifer management solutions while taking into consideration surface water availability, crop water demand, and groundwater quality and socioeconomic conditions. To improve management effectiveness, an integrated modeling approach is develop by linking a system dynamics model of the socioeconomic system components with the SGMP module of the Spatial Agro Hydro Salinity Model (SahysMod). The system dynamics model controls tube well development and capacity according to demand-based irrigation, groundwater quality and availability of funds. The SGMP module estimates the water table depth by replicating the hydrological conditions of the study area. Final results indicate that uncontrolled human behaviors and activities are responsible for the degradation of groundwater resources. A brief summary of upcoming challenges and effective management solutions is presented for policymakers to use in the sustainable management of groundwater resources in this study area and others in similar areas.

Abstract ID: 36688

Final Number: H24E-0249

Title: Hydrogeochemistry and isotopy of the groundwater intensely used in eastern Haouz and the area of Tassaout Upstream, Morocco.

Presenter/First Author: Samia Rochdane, Cadi Ayyad universitu, Marrakech,

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Co-authors: Abdennabi Elmandour, Cadi Ayyad university, Marrakech, Morocco; Paul Baudron, Polytechnique Montreal, Montreal, QC, Canada

Abstract Body: The Eastern Haouz and the Tassaout upstream area aquifer is the most stressed aquifer in the drinking water supply of cities, industrial processing and agricultural activity (more than 1000 wells and boreholes). This is an area where the demand for water is increasing year by year. Water levels measured in the study area shows a deep groundwater aquifer in the South and shallow in the North. The reservoir of the unconfined aquifer is characterized by a varying hydrodynamic parameters; the transmissivity varies between 1.10^{-4} to $3,6.10^{-2}$ m²/ s, and the storage coefficient is 2 to 10%. The piezometric map shows two areas of groundwater recharge; South from the High Atlas mountains and North from the Jebilets hills, two flows to the South West and the other to the North East.

A great variation is between the minimum and maximum values of the different ions, that variation is observed also in values of electrical conductivity, which varies between 761 and 7680 µS / cm, with an average of 2350 µS / cm. The analysis of several diagrams shows that there is a dominance of Na-Cl and Na-HCO3 facies with respectively a percentage of 48% and 12%. Groundwater of alluvial formations, surface water and also the water source have a slight dominance of Na-Cl, while the water circulating in the shales and Triassic formations show a high dominance of Na and Cl. Water samples from shale and Triassic formations are relatively mineralized and unfit for human consumption and for agricultural purposes. Groundwater in the central part circulating in the alluvium show low mineralization due to high power along the Tassaout River and infiltration of irrigation water from the water dam used to irrigate the agricultural area of the Tassaout upstream. Apart from salinity, about 25% of samples had nitrate concentrations above the allowable limits by WHO.

Measurements of stable isotopes show that the recharge of groundwater is controlled by local conditions that are feeding the unconfined aquifer by anastomosis in contact with limestone formations of the High Atlas and infiltration of the water dam used for the irrigation. The correlation between isotopic data and electrical conductivity has to distinguish isotopic differentiation characterized by three groups with a dominance of waters with the content of medium values of δ18O and electrical conductivities.

Abstract ID: 34707

Final Number: H24F-0250

Title: Connectivity between wetlands and streams: patterns of phosphorus export in the Prairie Pothole Region

Presenter/First Author: Md Aminul Haque, University of Manitoba, Winnipeg,

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Abstract Body: In the last 100 years, more than 50% of the wetlands in the Prairie Pothole Region have been lost or altered. The loss or alteration of these wetlands, which are usually considered as geographically isolated, has modified the frequency of water and pollutant exchanges between land and streams and thus affected regional water quality. Indeed, while intact wetlands act as nutrient sinks by effectively trapping runoff and associated pollutants, lost or altered wetlands are prone to release nutrients to nearby streams. Although the general impacts of wetlands loss or degradation at the regional level are well understood, little is known about local wetland properties that drive those changes. Hence, to evaluate stream-wetland connectivity and associated nutrient export, 10 intact and 10 altered/lost potholes were selected for study; they are located in Broughton's Creek Watershed (Manitoba, Canada) on both sides of a 5 km creek reach. Surface water was sampled from intact and consolidated wetlands while subsurface water was sampled below the ditches associated with drained potholes at least twice a month in 2013 and 2014. Creek water was sampled at the two extremities of the study reach at least once every two days during the same period, and all samples were tested for soluble reactive phosphorus (SRP). Initial data analyses show that SRP concentrations in the creek were strongly correlated to SRP concentrations in the altered wetlands and drainage ditches. In particular, SRP concentrations at the downstream end of the study reach closely followed SRP concentrations in the altered wetlands. Both extremities of the study reach showed considerable fluctuation in SRP concentrations, with notable increases at the downstream end following precipitation events. Future analyses will be carried to further characterize the role of wetland degradation on stream-wetland nutrient connectivity in different surface and subsurface runoff conditions.

Abstract ID: 34457

Final Number: H24F-0251

Title: Storm-Based Tracer Response of a Mesoscale Precambrian Shield Catchment with Mixed Landuse.

Presenter/First Author: David Robert McCorkell, Nipissing University, North Bay,

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Co-authors: April Lynda James, Nipissing University, North Bay, ON, Canada; Krystopher J Chutko, Nipissing University, North Bay, Canada; Merrin L Macrae, University of Waterloo, Waterloo, ON, Canada; Sue Miller, , ,

Abstract Body: This poster presents tracer-based stormflow responses collected from the Wasi watershed, a 235 km^2 Precambrian shield catchment located upstream of Callander Bay, Lake Nipissing, Ontario. Total phosphorus (TP) levels have regularly exceeded provincial water quality objectives since monitoring began in 2009. Sampling has, however, focused on summer baseflow conditions, which typically account for less than 20% of TP loads, suggesting there could be significant uncertainty in estimates of riverine P loading to Callander Bay. Contemporary studies show that turbidity is a useful surrogate for TP concentrations although relationships may be harder to quantify during periods when dissolved P flux is relatively greater. The objective of this study was i) to extend monitoring of streamflow to a wider range of hydrologic conditions, ii) to evaluate turbidity as a surrogate for TP for this watershed, and iii) to use additional tracer responses to inform TP sources to streamflow. In this poster we present tracer response (TP, SRP, TSS, specific conductance, temperature, stable water isotopes (SWI)) for three summer/fall 2014 storm events. Stormflows were sampled at a frequency of 2-3 hrs using autosamplers triggered by change in stream stage. For each storm, TSS and turbidity show strong positive correlations; TP-turbidity relationships will be reported. Two of the three storms show a counter-clockwise TSS-Q hysteresis, while a third storm shows a clockwise hysteresis consistent with flushing and subsequent exhaustion of sediment from the channel prior to peak streamflow. Bulk rainfall SWI signatures are distinct from pre-storm streamflow, although individual storms can overlap with groundwater signatures (e.g. ~-12.5‰) and/or surface water (e.g. -8.4‰). Specific conductance is used to help evaluate contributing sources of water. Analysis presented here aims to improve characterization of TP fluxes and sources from this mixed land-use watershed to the downstream water supply.

Abstract ID: 35026

Final Number: H31A-01

Title: Modelling the frequency distributions of peak streamflows on the Canadian Prairies

Presenter/First Author: Kevin Shook, University of Saskatchewan, Saskatoon, SK

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Co-authors: John W Pomeroy, University of Saskatchewan, Canmore, AB, Canada

Abstract Body: The peak flows of streams in the Canadian Prairies are difficult to fit to existing frequency distributions for the design of hydraulic infrastructure. The problem is exacerbated by the very low density of stream gauging in most of the region, and by the short record lengths of most of the gauges. Furthermore, nonstationarity in the forcing climate and in the landscape (i.e. in vegetation, and drainage) prevents the use of historical data for estimating future design flows. Prior research has shown that the most commonly used method for estimating design flows for ungauged Prairie streams is hydrologically and statistically invalid, leading to poor designs for infrastructure in the region.

It is demonstrated that physically-based hydrological modelling using the Cold Regions Hydrological Modelling platform (CRHM) is able to reproduce the streamflows, and therefore their frequency distributions, of Prairie streams over their periods of record. Using downscaled climate data, the frequency distributions of Prairie streamflows could be simulated for any future interval. From the generated frequency distributions of peak flows, design flows could be extracted for any desired return period. The logistical requirements for producing return-period flows over the Prairie region are discussed.

Abstract ID: 33581

Final Number: H31A-02

Title: Testing the ability of a semi-distributed hydrological model to simulate streamflow and contributing area relationships in cold regions

Presenter/First Author: Samson Girma Mengistu, Environment Canada Saskatoon, Saskatoon, SK

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Co-authors: Christopher Spence, Environment Canada Saskatoon, Saskatoon, SK, Canada

Abstract Body: A dry and cold climate, the prevalence of small depressions, and the lack of a well-developed drainage network are characteristics of environments with extremely variable contributing areas to runoff. These types of regions (e.g., the Prairie Pothole Region (PPR) of North America) arguably present the greatest challenge to properly understanding catchment streamflow generation processes. Previous studies from all types of regions have shown that contributing area dynamics are important for streamflow response, but the nature of the relationship between the two is not typically quantified. Furthermore, it is not known if hydrological models can properly represent contributing area while simulating streamflow. In this study, the relationship between streamflow and contributing area was first characterized using field and remote sensing measurements. We then tested the capacity of the PDMROF configuration of Environment Canada's MESH model to reproduce this relationship. The study focused on the St. Denis Creek watershed in central Saskatchewan, Canada, which with its considerable topographic depressions can be considered representative of much of the PPR, making it ideal for this type of investigation. Streamflow tended to scale with contributing area according to power law relationships (R^2 >0.75, p <0.001) for both model and remote sensing methodologies, and were in good agreement with each other. Ongoing challenges in defining quantitative relationships between streamflow and contributing area include data collection, and demonstrable hysteresis and spatial variation in the relationship among watersheds.

Abstract ID: 36302

Final Number: H31A-03

Title: Noah-MP Land Surface Model simulation for Boreal Forest (BERMS SK-OAS) Site

Presenter/First Author: Yanping Li, University of Saskatchewan, Saskatoon, SK

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Co-authors: Liang Chen, , , ; Fei Chen, NCAR/RAL, Boulder, CO; Alan Barr, Environment Canada, Saskatoon, SK, Canada; Bingcheng Wan, , ,

Abstract Body: In this study, a 10-year Boreal Forest (BERMS SK-OAS) site measurements were used to evaluate and calibrate the multi-physics version of the Noah Land-Surface model (Noah-MP) . Those processes which are crucial for the simulation were identified. The performance of different combinations of the parameterization schemes was evaluated statistically. The best combination was identified by the most appropriate simulation (CTL) of surface heat and moisture fluxes as well as soil temperature and moisture at different depths.

Although organic matter is not normally included in the current Noah-MP land-surface model, an organic soil layer was added in our simulation of BERMS site. By adding an 100% organic matter to the top 10cm of the soil alters the soil's thermal and hydraulic properties, and significantly improved the simulation of the thermal and hydrological components. The organic soil layer reduces summer soil temperatures while increases the winter soil temperatures, which (OGN) matches the observation much better than CTL. By including the organic soil layer in Noah-MP also improves the deep layer soil moisture simulation. The increase of the porosity and hydraulic conductivity of the organic soil increases soil moisture while decreases the surface evaporation at the same time.

For the 10-year observation, dry (2002-2003) and wet (2005-2006) phases are identified. The diurnal cycle of surface sensible and latent heat flux was studied to see the contrast between the dry and wet phases. The annual cycle of surface fluxes, water components were also studied to examine the different characteristics for dry and wet phases.

Abstract ID: 36492

Final Number: H31A-04

Title: Comparing Observed and Simulated Interannual Variability in the Carbon and Water Balances of the Southern Boreal Forest

Presenter/First Author: Omer Yetemen, University of Saskatchewan, Saskatoon, SK

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Co-authors: Andrew M Ireson, University of Saskatchewan, Saskatoon, SK, Canada; Jill F Johnstone, University of Saskatchewan, Saskatoon, SK, Canada; Alan Barr, Environment Canada, Saskatoon, SK, Canada; T. Andrew Black, University of British Columbia, Vancouver, BC, Canada

Abstract Body: There is a growing realization that Earth-system models must capture the linkages between climate, hydrology and vegetation dynamics. This study will focus on the southern boreal forest of western Canada, where the forest-grassland ecotone is controlled by the water balance and is therefore sensitive to climate change. Our goal is to evaluate and improve the quantification of the structural and functional responses of the southern boreal forest plant community in CTEM (the Canadian Terrestrial Ecosystem Model), which is coupled to CLASS (the Canadian Land Surface Scheme) in the Canadian GCM (General Circulation Model) framework. The long-term detailed ecological and meteorological observations at BERMS (Boreal Ecosystem Research and Monitoring Sites) in central Saskatchewan make an excellent test bed for the ecohydrological validation of CLASS-CTEM. The initial evaluation of CLASS-CTEM will be done at stand-level, based on observations from three mature forest: aspen, black spruce and jack pine. We will focus on seasonal and interannual variability in the carbon, water and energy fluxes with particular emphasis on vegetation phenology, freeze-thaw timing and summer soil-moisture limitation. We aim to reasonably represent the seasonal phenology of different vegetation types and to capture the interannual variations in the carbon, water and energy fluxes. The modeling results will improve our understanding of the ecosystem sensitivity to climate and hydrology, with important ramifications for the sustainability of fresh water resources and wildlife habitat.

Abstract ID: 34177

Final Number: H31A-05

Title: Simulation of Lake Heat Fluxes by the Canadian Small Lake Model: Offline Performance Assessment for Future Coupling with a Regional Climate Model

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Abstract Body: Lakes strongly influence local and regional climate especially in regions where they are abundant. Development of a lake model for the purpose of integration within a regional climate model is therefore a subject of scientific interest. Of particular importance are the heat flux predictions provided by the lake model since they function as key forcings in a fully coupled atmosphere-land-lake system. The first step to a coupled model, is to validate and characterize the accuracy of the lake model over a range of conditions and to identify limitations. In this work, validation results from offline tests of the Canadian Small Lake Model; a deterministic, computationally efficient, 1D integral model, are presented. Sensible and latent heat fluxes simulated by the model are compared with in situ eddy covariance (EC) observations from Landing Lake (NWT, Canada) for the 2007-2009 period. Agreement between the EC data and simulated heat fluxes is assessed in terms of atmospheric stability, closure fraction and model formulation. Minimal model error appears to occur for unstable atmospheric conditions. Theses results demonstrate the ability of the 1-D lake model to reproduce both diurnal and seasonal variations in heat fluxes and surface temperatures for the open water period.

Abstract ID: 34559

Final Number: H31A-06

Title: Long-term Changes in Distributed Precipitation Phase at Reynolds Creek Experimental Watershed, Idaho, USA.

Presenter/First Author: Patrick R Kormos, USDA Agricultural Research Service, Boise, ID

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Abstract Body: A warming climate poses significant challenges to water resource managers of the Western United States because the phase of precipitation often dictates hydrologic response. One of the few places in the world that we have sufficient measurements to accurately estimate precipitation phase is the Reynolds Creek Experimental Watershed. Distributed precipitation phase data are used to quantify changes in the volume of snow and mixed precipitation received over the past 30 years. We combine distributed air temperature and relative humidity from detrended kriging to obtain maps of dew point and wet bulb temperature. We then utilize a simple look up table to classify distributed precipitation as rain, snow, or mixed events.

Abstract ID: 35570

Final Number: H31A-07

Title: Estimating SWE distribution with a combination of ground-based radar measurements, modeling and remote sensing

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Abstract Body: Estimating the spatial distribution of snow water equivalent is often complicated by large spatial variability due to the effects of wind, vegetation, topography, and microclimate. In order to accurately capture important features of the snow distribution at local scale, measurements and models must be performed at resolutions that are often not practical over hydrologically significant scales. However, with recent increases in measurement technology and computational power, spatially distributed estimates of SWE at high resolution from both measurements and models are becoming feasible at the basin scale. We compare SWE estimates using traditional techniques (depth, core measurements) with estimates using ground-based radar, airborne LiDAR, and iSnobal model results for the Reynolds Creek Experimental Watershed, near peak SWE in March 2009. The combination of coincident high-resolution ground-based measurements, remote sensing, and modeling allows accurate quantification of the uncertainties in each technique, and this unique dataset is used to develop efficient data fusion strategies for accurate spatial estimates of SWE with quantified uncertainty.

Abstract ID: 35822

Final Number: H31A-08

Title: Fusing Basin-Scale Airborne Observations with Simulations to Quantify Mountain Snow Water Storage During a Severe Drought

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Abstract Body: One of the great unknowns in mountain hydrology is how much water is stored within a seasonal snowpack at the basin scale. Quantifying mountain water resources is critical for informed water resource management, but has proven elusive due to high spatial and temporal variability of mountain snow cover, complex terrain, accessibility constraints and limited in-situ networks. The Airborne Snow Observatory (ASO, aso.jpl.nasa.gov) uses airborne LiDAR techniques to derive snow depth combined with snow densities from a physically-based snow model to provide unprecedented basin-wide estimates of snow water mass (snow water equivalent, SWE). ASO was operational over selected basins in the Sierra Nevada in California during 2013 and 2014. Both years were very dry, with precipitation in 2013 at 75% of average, and 2014 – the driest year on record, 50% of average. Using over 10 weekly ASO acquisitions from peak SWE thru spring each year, we were able to provide water managers with reliable estimates of SWE volume, snow cover depletion and surface water input over the basin. However, shallow snow presents many difficulties for both LiDAR measurement of snow depth and for simulation modelling of precipitation distribution and snow density. The analysis presented here attempts to quantify and analyse these uncertainties. Our findings show that even during a drought year the LiDAR depth fields combined with the simulation model provide improved estimates of SWE volume in the basin. We also show the potential for the LiDAR depth fields to be used to improve precipitation estimates over this complex mountain region, and to update the snow distribution for improved density simulations. The NASA/JPL ASO program is the most important coupling of LiDAR remote sensing and snow hydrology in the last 50 years.

Abstract ID: 36709

Final Number: H31B-02

Title: Statistical analysis of flow dimension occurrences in natural aquifers from various geological environments: input on their conceptual interpretation

Presenter/First Author: Anouck Laura Ferroud, Unversité du Québec à Chicoutimi, Chicoutimi, QC

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Abstract Body: Interpretation of pumping tests with conventional models (e.g. Theis) can lead to an erroneous estimation of hydraulic properties in complex aquifers such as fractured, faulted, karstified, glacial deposits, heterogeneous and with a variable geometry.

The *Generalized Radial Flow* (GRF) model developed by Barker (1988) opens new avenues for pumping well test interpretation by introducing non-radial behaviors as defined by values of the flow dimension *n* different from two (Theis-like assumption). This parameter *n* expresses the influence of the aquifer's physical and hydraulic features on drawdown transient evolution. In fact, the temporal evolution of *n* represents the diffusion of the frontal equipotential wave of drawdown. It comes to realize a "scan" of the hydraulic conditions in the reservoir. However, the GRF model remains seldom used due to the difficulty to relate flow dimensions to conceptual aquifer conditions, in spite of its high diagnostic potential.

Flow dimensions sporadically reported in the literature in support of original models are not representative of their statistical distribution in nature. A systematic analysis of their occurrence, through the compilation of several pumping test databases, emphasizes the importance of multi-stage responses formed by temporal combinations of linear, radial, spherical and/or fractional flow regimes. Cross-comparison with bulk geological information provides valuable insights on the conceptual interpretation of flow dimensions. For instance, the frequency of fractional flow dimension into granular aquifer tends to invalidate their common interpretation as fractured media. Moreover, linear flow regime is dominant in glaciofluvial aquifers, which can be attributed to channels, deeply differing from their common interpretation as relating to highly conductive faults.

The field results are also coupled with numerical simulations to investigate the 3D front pulse diffusion in diverse heterogeneity conditions. This composite strategy is designed to highlight the influence of geological features, boundary conditions, wellbore characteristics or hydraulic properties on the flow patterns induced by a constant-rate pumping test. This approach illustrates especially the usefulness of the developed interpreting tools.

Abstract ID: 34788

Final Number: H31B-04

Title: Characterization of fractured and karstic reservoir by Spot imagery and Geophysical prospecting (Middle Atlas Causses, Morocco)

Presenter/First Author: Khaoula Qarqori, Moulay Ismail University, Sidi Yahia el Gharb,

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Co-authors: Mohamed Rouai, University of Moulay Ismail, Faculty of Sciences of Meknes, Meknes, Morocco; Ginette Saracco, , , ; Mustapha Boujamaoui, , , ; Ahmed Manar, , ,

Abstract Body: The Liassic Middle Atlas Causses, and their junction with the Saïs Basin, is the most interesting fractured and karstic reservoir in the northern Morocco. However, it is less studied and poorly understood.

This study presents a multidisciplinary approach for the characterization of this kind of discontinuous reservoirs. The application of remote sensing has overcome the challenge of the oldest state of the data and the large scale of the studied areas, the analysis of SPOT images and new ASTER elevation data has led to establish draw a new fracturing map of the Causses.

The characterisation of fracture networks, their spatial clustering and connectivity, have facilitated the detection of potential hard-rock aquifers. These ones were taken into account for the application of geophysical prospecting techniques at small scale.

The « Aïn Bittit » area, around an important karstic spring, and lying at the junction between the Causses and the Saïs basin, has been chosen as target for geophysical imaging such as Electrical Resistivity Tomography and microgravimetry. These geophysical methods showed high reliability in the detection and mapping of the structure of the underground organization and probable hydrological flow paths.

The overall results of spatial and geophysical studies validated by field measurements and by the drilling of a 100m borehole showed a convergence and complementarities. The reservoirs of Causses and their junction with the Saïs Basin are characterized by heterogeneous and high clustering fracturing which is predominated by NE-SW and NW-SE directions.

At «Aïn Bittit » area, a « mini-graben » structure-like has been identified. The geometrical modelling suggested, in addition to vertical groundwater flows through faults, the existence of horizontal drained zone in karstic Quaternary travertine at shallow depth. Locally, the preferential circulations depend upon the direction of fractures.

Abstract ID: 36470

Final Number: H31B-05

Title: Characterizing Complex Aquifers Using Flow Dimension Diagnostic Sequences

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Abstract Body: In hydrogeology, transient hydraulic tests are still interpreted assuming Theis-like conditions, involving gross approximations of natural aquifers heterogeneities, and inducing errors in hydraulic parameters estimation which relevance depends on various hydrogeological and practical factors. The petroleum industry adopted for decades the drawdown log-derivative analysis for reservoir characterization, as part of the diagnostic plots approach that integrates a panel of analytically-derived interpretative models handling non-purely theisian conditions. Our numerical experiments corroborate how drawdown log-derivative interpretation allows identifying subtle changes in hydrodynamic conditions that are totally invisible on conventional drawdown plots. Such changes relate to different flow regimes produced by heterogeneities of various types (faults, lateral variations, irregular boundary geometry etc.), indicated by changes in the flow dimension as calculated using the GRF model. These changes succeed one another as the front pulse propagates outward from the pump well and reaches successive heterogeneities, resulting in some temporal sequences of flow dimensions. Taking numerical examples, we investigate how these flow dimension sequences provide efficient diagnostic tools for aquifers heterogeneities.

Presented examples of heterogeneous flow simulations are: inclined substratum, laterally juxtaposed and faulted aquifers. In all cases, log-derivative analysis allows detecting heterogeneities by visualizing flow regime changes, with varying flow dimension values. For instance, a conductive fault crosscutting the aquifer generates a highly diagnostic flow dimension sequence, which varies if the fault is inclined and/or connected to the well. Also, variable-thicknesses aquifers or punctual connections to underlying leaky bedrock domains generate responses identical to a recharge barrier on conventional semi-log drawdown plots, leading to erroneous interpretations that may be avoided using the suggested methods. Several flow dimensions diagnostic sequences are presented, related to conceptual heterogeneous flow models. This constitutes a pioneer typological catalogue of refined interpretative tools available for an advanced analysis of pumping tests data.

Abstract ID: 36833

Final Number: H31B-06

Title: Permanganate Natural Oxidant Demand and Its Retarding Effect on Diffusion in Sandstone

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Abstract Body: Sandstone samples were collected from drill core at the Santa Susanna Field Laboratory in southern California where an In Situ Chemical Oxidation (ISCO) experiment is planned to test the efficacy of permanganate for remediation of chlorinated solvent contamination in groundwater. The permanganate natural oxidant demand (PNOD) was measured with batch experiments on a representative group of samples from above (oxidized) and below (unoxidized) the water table. Diffusion measurements were also conducted on the samples using a conservative tracer (tritiated water, HTO) and permanganate in separate experiments. The PNOD results indicate a dependency on the initial concentration of permanganate and the duration of the experiment, but in general PNOD values are highest for unoxidized samples. Mineralogical investigations indicate that organic carbon is the solid component that is most reactive with permanganate, whereas pyrite shows no indication of reactivity. The effective diffusion coefficients (D_e) for HTO are consistent with medium to coarse grained sandstone, ranging from 6.4×10^{-12} to 3.8×10^{-11} m^2/s. The apparent diffusion coefficients (D_a) for permananganate diffusion in the oxidized samples range from 1.1×10^{-12} to 2.8×10^{-11} m^2/s, but these values are subject to significant uncertainty because the permanganate diffusion flux was not stable during the experiments. In contrast, permanganate breakthrough was not observed during diffusion experiments conducted on unoxidized samples with 5g/L $KMnO_4$ tracer, thus it was not possible to obtain D_a values. Subsequent mineralogical analysis demonstrated that the permanganate tracer penetrated only 2.5 mm over a four month duration. These results indicate that the NOD may have a profound influence on the penetration of permanganate into the rock matrix during attempts to use ISCO for remediation of fractured porous bedrock systems.

Abstract ID: 33319

Final Number: H31B-07

Title: Trace element concentration and distribution in groundwater of Talcher coal field areas, Odisha, India

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Co-authors: Rudra Mohan Pradhan, Indian Institute of Technology Roorkee, Roorkee, India

Abstract Body: A study was carried out in and around Talcher coal field areas of Odisha to evaluate the current status of trace elements, their concentration and distribution in groundwater. The excess presence of trace elements concentration in groundwater affects different parts of human body. So there is a growing concern over the potential accumulation of trace elements concentration of Fe, As, Pb, Ni, Cr, Cd, Mn, Co, Cu and Zn in groundwater due to mining of coal and metal deposits. For the present study a total of 36 nos. of groundwater samples were collected in two different seasons (pre monsoon period and post monsoon period) from some parts of Talchir Coal field, Odisha, India. The water samples were analysed for nine trace elements using inductively coupled plasma mass spectrometry (ICP-MS). Among these trace elements the toxic elements like Pb and As are within permissible limit (WHO, 1984). But some other trace elements like Fe, Mn and Cr are significantly higher than other trace elements. The concentration of Fe, Mn and Cr ranges from 114-1262 µg/l, 0-263 µg/l and 2-21 µg/l respectively during pre monsoon period and during post monsoon period the concentration ranges from 81-1218 µg/l, 1-385 µg/l and 1-30 µg/l respectively. The higher concentrations of Fe, Mn and Cr in groundwater may be due to increasing of urbanization, industrialization and leaching from natural geological formations.

Keywords: Trace elements, Talchir coal field, groundwater

Abstract ID: 36037

Final Number: H31C-01

Title: Assessment of the impact of land cover and beneficial management practices on water quality in complex watersheds – challenges and research opportunities ahead

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Abstract Body: Many watersheds are characterized by heterogeneous or mixed land cover. As such, urban, agricultural, industrial and forested areas are often found in the same watershed. In the urban portion, water quality tends to be governed by variability in both dry and wet conditions; while in the agricultural and forested portions, it is mostly governed by wet conditions producing significant runoff. When mobilized sources of contaminants are transported, impaired water quality conditions can arise in surface and ground waters. The transport can be altered by managing sources and/or modifying both hydrological and sedimentlogical connectivity. From a surface hydrology point of view, the watershed represents the basic unit to assess the impact of various land covers and Beneficial Management Practices (BMPs) on water quality and ultimately on sustainable development. One way to accomplish this task is to apply an integrated modelling framework at the watershed scale. Several applications of such a modelling framework have demonstrated that evaluation of the effects of land covers and BMPs cannot be solely based on analysis of overland loads but must also focus on in-stream concentrations and loads as non-linear behaviors characterize the outcomes. A comprehensive cumulative impact assessment must further be performed and based on cost and environmental benefit analysis, as well as on biological integrity indices and probability of exceeding ecotoxicological criteria. Although models are continuously improved, recent field surveys highlight the need for further investigate sediment dynamics in the stream network as well as in the riparian zone. This is one example of the real challenges ahead. This presentation will discuss the challenges and research opportunities of modelling key processes at meaningful spatial and temporal scales with an emphasis on the modelling of vegetated filters and wetlands.

Abstract ID: 35217

Final Number: H31C-02

Title: The Influence of Surface Coal Mining on Hydrology and Solute Transport in the Elk Valley, British Columbia, Canada

Presenter/First Author: Christopher C Wellen, McMaster University, Toronto, ON

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Abstract Body: Surface mining of coal in the Elk Valley, British Columbia, involves blasting of overburden rock to access mineable ore. Waste rock is placed in adjacent valleys, where it interacts hydrologically and chemically with the environment. As part of a multi-year R&D program examining the influence of surface mining on hydrological and water quality responses in the Elk Valley, this study investigated the relationship between mining practices, stream flows and solute concentrations. This work focused on the interplay of hydrology, water quality, and mining practice. Concentration-discharge relationships from catchments covered by waste rock show virtually no change of weathering ion concentration with increases in flow. This suggests solute export is transport-limited. Bayesian networks of empirical models were used to calculate annual loads of selenium, a weathering solute, as well as estimate their uncertainty. Load estimates are used to drive a SPAtially Referenced Regression On Watershed attributes (SPARROW) model of selenium, the first known application of SPARROW to a metalloid. The significance of a range of variables associated with waste rock placement techniques were assessed, with most not significantly affecting selenium release rates. Reclaimed area on waste rock spoils was identified as a variable that influenced selenium release rate, with increasing reclaimed area associated with decreasing selenium release. Annual selenium release rates tracked annual runoff, providing evidence that selenium release is largely transport-limited.

Abstract ID: 36005

Final Number: H31C-03

Title: Regulation of the Distribution of Anthropogenic Contaminants by Physical Limnological Processes in a Relatively Pristine Watershed: the Breach of the Mount Polley Mine Tailings Impoundment, British Columbia, Canada

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Published Material: preliminary data has been submitted to GRL and is currently under review

Abstract Body: On 4th August 2014, the tailings impoundment of the Mount Polley copper and gold mine in British Columbia failed. Material from the impoundment (surface area = 2.7 km^2) flowed into nearby Polley Lake and Hazeltine Creek, before discharging into Quesnel Lake, a large (ca. 100 km long, >500 m deep), relatively pristine lake. Estimates suggest that approximately 25 Mm^3 of tailings (water and solids) and eroded soils and surficial materials from Hazeltine Creek were delivered to Quesnel Lake, raising the lake by 7.7 cm. Much of this material was deposited at the bottom of Quesnel Lake but a plume of fine-grained sediment (D_{50} of ca. 1 µm) remained suspended in the water column. The distribution of this sediment was monitored over several months using water column profiling for temperature, conductivity, fluorescence, turbidity and oxygen with depth. The plume movement was regulated by natural processes associated with the physical limnology of this large fjord lake, specifically, seiche events which transferred suspended particles both up-lake, against the flow regime and down-lake into the Fraser River. Documentation of the distribution of the plume in the first few months following the spill is presented and indicates the value of background knowledge of natural systems in the vicinity of mining operations and other facilities where significant inputs of contaminants could occur.

Abstract ID: 34674

Final Number: H31C-04

Title: From The (Relatively) Pristine to the Polluted: The Breach Of The Mount Polley Mine Tailings Impoundment, Quesnel Watershed, British Columbia

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Co-authors: Ellen L Petticrew, Univ Northern British Columbia, Prince George, BC, Canada; Sam J. Albers, Univ Northern British Columbia, Prince George, BC, Canada

Abstract Body: On 4th August 2014, the tailings impoundment of the Mount Polley copper and gold mine in British Columbia failed. Material from the impoundment (surface area = 2.7 km^2) flowed into nearby Polley Lake and Hazeltine Creek, before discharging into Quesnel Lake, a large (ca. 100 km long, >500 m deep), relatively pristine lake. Estimates suggest that approximately 25 Mm^3 of tailings (water and solids) and eroded soils and surficial materials from Hazeltine Creek were delivered to Quesnel Lake, raising the lake by 7.7 cm. Much of this material was deposited at the bottom of Quesnel Lake but a large plume of fine-grained sediment (d_{50} of ca. 1 µm) moved both up-lake towards important salmon spawning areas and down-lake into Quesnel River, which in turn flows into the Fraser River. Samples of lake water and sediment samples taken from the impacted area show elevated levels of metals and other elements, which may have important implications for the ecosystem in this watershed. Indeed, the breach occurred at a time when a peak run of sockeye salmon were returning to their natal streams in this watershed. This presentation describes the failure of the impoundment dam and presents preliminary findings of the aquatic impacts of this environmental disaster.

Abstract ID: 36430

Final Number: H31C-05

Title: Understanding and Modelling Hydrological Impacts of Land Use and Land Management Change

Presenter/First Author: Howard S. Wheater, University of Saskatchewan, Saskatoon, SK

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Published Material: Findings included in this presentation have also been reported in the following journals: 1) McIntyre, N., Ballard, C., Bruen, M., Bulygina, N., Buytaert, W., Cluckie, I., Dunn, S., Ehret, U., Ewen, J., Gelfan, A., Hess, T., Hughes, D., Jackson, B., Kjeldsen, T.R., Merz, R., Park, J-S., O'Connell, E., O'Donnell, G., Oudin, L., Todini, E., Wagener, T. and Wheater, H.S. 2014. Modelling the hydrological impacts of rural land use change. *Hydrology Research*, doi:10.2166/nh2013.145. 2) Bulygina, N., Ballard, C., McIntyre, N., O'Donnell, G. and Wheater, H.S. 2012. Integrating different types of information into the hydrological model parameter estimation: Application to ungauged catchments and land use scenario analysis. *Water Resources Research,* 48(6): W06519,
DOI: 10.1029/2011WR011207. 3) Fraser, C.E., McIntyre, N., Jackson, B.M. and Wheater, H.S. 2013. Upscaling hydrological processes and land management change impacts using a metamodeling procedure. *Water Resources Research*, 49: 1-17, doi: 10.1002/wrcr.20432

Abstract Body: Understanding the impacts of human activities on the water environment is a grand challenge for hydrological science; effects include land-atmosphere feedbacks, as well as changes to surface water and groundwater systems. There is therefore a need to understand local impacts and also their larger scale effects, with associated implications for observations and modelling. Urbanisation remains one of the most dramatic changes to the natural environment, but changes to flood runoff processes are relatively well understood, are identifiable from regional analysis of catchment response and are routinely accounted for in urban storm-water design. However, the representation of basin-scale impacts of urbanisation remains a challenge, as local detail of urban development and drainage design are important factors in determining larger scale response. Other unresolved issues include quantification of urban water balances, land-atmosphere interactions, and water quality impacts. Agricultural land management effects are more subtle and often poorly understood. Regional hydrological analyses have failed to identify large-scale effects on runoff response, but have provided some insights into nutrient processes. There is an urgent need for detailed monitoring and modelling of fine scale processes, and the development and application of appropriate models at basin and regional scales, to guide management and policy. Recent developments in modelling the effects of agricultural land management change across scales are discussed; outstanding challenges for observations and modelling are identified.

Abstract ID: 36498

Final Number: H31C-06

Title: Net Evaporation Resulting from the Creation of a Boreal Hydroelectric Reservoir

Presenter/First Author: Ian B Strachan, McGill University, Montreal, QC

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Co-authors: Alain Tremblay, Hydro-Québec, Montreal, QC, Canada; Simon Tardif, , , ; Christian Turpin, , , ; Luc Pelletier, McGill University, Montreal, QC, Canada

Published Material: An earlier version is published in Tremblay, A., Tardif, S., Strachan, I.B., and Turpin, C., 2014. Net water evaporation from the

Eastmain-1 reservoir. *Hydro Review* 33(5): 52-60. The information has been reworked and expanded.

Abstract Body: The creation of hydroelectric reservoirs results in a land-use change through the flooding of ecosystems and the environmental footprint of this change is of interest. In particular, there is increasing debate as to whether hydroelectric reservoirs are a significant consumer of water through evaporation. To date, most studies evaluating this change have used gross evaporation (indicating consumption). However, such studies neglect to account for the water loss that would have occurred through the pre-flooded ecosystem evapotranspiration (ET). Instead, the net ET is required to assess the net impact of the creation of a hydroelectric reservoir on the water consumption. We studied net ET loss in the Eastmain-1 hydroelectric reservoir located 800 km north of Montreal, QC from 2006-2012. The reservoir has a surface area of 600 km² and resulted from flooding of mature coniferous forest, peatlands, burned forest and aquatic systems. In contrast to the limited number of previous studies, we used eddy covariance (EC) towers to directly measure evaporation from the reservoir itself and ET from representative forests and wetlands at the same time. As expected, our results show that the ET rates were higher during the warmer months than during fall-winter time and that the gross ET and evaporation rates for the natural ecosystems and the reservoir were similar to those measured in other northern systems. Overall, we found the net evaporation [(reservoir – pre-flooded ecosystem ET) / kWh] to be on the order of 5-25% of gross. If the reductions in reservoir water level that normally occur through management are considered, this number reduces further indicating that northern reservoirs are small net consumers of water.

Abstract ID: 36653

Final Number: H31C-07

Title: Estimating the Impact of Depressional Storage Drainage on the Hydrology of a Canadian Prairie Basin using Physically Based Modelling

Presenter/First Author: John W Pomeroy, University of Saskatchewan, Canmore, AB

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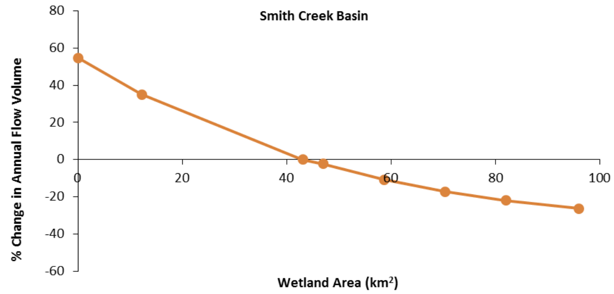
Published Material: Some of these findings were reported in Centre for Hydrology Report No. 14: *Pomeroy J.W., Shook K., Fang X., Dumanski S., Westbrook C. and Brown T.* Improving and Testing the Prairie Hydrological Model at Smith Creek Research Basin (2014). Some of these findings have been reported in the media: Globe and Mail, CBC The National, CBC The Current, Winnipeg Free Press, Regina Leader Post, CTV National News, PostMedia News.

Abstract Body: The impact of depressional storage change on the hydrology of small Canadian Prairie basins has been unclear because of conflicting conclusions on the degree of impact between studies of runoff in very small scale drainage systems and those of multi-year streamflow characteristics of larger basins. To better understand and predict the impact of depressional storage drainage (DSD) on prairie streams, the Cold Regions Hydrological Modelling platform was used to create the Prairie Hydrological Model (PHM) which simulates blowing snow redistribution, snowmelt, infiltration to frozen soils and the fill and spill of networks of ponds at multiple scales. The PHM was used to simulate the hydrology of Smith Creek Research Basin, Saskatchewan (~400 km²) with various DSD scenarios. Smith Creek basin has undergone substantial DSD from 1958 when it contained 96 km² of ponds covering 24% of the basin area to 43 km² covering 11% of the basin in 2008. This model simulations show that DSD can increase annual and peak daily flows substantially, and that notable increases to estimates of the annual volume and peak daily flow of the flood of record have derived from DSD to date and will proceed with further DSD. Restoration of depressional storage from the current extent back to that of 1958 decreased the simulated 2011 flood peak by 32% and the 2011 yearly volume of streamflow by 29%. Overall, Smith Creek total flow volumes over six simulation years increased by 55% due to complete DSD from the current (2008) state, and decreased by 26% with restoration to the 1958 state. Whilst the greatest proportional impacts on the peak daily flows are for dry years, substantial impacts on the peak daily discharge of record (2011) from DSD (+78%) or restoration (-32%) are notable and important in Smith Creek and downstream.



Abstract ID: 33502

Final Number: H32A-01

Title: Hydrologic and Thermal Responses to Rapid Retreat of a Lake-Terminating Glacier

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Published Material: Some initial results based on thesis research were presented by Matt Chernos and Lawrence Bird (then MSc students) at the CGU 2014 Annual Meeting. This presentation draws upon more complete analyses, along with material that has not yet been presented. There are two manuscripts currently in preparation based on Bird's and Chernos' thesis research, but neither has been submitted.

Abstract Body: There has been increasing concern about the effects of ongoing glacier retreat and its influences on downstream river flows and aquatic habitat, including water temperature. Few studies have focused on the downstream effects associated with the formation of proglacial lakes, and no studies to our knowledge have focused on the effects of icebergs calved from lake-terminating valley glaciers. To address this knowledge gap, we are studying Bridge Glacier in the Coast Mountains of British Columbia, Canada, which currently terminates in a proglacial lake with a maximum depth of ~180 m. Analysis of Landsat imagery and application of an inverse linear response model indicate that the rate of retreat increased by two- to three-fold over predicted rates when the glacier terminus retreated into an over-deepened basin ca 1991. Field observations and energy-balance analysis for summer 2013 demonstrate that the presence of icebergs reduced summertime warming of the lake, as a result of a) the reduced area of water surface exposed to energy exchange and b) the consumption of thermal energy to drive sub-aqueous melting. During the 2013 field season, iceberg calving represented about 25% of the total mass loss of the glacier, and an energy balance analysis suggested that iceberg melting accounted for 6-7% of the total discharge recorded downstream of the lake. Once Bridge Glacier retreats to the point it becomes land-terminating, the loss of iceberg production will result in increased summertime lake warming and a reduction in meltwater runoff, with

implications for downstream aquatic environments. Ongoing research is focused on generating longer-term estimates of iceberg dynamics and their influence on summer streamflow trends.

Abstract ID: 35419

Final Number: H32A-02

Title: Geophysical Approaches to Improve Holocene Ice Core-Based Hydroclimate Reconstructions in the Northeast Pacific

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Published Material: I will present some of the Alaskan results of this work at the March 2015 Northeast Geological Society of America meeting, but will focus here on our work in the Yukon Territory.

Abstract Body: Paleoclimate data from the Pacific basin show significant hydroclimate changes over the past millennium, possibly in response to changes in the mean state of the El Niño Southern Oscillation. One hypothesis invokes a change from a persistent La Niña-like state during the Medieval Climate Anomaly (MCA) to a persistent El Niño-like state during the Little Ice Age (LIA). A test of this hypothesis is to reconstruct and evaluate the spatial precipitation anomaly pattern in the Northeast Pacific across the MCA-LIA transition, because modern observations show an enhanced (weaker) coastal-inland precipitation gradient in the region during La Niña (El Niño) conditions. We therefore predict that the NE Pacific precipitation anomaly pattern will weaken across the MCA-LIA transition. For the past decade, we have been developing an ice core array in the NE Pacific that targets the two nodes of this precipitation dipole (i.e., St. Elias Range and Central Alaska), most recently (2013) with the recovery of two surface-to-bedrock 210-meter ice cores from Mt. Hunter (Denali National Park). To determine precipitation variability at the Mt. Hunter site over the past millennium, we rely on a suite of supporting geophysical data to constrain glacier geometry (including digital elevation models and bedrock topography from ground penetrating radar), velocity, boundary conditions, and rheological properties in a 3-dimensional finite element numerical model. The combined observational and model datasets will allow us to remove influences of ice flow (which causes layer thinning) and spatial variability in snow accumulation rate to estimate temporal accumulation variability from the two ice cores. Here we focus on our overall approach and plans for future work in the St. Elias Mountains, where ice cores were recovered in 2002 (Eclipse Icefield and Mt. Logan). In particular, we highlight results of ground penetrating radar and terrestrial laser scanning (TLS) conducted on the Mt. Hunter plateau during May-June 2014 with the goals of producing a high precision DEM as input for the glaciological model and evaluating surface elevation change through time.

Abstract ID: 35575

Final Number: H32A-03

Title: Melt Processes at Glacier Margins: High-Resolution Ground-Based IR Imagery in the Cordillera Blanca, Peru

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Published Material: About 25% of this material had been presented at the 2014 AGU Fall Meeting.

Abstract Body: Alpine glaciers provide water resources to some of the most populated regions on Earth. However, these resources are threatened by ongoing and accelerating glacier retreat. To properly understand the impact of this retreat on water resources downstream, we need to understand the processes driving the ablation of these headwater glaciers. Due to their remote location and often complicated access, obtaining in-situ, glacier-wide data for alpine glaciers is challenging. An emerging technique to investigate melt processes in these complex settings is ground-based infrared imagery. Infrared images, captured simultaneously with traditional weather stations monitoring on and off the glacier, can be processed to obtain high spatial and temporal resolution temperature maps of the glacier surface. This spatially distributed temperature data allows for the investigation of small scale surface processes such as the impact of surface cover and temperature gradient at glacier margins. These processes are investigated for a tropical glacier in the Cordillera Blanca, Peru. Daily time-lapse infrared imagery (5-30 minute spacing) of the glacier and close-up images of the margin, were acquired for the 2013 and 2014 dry season. The results indicate that the temperature gradient between the surrounding rocks and the glacier margins is highly dependent on topographic shading in addition to atmospheric and meteorological conditions. In clear sky conditions, incoming shortwave radiation heats the exposed rock faster than the adjacent ice, leading to a net radiation flux toward the glacier. This effect is also seen in late afternoon, when there is no more direct solar forcing. These energy transfers at the glacier margins appear to be a small but significant contribution to the overall melt generation for small alpine glaciers. This study shows the potential utility for collecting and analyzing ground based infrared imagery for glacier studies, with implications for hydrologic and water resource applications.

Abstract ID: 35915

Final Number: H32A-04

Title: Post Peak Water in the Cordillera Blanca, Peru: Toward a Redistribution of Water Resources.

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Abstract Body: Recent researches have shown that the upper Rio Santa and some of its tributaries that drain the western slopes of the glacierized Cordillera Blanca in Peru have already passed peak water, the moment of maximum water availability, and now exhibit decreasing dry season discharge as a consequence of glacial retreat. In addition, it was suggested that the glacier retreat impact of stream discharge is not uniform across the watershed. For instance, two different points along the Rio Santa were shown facing two different levels of glacier retreat impact on dry season discharge.

In the present study, we extend the exploration of the peak water situation spatial repartition by dividing the Rio Santa watershed into 26 sub

catchments and analyzing the impact of the glaciers retreat on these sub catchments dry season hydrology. We measured stream discharge at 11 locations along the entire course of the Rio Santa and sampled water at 33 locations to analyze for major dissolved ions and the stable isotopes of water. We interpreted the sample characteristics using a distributed hydrochemical watershed mapping tool called the Hydro-chemical Basin Characterization Method (Baraer et al., 2014). Glacier retreat simulations were then used to project future hydrological changes as a function of glacier mass loss and evaluate the downstream repercussions.

The results confirm that the entire Rio Santa watershed has passed the peak water. An overall decline of the dry season discharge of 30% of the actual level is anticipated just upstream of the major coastal diversions installations, a level that situates below the present demand for coastal uses. The geospatial heterogeneity in glaciers hydrological influence on stream discharge is explained by differences in glacier cover as well as in glaciers retreat rates. The most pronounced discharge reduction should be observed in the central part of the Cordillera Blanca where towns like Huaraz, the province capital, should be deeply affected.

Abstract ID: 34183

Final Number: H32A-05

Title: Using isotopic and geochemical tracers to determine the contribution of glacier meltwater to streamflow in a headwater catchment of Heihe River Basin, Northwestern China

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Abstract Body:
Glacier meltwater contributes significantly to the rivers flowing off the cold mountains to the arid basins in inland area, Northwest China. However, th e processes and mechanisms that control runoff generation in the cold hig h mountains where glacier meltwater, permafrost and frozen ground pred ominate have undergone few studies. Our objective is to determine the co ntribution of glacial meltwater to the streamflow in the Hulugou catchmen t, a headwater catchment of the Heihe River Basin, NW China. Water samp les from glacier meltwater, rainfall, stream and groundwater were collecte d between June and September 2012 and then were analyzed for isotopic and hydrochemical composition in laboratory. Three-
component hydrograph separations were used to identify the spatial and t emporal water sources of streamflow based on the data of stable water iso topes (δD) and chloride ion (Cl-
). Our results show that base flow dominates the streamflow, contributing 42% to the streamflow in rainy season (June to August) whereas glacier me lt water (24%) and rainfall runoff (34%) contribute the rest of streamflow. I t is an interesting finding that base flow increases in both amount and prop ortion following relatively insensitive rainfall events. During the study perio d, the contribution rate of glacier meltwater varies significantly, ranging fro m 0% to 40%. An obvious increase in contribution rate of glacier meltwater was also observed when rainfall event was over. There is a significant nega tive correlation between the contribution rate of glacier meltwater and rai nfall. Result from this research could improve our understanding of source waters in alpine catchments where discharge is dominated seasonally by gl acier meltwater, and consequently provide the theoretical basis for the de velopment of distributed runoff model.

Abstract ID: 34831

Final Number: H32A-06

Title: The hydrology of biological hotspots in a glacierized catchment: developing conceptual understanding of spatiotemporal variation in water sources and flow paths

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Co-authors: Nicholas Kettridge, University of Birmingham, Birmingham, United Kingdom; Chris Bradley, University of Birmingham, Birmingham, United Kingdom; Alexander Milner, University of Alaska, Fairbanks

Abstract Body: Stream emergences on floodplain terraces in glacierized catchments are often widespread and act as important 'biological hotspots', typically supporting elevated in-stream biotic diversity, and abundance. However, the water sources and flow paths supporting these stream systems and their spatiotemporal variation remains poorly understood, particularly in the context of a changing climate. It is important to understand how changes in the water balance, given glacial retreat, melting permafrost, and shifting precipitation patterns will affect their structure and function. Here we present the results of a hydrogeomorphic and hydrologic study of one such terrace on the Middle Fork Toklat River, Denali National Park, Alaska (63° 29' 38.2"N, 149° 58' 6.0"W), in which a network of 22 nested piezometers and environmental tracers (major ion solutes and stable isotopes) were used to track water sources and establish flow paths. A number of hydrofacies units were identified across the terrace thereby indicating a heterogeneous structure. Groundwater recharge occurred consistently through the spring and summer and the terrace aquifer did not display a flashy response to storm or melt events. We present water chemistry and stable isotope data (δD & $\delta^{18}O$) which suggest that hillslope runoff processes, and associated water sources (snowmelt, discontinuous permafrost, and summer rainfall), are the dominant control upon terrace aquifer recharge, and not meltwater from up-valley glaciers. Findings suggest colluvial deposits on the slopes above the terrace act as small, but significant temporary storage aquifers, and are an important flow path that supports terrace aquifer recharge. Finally, the heterogeneous structure of the terrace fluvio-glacial deposits and associated spatial variation in water chemistry observed indicate the presence of multiple flow paths in the terrace subsurface and potential significance of preferential flow pathways (PFPs) to the existence of stream emergences. The work highlights the importance of hillslope runoff processes, rather than up-valley glacial retreat, when considering the implications of a changing climate upon these systems.

Abstract ID: 33619

Final Number: H32A-07

Title: Assembly of a twenty-year record of hourly meteorological data for Peyto Glacier basin with modelled mass balance and runoff time series.

Presenter/First Author: D Scott Munro, University of Toronto, Toronto, ON

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Abstract Body: The first complete year of recorded hourly global radiation, air temperature, relative humidity, wind speed and precipitation for the Peyto Glacier basin was obtained in 1992, continuing to the present day, thus distinguishing it as one of the longer such glacierized basin records in the world. One air temperature sensor has remained the same throughout this period, never to change position, but all others have changed due to sensor failure, fatigue and equipment updates. Also, there are significant gaps in the records of 1998, 1999 and 2009 due to power failures, thus requiring substitute values for modelling purposes. Most problematic is the precipitation record, the first half of which comes from an old Fischer-

Porter gauge, using unconventional procedures, the second from a modern Geonor gauge with standard data processing rules.

Discounting the three years when data gaps occurred, mean annual air temperature from 1992 to 2011 is -1.27 ±0.68 ˚C, the first decade of record almost 0.5 ˚C colder than the second. Mean yearly total precipitation is 1159 ±239 mm, approximately 64 ±11 % of which falls as snow according to a <1.5 ˚C threshold. The first ten years of record, solely from the Fischer-Porter gauge, suggest 1205 ±302 mm a^{-1} of precipitation, while the Geonor record of the second ten years indicates 1118 ±175 mm a^{-1}, the larger deviation a possible reflection of procedural differences. The data are used in conjunction with a LiDAR derived DEM to drive a 25 m resolution raster based mass balance model of the glacier surface which is applied cumulatively to estimate winter and summer mass balances over the twenty-year period, as well as daily summer runoff.

Abstract ID: 33860

Final Number: H32A-08

Title: Developing a Glacier Hydrology Model for the Canadian Rockies

Presenter/First Author: Dhiraj Pradhananga, University of Saskatchewan, Canmore,

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Co-authors: John W Pomeroy, University of Saskatchewan, Canmore, AB, Canada; Michael N. Demuth, , , ; Xing Fang, University of Saskatchewan, Saskatoon, SK, Canada; Tom Brown, University of Saskatchewan, Saskatoon, SK, Canada

Abstract Body: Mountain snow and ice play important roles in hydrological cycle of alpine regions by regulating water availability downstream in terms of both quantity and its seasonal variations. Many hydrological models have been developed, but very few explicitly calculate the snow and ice energy-budget and snow redistribution to estimate melt rates and mass balance. In this study, a model was developed in the Cold Regions Hydrological Model platform (CRHM) to calculate the hydrology of a glaciated stream influenced by the energy and mass balance of Peyto Glacier Research Basin in the Canadian Rockies. The model includes a new energy-budget glacier module, a new avalanche module, novel deployment of a layered energy balance snowmelt model, and a blowing snow model to a glacier surface. The model considers redistribution of snow by wind and avalanche as well as full radiation and turbulent transfer energetics to snow and ice. The model was set up using hydrological response units that consider elevation bands, slope and aspect units, wind exposure and avalanche runout as well as the heterogeneity of non-glaciated terrain. Meteorological observations from the stations within the basin and nearby locations were used to drive the model. The model was tested by comparing the simulated mass balance to observations from snow and ice depth on ice and off ice stations. Snow redistribution components of the model were evaluated by falsification of the model. This evaluation process is used to assess the uncertainty in comprehensive, physically based glacier melt modelling. Such a modelling approach is important for quantifying the melt rates in a glaciated basin in the context of climate change and variability.

Abstract ID: 33358

Final Number: H32B-01

Title: A survey of physically-based catchment-scale modeling over the last half century

Presenter/First Author: Claudio Paniconi, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec City, QC

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Co-authors: Mario Putti, University of Padua, Padua, Italy

Abstract Body: Integrated, process-based based numerical models in hydrology and connected disciplines (ecohydrology, hydrometeorology, hydrogeomorphology, biogeochemistry, hydrogeophysics, etc) are rapidly evolving, spurred by advances in computer technology, numerical algorithms, and environmental observation, and by the need to better understand the potential impacts of population, land use, and climate change on water and other natural resources. At the catchment scale, simulation models are commonly based on conservation principles for surface and subsurface water flow and mass transport (e.g., the Richards, St. Venant, and advection-dispersion-reaction equations, and approximations thereof), and need to be resolved by robust numerical techniques for space and time discretization, linearization, interpolation, etc. Model development through the years has continually faced physical and numerical challenges arising from heterogeneity and variability in parameters and state variables; nonlinearities and scale effects in process interactions and interface dynamics; and complex or poorly known boundary conditions and initial system states. We give an historical perspective (past 50 years) on some of the key developments in physically-based hydrological modeling, examining how these various challenges have been addressed and providing some insight on future directions as catchment modeling enters a highly interdisciplinary era.

Abstract ID: 34932

Final Number: H32B-02

Title: Generalizing the Seepage Face Boundary Condition

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Co-authors: Damiano Pasetto, University of Padua, Padua, Italy; Claudio Paniconi, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec City, QC, Canada; Mario Putti, University of Padua, Padua, Italy

Abstract Body: The seepage face is a non-linear dynamic boundary. The way it is handled in groundwater modeling strongly affects the pressure head distribution, the water table configuration, and the flow field. In addition, under conditions of heterogeneity and surface flow, complex scenarios may arise. In this study we address four specific questions: 1) When are seepage face boundary conditions critical and when, instead, is it acceptable to use a simpler fixed Dirichlet boundary condition? 2) How do strong vs weak constraints on seepage face convergence affect the accuracy and efficiency of the overall subsurface flow solution procedure? 3) How do we resolve seepage face outflow under conditions of layered and random heterogeneity? 4) In integrated surface-subsurface modeling, how does a seepage face boundary interact with the catchment outlet boundary condition used in overland and channel flow models? This last case is especially intriguing as the two conditions are diametrically opposed: a catchment outlet cell causes convergent flow patterns towards the land surface while a seepage face is typically used to represent outflow from the base of a hillslope. The analysis is performed with the CATHY (CATchment HYdrology) model, a physically-based model for the solution of the three-dimensional Richards equation coupled to a diffusion wave equation for surface flow propagation. The simulations will be conducted for synthetic hillslopes under various configurations (rainfall rate, slope angle, degree of heterogeneity, etc) and for the specific conditions represented by the convergent landscapes at the Biosphere 2 facility in Arizona.

Abstract ID: 36836

Final Number: H32B-03

Title: Improvement of Designs for Enhanced Infiltration Rates in MAR (Managed Aquifer Recharge) Technique at the Coastal Aquifers of South-Western Bangladesh

Presenter/First Author: Nazia Nawrin, University of Dhaka, Dhaka,

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Abstract Body: Increasing salinity of natural drinking water sources has been reported as one of the many problems that affect low-income countries, but one which has not been fully explored.

Drinking water from natural sources in coastal Bangladesh has become contaminated by varying degrees of salinity due to saltwater intrusion from rising sea levels, cyclone and storm surges, upstream withdrawal of freshwater and increased shrimp and crab farming along the coastal areas. This crisis is also exacerbated owing to climate change. The problem of salinity can have serious implications with regard to rising rates of hypertension and other public health problems.

There are very few options of safe drinking water for more than 2 million people living in these regions. During dry period people of those areas rely largely on surface or pond water, PSFs and RWHs which can be vulnerable to pathogens and thus suffer largely from lack of safe potable water and health problem.

A potential solution was very much needed to overcome the fresh water scarcity problem of the area. Managed Aquifer Recharge (MAR) is an alternative, cost effective and durable option to store fresh water (roof top rain water and filtered pond water) into shallow brackish aquifer during the monsoon and subsequent recovery of fresh water from storage and its supply to the community people during the dry period.

About 70 percent rainfall occur during the monsoon period in the coastal belt of Bangladesh (Khulna-Satkhira) is potential for MAR. MAR techniques operate to store the rain water into underground aquifer, reduce the salinity and then get recovery of fresh water from groundwater storage which is provided to local people as a safe source of drinking water throughout the year particularly during dry season.

The successful implementation of MAR technique has brought “the solution” of drinking water problems in some extent in the SW coastal areas of Bangladesh. The improvement of design in MAR is required for enhanced infiltration rates. So the expected result would be the maximum infiltration as it ensures more freshwater storage, better quality improvement of groundwater and more availability of safe drinking water with minimum management cost for the community people.

Abstract ID: 34631

Final Number: H32B-04

Title: Multi-Observation Calibration of a Regional Scale Groundwater Flow Model

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Abstract Body: Since 2009, a regional groundwater characterization program is ongoing in the province of Québec (Canada). Among the numerous results from these projects, regional distributed groundwater recharge rates, groundwater ages from isotopic tracers and hydraulic properties were obtained. Integrating these data into a regional groundwater flow model has not yet been attempted in the St. Lawrence Lowlands. The objective of this work was to use multiple source data to calibrate a regional scale groundwater flow model. The study area is located in the central part of the St. Lawrence Lowlands and in the Appalachian mountains on the south shore of the St. Lawrence River (SLR) (7750 km²). Between 2009 and 2014, groundwater was sampled for ^{3}He, ^{3}H and ^{14}C analyses (42 samples). A distributed water budget calculation based on the Runoff Curve Number was used to calculate recharge for the entire study area. Groundwater outflow to peatlands was estimated based on a local Darcy approach. The steady-state 3D groundwater model was developed using Modflow, based on 100 m x 100 m cells and six vertical layers. The first layer represents the Quaternary sediments and the five others represent the fractured bedrock aquifer. The model was calibrated to reproduce 11 300 measured water levels, 22 measured river baseflows, estimated groundwater seepage to peatlands and groundwater ages obtained from $^{3}H/^{3}He$ and ^{14}C. The calibrated model shows that the majority of the recharge water is discharged at the scale of local watersheds, that regional groundwater flow is limited, and that almost no deep groundwater flows to the SLR. This confirms data from the regional water budget. Groundwater outflow to peatlands represent the range of flows estimated from local hydraulic gradients and hydraulic conductivities. The average and maximum particles travel times at the sampled wells compare favorably to the results from isotopic tracers with ages ranging from 2 to 22 000 years. Using different types of calibration data provided a model that simulate adequately a wide range of processes.

Abstract ID: 36020

Final Number: H32B-05

Title: Groundwater modeling of three hydrogeological contexts on St-Lawrence Lowlands and Appalachian foothills (southern Quebec, Canada)

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Abstract Body: Regional scale groundwater flow dynamics are influenced by local flow conditions which are rarely characterized thoroughly. In glaciated regions, complex surface geology conditions often create highly

variable flow conditions within small distances. The objective of this study is to understand local groundwater flow in different hydrogeological contexts of a regional scale aquifer. The study area is located on the south shore of St. Lawrence River between Montreal and Quebec (4500 km²). In this region, groundwater is the drinking water source for half of the population and is used for agricultural activities. Three different environments are specifically studied: 1) a U-shape valley upstream of watershed filled with glacial sand, till and silt on a fractured rock aquifer, 2) a partially unconfined granular sandy aquifer, linked with the bedrock aquifer with lenses of fine sediments, and 3) a confined/semi-confined bedrock aquifer downstream of the region with till, silt and silty sand. Each context has been simulated in a 2D cross-section having 3 to 8 km in length. The models were developed in Modflow with 1 m X 10 m X 10 m cells over 50 m. The steady-state models were calibrated based on groundwater levels, recharge and field-measured hydraulic conductivities. The transient-state models were further calibrated and run on a daily time step over one year. The three models reproduce well the seasonal variations of groundwater levels. Groundwater recharge is 10 times more important for section one compare to section three. The results show that groundwater dynamics are determined by the hydraulic properties of the different materials on each transect, as well as by the topography variations. The transect located in the granular unconfined sandy aquifer reacts five times faster to hydraulic stresses than the other two transects, and is more sensitive to recharge decreases. The model complexities help to understand discharge to rivers, to detect vulnerable areas and to locate precisely small recharge zones that are imperceptible at the regional scale.

Abstract ID: 35979

Final Number: H32B-06

Title: Alberta's 2013 flood: Response of a mountain peatland

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Abstract Body: In mid-June 2013 heavy rainfall in the Canadian Rocky Mountain foothills led to severe flooding in western Alberta. Consequently, there is interest from flood risk managers and scientists in exploring the role of foothill wetlands and beaver ponds in storage of floodwaters. Sibbald is a 0.63 km² foothills peatland in the foothills of the Rocky Mountains where a series of three beaver ponds, one groundwater well and the stream were instrumented with automated level recording devices one day before the onset of rainfall. A meteorological station recorded standard hydrometeorological variables throughout the event. The total rainfall over 20-22 June was 190 mm, with a 6-hr break in the rain occurring the afternoon of 21 June. Soil coring in the three days preceding the rain event revealed that the peat was frozen in many locations at a depth of 20-60 cm but was not frozen beneath the beaver ponds. Available peat storage above the frost table was filled in the first few hours of the rain event, causing the water table to rise well above the ground surface where it remained until after 22 June. The three beaver ponds offered 10-50 cm of water storage in the initial stages of the rain event. The pond hydrograph recessions during the break in rain indicate that they were losing water to the groundwater system. Although the middle beaver pond in the series outburst through a 10-m long breach during the first wave of rain, it stored 15 cm of water during the second wave. The results suggest that temporary storage of floodwaters offered by beaver ponds can enhance recharge to the groundwater system and attenuate downstream peak flows during flood events.

Abstract ID: 34302

Final Number: H33A-01

Title: An Assessment of Past and Projected Future Hydro-Climatic Extremes over Key Watersheds within Western Canada

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Co-authors: Charles Cuell, , ,

Abstract Body: Since human activities and ecosystem health are dependent on adequate, reliable water supplies, hydro-climatic extremes, including the occurrence of severe droughts and excessive moisture pose a serious threat to society and the environment. Western Canada is a region with high natural hydro-climatic variability, including the periodic occurrence of drought and excessive moisture conditions, however, recent dramatic shifts between extreme drought and extreme wet conditions have suggested that this variability may be increasing. This investigation assesses the occurrence and atmospheric causes of both the past and projected future hydro-climatic variability and extremes over key watersheds within western Canada. Incorporation of the Standardized Precipitation Evapotranspiration Index (SPEI) reveals considerable decadal-scale variability in hydro-climate over many regions of western Canada with no discernible long-term trends. In addition, an assessment of the mid-tropospheric (500 hPa) circulation patterns associated with identified hydro-climatic extremes indicate that major drought episodes were associated with significantly higher frequencies of circulation types that included distinctive ridging patterns over the Prairie region, and lower incidences of zonal and mid-tropospheric troughing patterns. Excessive moisture conditions had opposite responses. Model output from a suite of Regional Climate Models (RCMs) from the North American Regional Climate Change Assessment Program suggests a drier summer climate in the region with likely increases to inter-annual hydro-climatic variability. In addition, preliminary results indicate that those atmospheric circulation patterns associated with extreme dry and wet conditions will continue to occur in the future and in some cases, increase in frequency. Results from this analysis have increased the understanding of historical synoptic-scale controls of hydro-climatic extremes in western Canada and have provided insight into potential future changes to these extremes as driven by changes to key, synoptic-scale atmospheric circulation patterns.

Abstract ID: 35186

Final Number: H33A-02

Title: Threshold Responses in Regional Runoff from a Heterogeneous Low Relief Terrain – Western Canada's Boreal Plains

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Abstract Body: Runoff from larger catchments (>500km) in the continental Boreal Plains (BP) eco-region of western Canada, although low, can range over 2 orders of magnitude (4 to 350 mm/yr) among years and be difficult to predict. This region is experiencing unprecedentedly rapid and large

scale industrial resource extraction. There is a need to assess and understand the dominant controls on the temporal and spatial threshold responses of regional runoff generation to be able to predict and mitigate the potential impacts of land use and effectiveness of reclamation practices on surface water quantity and quality.

The BP climate has a regional moisture deficit (P< PET) and decadal wet and dry cycles. There are dynamic and complex surface and groundwater interactions because the landscape is made up of large Hydrologic Response Areas (HRAs) characterized by heterogeneous deep glacial deposits with different storage and water transmission properties. These HRAs are below a mosaic of surface Hydrological Units (HUs) of deciduous and coniferous forests and wetlands, with some areas having greater than 50% peatland coverage. We examine the interaction among the wetland (peatland) and forest HUs, the HRAs and decadal climate cycles on the threshold response of regional runoff in 30 meso-scale catchments in the BP of Alberta. Annual runoff and efficiency were poorly correlated with annual precipitation, but showed a strong threshold relationship with multi-year cumulative moisture deficit (CMD). Changes in precipitation patterns result in decadal cycles of dry (CMD < -200 mm) and mesic (CMD ~ 0 mm) states, with wet (CMD > 200 mm) states occurring every 2-3 decades. The differing CMD states altered the hydrologic connectivity among different HRAs and HUs within catchments. During dry states, base flow conditions ranged by over an order of magnitude (2 to 80 mm/yr), and increased with percent area of coarse textured HRAs. During mesic conditions, runoff coefficients were positively correlated with percent peatland area. During the infrequent wet states, runoff coefficients were similar among all catchments. Integrating the CMD with the configuration of HUs and HRAs rather than topographic drainage networks appears to better represent water cycling and sink source dynamics controlling runoff in low relief glacial landscapes such as the BP.

Abstract ID: 36800

Final Number: H33A-04

Title: State of Flood Forecasting in Canada

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Abstract Body: The analysis of the results of two independent nationwide inquiries along with literature review is used to assess the state-of-the-art in flood forecasting in Canadian Provinces and Territories. Flood forecasting falls under provincial jurisdiction and each province has a hydrologic forecasting center tasked with that responsibility. In addition, some municipalities also have their own flood forecasting agencies. Water survey and meteorological services of Environment Canada are the main data providers although some provinces and municipalities maintain local water and weather monitoring stations. Operational flood forecasting is essentially deterministic and based on a single model. There is no common hydrologic model used by the various flood forecasting centers. However, the common needs across provinces are better flood forecasting system, better tools to facilitate data processing, and probabilistic forecasts to apprehend forecast uncertainty. New initiatives on real-time data dissemination by Environment Canada and the development of adaptive flood forecasting systems by a strategic network – FloodNet will help to fill the gaps and enhance flood forecasting and management capacities in Canada.

Abstract ID: 36583

Final Number: H34A-0130

Title: A Modified Technique for Measuring the Unsaturated Hydraulic Conductivity in Moss and Peat Soils

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Abstract Body: Currently, there are two methods for measuring unsaturated hydraulic conductivity (K_{unsat}) in *Sphagnum* mosses: the original method developed by Price et al., (2008) and a modification of this method by McCarter and Price (2014) (herein referred to as the “original” and “modified” methods, respectively). The original method has a soil-water pressure (ψ) gradient across the sample and requires 1-2 days to complete, whereas the modified method maintains a constant ψ within the sample but requires ~3 weeks to parameterize. The concern is that the gradient in original method may result in a distribution of K_{unsat} in the sample that is not represented by the mid-depth pressure. Twenty samples (10 cm diameter, 5 cm height) of horticultural peat were compressed to a target bulk density (0.19 ± 0.01 g cm³). Measurements of K_{unsat} were conducted at ψ = -5, -10, -15, and -25 mb using both the original and modified method. The volumetric soil water content (VWC) was lower (t-test: df = 19, p<0.001) at both -10 and -15 cm using the modified method, while no statistical difference was found (t-test: df = 19, p>0.1) at -5 and -25 cm. However, the K_{unsat} was lower with the modified method at all ψ tested (Wilcoxon signed rank test: V = 210, p<0.001). A general linear model used to elucidate factors controlling K_{unsat} found VWC (p<0.001) and the method (p<0.01) were the only significant relationships; thus, the ψ distribution in the original method was partly driving the difference in K_{unsat}. Although the original method is appropriate for representation of field conditions where a *ψ* gradient is typically imposed, the modified method appears to be representative of the actual K_{unsat} of the sample.

Abstract ID: 36817

Final Number: H34A-0131

Title: Response of Peatland Ecohydrology to Changing Precipitation Frequencies

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Abstract Body: *Sphagnum* moss, the primary peat-forming vegetation in ombrotrophic peatlands, require sufficient surface moisture for growth and survival. Climate change projections for some regions include more intense but less frequent precipitation events that are predicted to lead to lower water tables and drier surface conditions. Recent studies have highlighted the importance of precipitation in these systems; however, few studies consider how the temporal distribution of rainfall will impact moisture within the moss layer, particularly among different land cover types. As such, the main objective of this study was to investigate the feedbacks between soil moisture, evapotranspiration (ET), and the rates of photosynthesis and respiration of *Sphagnum* moss under varying precipitation frequencies, and in the presence of common vascular vegetation. Soil cores were taken from a pristine Southern Ontario

peatland containing three different plant communities (*Sphagnum*, *Sphagnum* and sedges, *Sphagnum* and ericaceous shrubs) and watered at varying frequencies (3X/week, 1X/week, 0.5X/week) while maintaining a constant total water supply between treatments. To assess the importance of changing precipitation frequencies on the moisture state of *Sphagnum* moss, the vertical distribution of soil moisture and ET rates were measured among the different plant cover types. Preliminary results suggest that precipitation frequency is particularly important for the moisture state of *Sphagnum* in cores with ericaceous shrubs, as higher ET rates led to drier surface conditions than in cores without shrubs. The implications of varying moisture conditions under the three precipitation regimes for rates of photosynthesis and respiration of *Sphagnum* is also discussed. This study highlights the importance of considering the temporal distribution of precipitation when predicting climate change impacts on ecohydrological feedbacks in Northern peatlands, and indicates that this response can vary among different land cover types.

Abstract ID: 36661

Final Number: H34A-0132

Title: Evaporation from *Sphagnum* monoliths under controlled water table and humidity conditions

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Abstract Body: Despite a long interest in characterizing evaporation from bryophytes there remains a poor understanding of the mechanisms of water delivery, and of the rates of loss according to species and setting. We sampled three shallow (25 cm) monoliths (15 cm diameter) each of *Sphagnum fuscum* and *S. rubellum*. Along with an open water "column", the evaporation rate (*E*) from each *Sphagnum* monolith was monitored in an environmental chamber with relative humidity (*RH*) at 80, 50 and 30%, with water table (*wt*) set at 0, 5, 10 and 20 cm below the *Sphagnum* surface for each humidity level. Total *E* over the 65-day period encompassing all *RH* and *wt* levels was the most variable for *S. rubellum*, which ranged from 63 to 128 mm (avg. 100 mm), whereas *E* was between 59 to 98 mm (avg. 76 mm) for *S. fuscum*. Open water evaporation was 89 mm. *E* was far more sensitive to *RH* than *wt*. For example, the variation of $E_{rubellum}$ at different *wt* when *RH* was 30%, was ±0.3 mm/d. In contrast, $E_{rubellum}$ dropped from 2.9 to 0.7 mm/d as *RH* increased from 30 to 80%. The hydraulic properties of *S. rubellum* within a profile and between monoliths was much more variable than in *S. fuscum*. In fact, the variability in *E* in all monoliths was easier to explain on the basis of the hydraulic properties of individual monoliths, rather than by species. *S. rubellum* had higher bulk density than *S. fuscum*, so at a soil matric potential of -30 cm their respective water retentions averaged 0.45 and 0.35. Therefore, with more water in the pores the geometric mean unsaturated hydraulic conductivity across all depths and samples (ψ = -5 to -30 cm) was higher for S. rubellum (1.2e-03 cm/s) compared to *S. fuscum* (and 0.6e-03 cm/s), facilitating more effective water transport in *S. rubellum*, hence higher *E*. While the *E* behavior for given *RH* and *wt* settings was best explained by the monolith's hydraulic properties, a much larger sample size is required to generalize about differences between these two species.

Abstract ID: 36698

Final Number: H34A-0133

Title: Determining the Impacts of Sub-Surface Irrigation on *Sphagnum* Moss Carbon Uptake in a Reclaimed Peatland

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Co-authors: Maria Strack, University of Calgary, Calgary, AB, Canada; Jonathan S Price, University of Waterloo, Waterloo, ON, Canada

Abstract Body: *Sphagnum* biomass production is a feasible and sustainable alternative to current peatland harvesting practices; however, maintaining optimal hydrological conditions for fiber accumulation (i.e. net carbon sequestration) can be challenging, and water requirements remain uncertain. The objectives of the research are to evaluate the efficacy of different sub-surface irrigation techniques on water distribution within *Sphagnum* fiber production plots, and to assess the optimal hydrological conditions for *Sphagnum* biomass accumulation. An abandoned block-cut peatland in Shippagan, New Brunswick, has been manipulated to control the water table in six *Sphagnum* biomass production basins. The hydrology of each basin is controlled by a change in irrigation arrangement or position of the water table (-20cm or -10cm) below the surface. Instantaneous CO_2 fluxes under various light conditions were measured to calculate the gross ecosystem productivity (GEP) of each basin. GEP values were compared to various hydrological variables, such as water table level, soil water tension, and volumetric soil moisture content. Preliminary data suggests that there is a weak relationship between instantaneous water table and carbon flux measurements, but there is a strong relationship between the average seasonal mean water table and productivity values between basins with sub-surface irrigation. The most productive site had an average seasonal water table of -7.8 cm and GEP of -4.1 g C m^{-2} d^{-1}. The two least productive sites were the only basins without sub-surface irrigation, and had average seasonal water table of -14.1 cm and -8.1 cm, and GEP of -3.0 C m^{-2} d^{-1}. and -2.5 C m^{-2} d^{-1}, respectively. The least productive site had a high water table (-8.1 cm), but combined with saturated soil conditions and frequent pooling of water at the surface, could indicate that frequent saturation may decrease productivity, and that sub-surface irrigation is a better method of water management.

Abstract ID: 36799

Final Number: H34A-0134

Title: Evaluation of snow dynamics in a basin fen-bog complex in the Western Boreal Plains, Canada.

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Co-authors: Scott J Ketcheson, University of Waterloo, Waterloo, ON, Canada; Jonathan S Price, University of Waterloo, Waterloo, ON, Canada

Abstract Body: In the Western Boreal Plains (WBP) region of Northern Alberta, snow represents ~25% of annual precipitation and is, therefore, a potential recharge water source for landforms (e.g. bogs, coarse textured hillslopes) during spring thaw. Influences on snow accumulation and redistribution during winter include canopy openness, tree-stem density and wind fetch. These are not consistent across landform/peatland types in the WBP, where contrasting tree density, size and species may influence accumulation, redistribution and ablation dynamics. Inclusion of snow dynamics is essential for understanding water availability in the sub-humid WBP climate. Few studies focus on snow dynamics in the WBP and distribution of over-winter precipitation stores across upland-peatland systems remains unclear. Snow distribution, ablation, radiative forcings, basin dynamics and controls are quantified for a poor fen-bog complex, situated in an elongated, sloped perimeter basin. Field measurements, taken March-May, 2012-2014, found snow depth lowest in the sparsely treed, open fen, and highest in the densely treed bog and at changes in slope, suggesting wind to be the dominant snow redistribution control.

Increased tree density and height correlated with decreased ablation in the bog-complex. Canopy/stem density decreased wind speeds above the snow pack, making aeolian redistribution negligible. Beyond developing a better understanding of snow dynamics in natural basin-fen systems, it is also of particular relevance to landscape reclamation design, given basin features on post-mined landscapes are targeted as future wetlands.

Abstract ID: 34406

Final Number: H34A-0135

Title: Evolution of a Saline Fen near Fort McMurray, Alberta: Applications from Paleoecology to Wetland Reclamation

Presenter/First Author: Olena Volik, University of Waterloo, Toronto,

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Abstract Body: Wetland reclamation, which is crucial for Canada's oil sands industry, is greatly challenged by salinization. Thus, understanding the origin and development of boreal saline wetlands, the most suitable natural models for potential reclamation pathways, could be of paramount importance for enhancing wetland construction design, providing a basis for setting reclamation targets. Preliminary investigation of the evolution of a saline fen in the Fort McMurray area (56°34'28.84" N, 111°16'38.39" W) confirms the usefulness of paleoecological data for the creation of wetland reclamation strategy. Variations in physicochemical properties and microfossil (pollen, non-pollen palynomorphs, and diatom) assemblages in pond sediment cores demonstrate paleoenvironmental changes associated with the saline fen initiation and its further development. The transition from clay sediments, characterized by low concentration of microfossils, to gyttja indicates that the drainage of large and deep proglacial Lake McMurray preceded the fen establishment. Further detailed studies of primary succession that took place at that time can provide a framework for the transformation of mineral tailings lacking vegetation, into peatlands tolerant of saline conditions. Upcore shifts in microfossil assemblages reflect change in salinity suggesting the existence of periods of higher salinity (recorded by a dominance of brackish diatoms) followed by period of decreased salinity (indicted by a rise in freshwater species) with gradual increases in salinity thereafter. In-depth paleoecological research should help to identify natural drivers of salinity variation that can be used to reduce salinity at contracted wetlands; on the other hand, assessment of temporal changes in ecosystem functioning associated with differences in level of dissolved salts may lead to different reclamation approaches capable of dealing with the higher salinity conditions.

Abstract ID: 36828

Final Number: H34A-0136

Title: The Hydrological Function and Connectivity of a Basin Fen-Bog Complex in Northeastern Alberta, Canada

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Abstract Body: Within the Western Boreal Plains (WBP) wetlands comprise up to 65% of the landscape, the majority of which are peatlands. However, hydrologic interactions between classes within peatland complexes are not as thoroughly understood and the influences of regional-scale connections beyond the local-scale and over the long-term are required. Accordingly, this research aims to advance our understanding of the hydrological function of peatland classes within a peatland complex and to place this into the context of regional connectivity within the WBP setting. We examined the hydrology of a ~11 ha basin fen-bog complex situated within the Stony Mountain range ~40 km south of Fort McMurray. The low-lying basin depression forms an elongated hourglass-shaped configuration and is bordered by upland slopes. The bog is located at the topographic high within the peatland system and a small mineral upland marks the sharp transition between the bog and fen. Within the fen, peat thickness ranged from >12 m in the lower lobe to ~3 m in the bog. For the entire basin, the peat profile thinned rapidly towards the bordering uplands. Water table levels were typically close to or above the surface for most years and mirrored surface topography along the bog-fen sequence, with ground and surface water flowing from the bog towards the fen for the majority of the season. However, during dry periods, groundwater flow direction temporarily reversed and the water table sloped towards the bog. During precipitation events, the bog water table exhibited a ~12 hour lag in response compared to the water table within the fen. While vertical hydraulic gradients indicated that the basin was a groundwater recharge feature, the rate of recharge was minimal due the low hydraulic conductivity of the surrounding slopes and mineral substrate underlying the peat. The large storage capacity of the upland moss layer was rarely exceeded and shallow groundwater and surface flow was also low. Precipitation totals for the growing season were always well above the regional average and was the dominant input for the basins water balance. This study highlights the hydrologic function and varying interactions that can take place within bog-fen complexes in the subhumid Boreal Plains.

Abstract ID: 35917

Final Number: H34A-0137

Title: Can an invasive species alter the hydrologic regime of a wet prairie?

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Co-authors: Katybeth Coode, , Louisville, KY

Published Material: Preliminary analysis of the data was presented in the Ecological Society of America annual meeting in August 2014. These findings are not under review for publication by a scientific journal.

Abstract Body: , which have altered the natural flow making it an unusually variable and artificial system. Groundwater and ditch levels were monitored at six wet prairie restoration sites during three years. Each site consisted of a clustered set of five piezometers positioned on a transect perpendicular to the main ditch. Within each ditch reach, a surface water monitoring location was also set. Of the six sites, two were set as control sites, where the glossy buckthorn was not removed for a period of time. Results show a different response in the groundwater level of the control sites, but only under certain hydrologic conditions. The longer growing season of the buckthorn depressed groundwater levels until the beginning of November during dry years, though not under wet or normal years.

Abstract ID: 35802

Final Number: H34A-0138

Title: Ice Storm Damage in an Ash- and Maple-Dominated Swamp of Southern Ontario: An Investigation of Precipitation Partitioning

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Abstract Body: Interactions between vegetation and the hydrologic cycle are important to investigate for determining the effects of climate change, land-use change, and a growing human population on water resources in and around wetlands. Changes in precipitation (P) regimes (frequency and magnitude) or stand characteristics, such as a loss in canopy due to natural or anthropogenic sources, can all have major influences on the amount water received by a wetland. The hydrological input of throughfall (TF) and stemflow (SF) are especially important to quantify for swamps, as small changes in P have the ability to induce shifts and/or losses of species present within wetland communities. This study presents the investigation of the quantity of TF and SF during P events in two swamps of southern Ontario. With the aid of this research, wetland conservation and management authorities can obtain important information regarding the fluxes of water into swamp ecosystems pre- and post- ice storm. This study was designed to determine the quantity of understory P (as TF and SF) in two mixed-deciduous swamps and how these fluxes differ between the two distinct canopy types as well as to how these fluxes differ between years separated by a major ice-storm. Additionally, an analysis of P characteristics (i.e. amount of P, duration and intensity) was performed to determine how they may dictate TF and SF amounts in the two wetland sites.

TF quantities for the ash-dominated swamp averaged 5-10% higher than TF at the maple-dominated swamp over the course of both growing seasons (2013-2014), while SF was only slightly higher in the ash than maple site. The results indicate that even though there was less rainfall in 2014 than 2013, the amount of TF increased at both sites, suggesting that canopy loss after the ice storm significantly increased TF amounts. Additionally, a positive linear relationship was found between amount of P, duration of rain events and P intensity to both TF and SF depths.

Abstract ID: 33879

Final Number: H34B-0140

Title: Analysis of Precipitation and Temperature of the Lower Liard River Basin, using Wavelet Transform

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Abstract Body: Since the mid-90s, discharge from streams and rivers draining the discontinuous permafrost zone of the southern Northwest Territories has increased and these rates have accelerated in recent years. Work done by Connon and others suggested two hypotheses; one is related to meteorology and other to landscape changes and feedbacks caused by the permafrost thaw. To address the meteorological hypothesis wavelet transforms of observations were used to explore the dominant oscillations of precipitation and temperature in the Lower Liard River Basin between 2004 and 2014. Wavelets provide information about the nature and time– frequency localization of oscillations. Preliminary results show considerable similarity among individual series from ten climate stations for temperature and for precipitation. As expected, there are differences in the interannual between temperature and precipitation variability; for temperature, there were significant oscillations of about 4, 8, 16 and 256 to 365 days in all stations, for precipitation the significant oscillations were at 16 to 32 days. These results suggest that the temperature signal has a large spatial domain, while the precipitation signal has a smaller spatial domain

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Abstract ID: 36025

Final Number: H34B-0141

Title: Diagnosis of Current and Future Shifting of Hydrological Regimes of the Changing Upper Salween and Mekong River Basins

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Abstract Body: The upper Salween and Mekong River Basins, flowing parallel from cold mount glacial primitive area to warm cultivation area through Tibet-Yunnan Plateau, is one of the most sensitive areas to global climate change. It is also data scarce. By detail simulation with Vegetation Interface Processes (VIP) model, co-run Hydro-Information Modelling System (HIMS),with detail field investigation to determine parameters, daily water availability and water demand by vegetation are obtained from 1981 to 2012. It is shown that seasonal patterns of discharge within the cold region are more similar to each other than the patterns within the basin. The increasing rate of temperature in the cold region is much higher than that in the warm region. The rate in recent years is much higher than that in previous years. The cold region is drier than the warm region. Over the next 20 or 50 years, there is a tendency that dry cold region will become wetter and wet warm region will be drier. Understanding of and predictive capacity for the dynamics of the twin cold regions processes and systems will be helpful to provide scientific suggestions, such as to local people living in downstream comparatively to adopt suitable and different adaptation countermeasures to possible climate change.

Abstract ID: 35613

Final Number: H34B-0142

Title: Verification of winter precipitation forecasts and analyses

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Co-authors: Bruce Jamieson, , ,

Published Material: Similar oral presentation on the ISSW 2014 in Banff. Submitted to The Cryosphere and published in The Cryosphere Discussions doi:10.5194/tcd-8-5727-2014

Abstract Body: Numerical Weather Prediction (NWP) models lack verification for mountainous regions during the winter season, although they are providing input for hydrological modelling and for decision makers. Winter precipitation from two NWP models (GEM-LAM and GEM15) and from a precipitation analysis system (CaPA) was verified at approximately 100 stations in the mountains of western Canadian and northwestern US. Instead of rain gauges which have a systematic undercatch for solid precipitation and a rather unknown performance in complex terrain, ultrasonic snow depth sensors and snow pillows were used to observe daily precipitation amounts. Another advantage of these sensor networks are that they are available in relevant elevations in Canada. A detailed objective validation scheme highlights many aspects of forecast quality. Overall, the models underestimated precipitation amounts, although low precipitation categories were overestimated. This is oppositely to former verifications of these models, which were mainly performed in the summer and in flat terrain and/or with rain gauges. The finer resolution model GEM-LAM performed best in all analysed aspects of model performance, while the precipitation analysis system performed worst. An analysis of the economic value of large precipitation categories showed that only mitigation measures with low cost/loss ratios (i.e. measures that can be performed often) will benefit from these NWP models. This means that measures with large associated costs (relative to anticipated losses when the measure is not performed) should not or not primarily depend on forecasted precipitation.

Abstract ID: 36022

Final Number: H34B-0143

Title: Detecting the effects of atmospheric rivers on glacier mass balance: a case study in Denali National Park, Alaska

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Published Material: The field work portion of this study was featured in NSF and PBS videos early this fall:http://www.nsf.gov/news/special_reports/science_nation/denaliglaciers.jsphttp://www.pbs.org/newshour/bb/scientists-read-layers-alaskas-ice-snow-track-climate-change/

Abstract Body: An atmospheric river made landfall over Alaska on January 23, 2014. This system advected moisture and heat from the Pacific Ocean east of Hawaii to Alaska over the course of two days causing anomalously high temperatures, heavy rainfall, avalanching, and disruption of human infrastructure. There likely was also rainfall at higher elevations, which would cause a significant change in the mid-winter energy and mass balance of regional glaciers. To investigate whether there is a detectable physical and chemical signature of the atmospheric river event in Central Alaska glaciers, we collected geophysical and geochemical data on the Ruth, Kahiltna, and Mt, Hunter Plateau Glaciers during May-June 2014. High-frequency (400 MHz) ground penetrating radar (GPR) transects over a total of 10 Km were collected on the Ruth Glacier to determine the spatial continuity of an ice layer potentially created by the event. Two snowpits on the Ruth Glacier (1.2 and 3.5 meter depths), one on the Kahiltna Glacier (3 m depth), and one on the Mt. Hunter Plateau (4.05 m depth) were sampled for $\delta^{18}O$ and δD analysis. Based on simple isotope fractionation modeling, we hypothesize that moisture from the atmospheric river event would be isotopically heavy relative to typical mid-winter precipitation in the area. We observe a positive $\delta^{18}O$ deviation in the Mt. Hunter and eastern Ruth Amphitheater snowpits at 3-3.5 meter depth, which given estimated snow accumulation rates may be consistent with the river event. We will discuss ongoing statistical comparison of snowpit physical and isotope data, processing and interpretation of the GPR data, and detailed time-series analysis of the river event using climate reanalysis and station data.

Abstract ID: 33229

Final Number: H34B-0144

Title: Regional monitoring and online publication of winter snowpack to spring and summer water levels by integrating satellite and aerial remote sensing data

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Published Material: Initial results of the open water classification routine were presented at 2014 Fall AGU (poster) but not the snowpack or portal components. Approx 25% of the presentation material will be recycled. None of this work has been otherwise published or submitted for review.

Abstract Body: The ability to map and monitor headwater snowpacks, and downstream spring and summertime open water storage at regional scales allows improved estimates and simulation of watershed water balance and flood inundation potential. The study presents early development stages of an online Provincial monitoring framework for snowpack and wetland open water storage. Winter snowpack assessments in mountainous catchments in the Rockies, urban and wetland environments in Alberta will be presented for 2013 to 2015, as will summertime open water classifications for a prairie watershed in Alberta, western Canada. Airborne lidar data were used to map baseline and snow surface data in headwaters while temporal satellite image stacks from the RapidEye and RadarSat satellites were integrated with high-resolution lidar to delineate water inundation extents. GIS techniques were developed to extract lidar-derived water surface elevations and track the spatio-temporal variation in pond and lake levels. Water bodies were assigned unique identifiers so that levels could be tracked and linked to their associated watershed channel reach. The procedure of optical image classification through to merging of individual water bodies into watershed channel topology and extracting reach water levels has been automated with python scripts. The presentation will describe the methods, early results, existing challenges, as well as the anticipated online delivery of this Alberta cloud-based water monitoring portal. Future efforts will be directed towards integration of the cloud-based system with existing provincial and federal hydrometric data sources and models to supplement operational resource management needs whilst supporting more rapid and open access to data.

Abstract ID: 36071

Final Number: H34B-0145

Title: Hazard Assessment of Glacial Lake Outburst Flood and Potential of ICTs for Coping: A Case of Eastern Himalaya of Nepal

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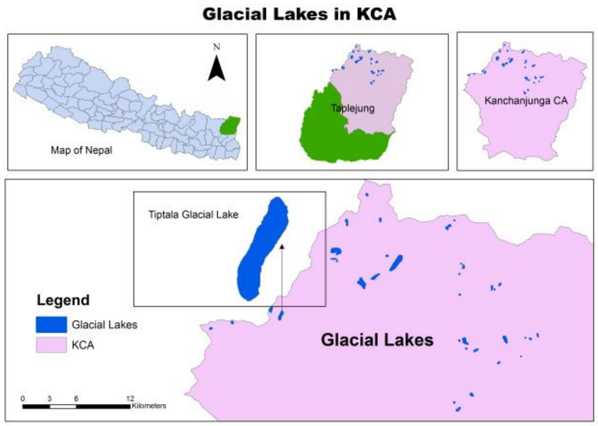
Abstract Body: Retreat of glaciers and formation of glacial lakes in Nepal Himalaya have been reported to be related with the temperature rise in the region. Glacier Lake Outburst Floods (GLOF) are the growing climate induced hazards in the Himalaya. GLOF has increased the vulnerability of community and fragile ecosystem in the mountain valleys. This study has analyzed the potential impacts from GLOF in the highland of eastern Nepal and the potential role of Information Communication Technologies (ICT) to cope with such impacts. I analyzed the trend of climatic pattern (temperature and precipitation) of the Eastern Himalaya Region of Nepal available from the Department of Hydrology and Meteorology, Government of Nepal, and prepared the latest location map of the glacial lakes using google earth and ArcGIS applications in the highland of the Kanchanjungha Conservation Area of the region. Tiptala glacial lake, located at an elevation of 4950 m, within the conservation area, was selected for the GLOF hazard assessment. I used semi-structured questionnaire survey and key informants' interviews in the community in order to assess the potential hazard of GLOF. With the varying sizes, 46 glacial lakes were located in the region, which covers over 2.57 sq. km in

total. Though the larger portion of the downstream area of the Tiptala glacial lake fall in the remote location away from major residential area, few villages, major pasture lands for Yaks, foot trails, and several bridges across the Tamor River below the lake are in risk of GLOF. Poor access due to extreme geographical remoteness and capacity to afford the modern technologies in the community are the major limiting factor to the knowledge and information about the climate change and related impacts. Modern ICTs has high potential to reduce the risk of climate related hazards in the remote area by information dissemination and awareness.



Abstract ID: 33197

Final Number: H34B-0147

Title: MASS BALANCE MEASUREMENT OF RIKHA SAMBA GLACIER, HIDDEN VALLEY, MUSTANG, NEPAL

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Abstract Body: Various studies suggest that most of the Himalayan glaciers are retreating though the rate of retreat varies from glacier to glacier, depending upon the terrain and climatological condition. Relation between climatic and mass balance studies remains unclear and almost nonexistent in this region. In this study, climatic and net mass balance analysis was performed using in situ measurements of stakes and meteorological parameters in Rikha Samba Glacier, Hidden Valley. Stake measurements are taken at two separate periods. Long-term temperature and precipitation trend are calculated by using the data recorded at Jomsom. The glacier shows net mass balance of -1.80 ± 0.097 m w.e. for the lower part of the glacier below 5800 m altitude from 10 September 2011 to 3 October 2012 and - 0.206 ± 0.019 m w.e. for the entire glacier from 4 October 2012 to 30 September 2013. The equilibrium line altitude (ELA) of Rikha Samba Glacier is estimated at 5800 m a.s.l. in 2013. Average temperature trend of 0.023 °C/yr at 5% level of significance is observed from 1980 to 2012 with no significant trend in precipitation in that period.

KEYWORDS: Ablation, accumulation, climate change, glacier mass balance, Himalayan glacier

Abstract ID: 36106

Final Number: H34B-0149

Title: Evaluation of SMOS Frozen Ground Flags

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Abstract Body: The Soil Moisture Ocean Salinity (SMOS) L2 soil moisture product is provided with science flags to indicate the reliability of the soil moisture estimates based on the surface conditions which may impede the ability to accurately estimate the soil moisture for a region. During periods of soil freezing, the soil dielectric decreases as the water in the soil freezes, resulting in an increase in measured brightness temperature by passive microwave sensors. Inaccurate estimates of frozen soil conditions could result in an assumption that there is a decrease in soil moisture. SMOS uses modelled data from the European Centre for Medium-Range Weather Forecasts (ECMWF) soil temperature level 1 (0-7cm) (STL1) depth as a flag for frozen soil conditions. The flag is set when the STL1 indicates a temperature below 270K. These flags were evaluated against data collected at the Kenaston soil moisture network, south of Saskatoon, Saskatchewan. For this analysis, data were collected during 2012, with data used from January to April, 2012 to monitor the spring thaw, and data from October to December 2012 to monitor the winter freeze. Flags were examined for both ascending and descending SMOS pass times. It was found that there was greater agreement between the in-situ probe installed horizontally that 5cm than the vertically installed probe (which provides soil surface temperature) with greater agreement occurring for descending passes. When using the threshold of 270K to indicate frozen soil conditions (as is used for the SMOS frozen ground flag), the SMOS flag indicated a false positive (SMOS flag indicates thawed soils when the network indicates frozen) rate of 32.9% for ascending passes (compared to the 5cm sensor) and 18.8% for descending passes. If the threshold were increased to 273.15K, the false negative rate would be reduced considerably, to 15% for ascending passes and 2.8% for descending passes.

Abstract ID: 33682

Final Number: H34B-0150

Title: Preliminary study of stable isotope in Chhota Shigri glacier (H.P) India

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Abstract Body: To infer the variation in isotopic composition, stable – water isotope data ($\delta^{18}O$ and δD) from five groups of samples (Fresh snow, old snow, snow core, rain water and melt water samples) collected from Chhota Shigri glacier during summer (2013) were presented. Snow core sample traces the variation of $\delta^{18}O$ with depth. Fresh snow, old snow and melt water collected at different altitude has been focused to explore the altitudinal effect on isotopic composition of these samples. Altitude effect on the variation of isotopic composition is best marked by fresh and old snow while melt water did not encounter such effect. Different pattern of $\delta^{18}O$ variation is observed with altitude for the fresh and old snow. Different trend in the depletion of $\delta^{18}O$ of fresh snow and old snow with altitude shows clear demarcation of changes for winter and summer snow

fall. This study shows that large variation of d-excess (-1.14‰ to 24.9‰) of all rain water events reflects the influence of local climatic factors as well as south-west monsoon precipitation. Deuterium excess (d-excess) value (1.92‰ to 7.41‰) of fresh snow confirms influence of south-west monsoonal precipitation. Linear regression analysis was applied to stable hydrogen and oxygen isotope data sets for snow core, precipitation and melt water samples in order to establish the local meteoric water line (LMWL) for Chhota Shigri glacier (HP) India. The LMWL was derived with a regression value of 0.99. The LMWL shows an equation $\delta D = 8.5\ \delta^{18}O+12.9$.

Abstract ID: 36612

Final Number: H34B-0151

Title: Measurement and modeling of the surface conductance of boreal aspen and black spruce stands

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Abstract Body: Boreal forest accounts for 30% of the Canadian landscape and plays an important role in the global water and carbon cycles. How these processes will change with respect to climatic variability is poorly understood. Our goal is to improve our understanding of the integrated system response of the southern boreal forest to variation in climate. Continuous measurements have been made since 1996 at Old Aspen (OA) and 1999 at both Old Black Spruce (OBS) as part of the Boreal Ecosystem Research and Monitoring Sites (BERMS) program and Fluxnet Canada/Canadian Carbon Program. In addition to climate variables, we have high-quality year-round eddy-covariance measurements of evapotranspiration (*E*), and related micrometeorological fluxes of momentum, sensible heat, and CO_2. From 1996 to 2013, *E* at OA and OBS has ranged from 264 mm y^{-1} to 450 mm y^{-1} and 271 mm y^{-1} to 331 mm y^{-1}, respectively. The lower average *E* at OBS has resulted in a significantly higher contribution to groundwater (i.e., precipitation (*P*) - *E*), especially over the 10 years after the drought that occurred in 2001-2003. During the drought years the difference between the sites was much greater, with mostly negative *P - E* values at OA. As part of research to improve models of forest *E,* data analysis is under way to compare two surface conductance models. Variations in the conductance are evaluated through comparisons of the models' controlling variables on the conductance, such as photosynthetically active radiation, vapour pressure deficit, CO_2 concentration, soil water matric potential and leaf are index. The relationship between the controlling variables and conductance is being monitored for changes over the long term, including drought and wet periods. This research contributes to improving the parameterization of hydrologic processes in land surface models such as CTEM and CLASS.

Abstract ID: 35707

Final Number: H34B-0152

Title: Towards running a physically-based snow model for near real time operational water forecasts

Presenter/First Author: Scott Havens, USDA Agriculture Research Serv, Boise, ID

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Abstract Body: Traditional operational modeling tools for forecasting water inflow to reservoirs are challenged by more frequently occurring uncharacteristic flow patterns caused from climate change. To tackle these uncharacteristic events that do not follow historical patterns, water managers must turn to new models based on the physically based, energy balance modeling techniques. Currently, the USDA-ARS produces near real time snow water equivalent (SWE) maps using *Isnobal* for two mountain basins, the Boise River Basin in southwest Idaho and the Tuolumne Basin in California that feeds the Hetch Hetchy reservoir. However, both basins have minimal weather data from automatic weather stations, making model input and model validation difficult. This presentation will examine how *Isnobal*, coupled to a water routing model, has performed over the past three years of near real time water forecasting. Input data to drive the modeling in these data sparse areas will be derived from the sparse weather station network and high resolution weather forecast models, providing new distributed forcing data for modeling.

Abstract ID: 33993

Final Number: H34B-0153

Title: Streamflow Response During Rapid Retreat of a Lake-Calving Mountain Glacier

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Abstract Body: There has been increasing attention over the last decade to the potential effects of recent and projected future glacier retreat on downstream discharge and aquatic habitat. Of particular interest is the timing of "peak water," the time at which the reduction in ice area associated with retreat begins to offset the increased rate of ice melt associated with climatic warming. This study examines the streamflow variability downstream of Bridge Glacier, located in the southern Coast Mountains in British Columbia. The glacier currently terminates in and calves icebergs into a proglacial lake, and has been retreating rapidly since 1991, when the terminus retreated into an overdeepened basin. The glacier's area has decreased from 92 km^2 in the early 1990s to 81 km^2in 2013. Despite this decrease in area, there has not been any clear reduction in late-summer streamflow. The objective of this study was to diagnose the relative contributions of snowmelt, ice melt, and off-glacier runoff to streamflow. Snow and ice melt were estimated using a semi-distributed melt model, supported by snow-covered area determined from MODIS imagery and the area of the glacier as determined from Landsat imagery. Surface melting from icebergs was computed using a melt model and the area of the lake surface occupied by icebergs, as determined by linear spectral unmixing of Landsat and MODIS imagery. Sub-aqueous iceberg melt was estimated by assuming that net radiation received by the portion of the lake occupied by icebergs was consumed by sub-aqueous melt rather than heating of the water column, based on results of fieldwork conducted in 2013. Rainfall-runoff from both glacierized and non-glacial portions of the catchment were estimated using a semi-distributed hydrologic model. The results from this study contribute to our understanding of streamflow response for retreating valley glaciers, many of which will likely experience a transient lake-terminating phase as the terminus retreats into over-deepened basins.

Abstract ID: 34276

Final Number: H34B-0154

Title: Towards a large scale modelling of wetlands water dynamics in northern basins.

Presenter/First Author: Vanessa Pedinotti, , Toulouse,

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Abstract Body: Understanding the hydrological behaviour of low topography, wetland-dominated sub-arctic areas is one major issue towards the improvement of large scale hydrological models. These damp organic soils cover a large extent of Northern America and have a considerable impact on the rainfall-runoff response of a catchment. Moreover their strong interactions with the lower atmosphere and the carbon cycle make of these areas a noteworthy component of the regional climate system. In the framework of the Changing Cold Regions Network (CCRN), this study aims at providing a model for wetland water dynamics that can be used for large scale applications. The modelling system is made of two main components : a) the simulation of surface runoff using the Modélisation Environmentale Communautaire – Surface and Hydrology (MESH) land surface model driven with several gridded atmospheric datasets and b) the routing of surface runoff using the WATROUTE channel scheme. As a preliminary study, we focus on two small representative study basins in Northern Canada : Scotty Creek in the lower Liard River valley of the Northwest Territories and Baker Creek which is located just a few kilometers north of Yellowknife. Both areas present characteristic landscapes dominated by a series of peat plateaus, channel fens, small lakes and bogs. The challenge of the wetland model is to represent the hydrological functioning of these different types of landscape units and their interactions using rather simple numerical formulations that can be later extended to larger basins such as the Mackenzie river basin. The performance of the model will be assessed using in-situ discharge datasets.

Abstract ID: 34598

Final Number: H34B-0155

Title: Trends and Projections for North American Lake Ice

Presenter/First Author: Laura Brown, University of Toronto, Toronto, ON

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Abstract Body: Lakes comprise a large portion of the surface cover in North America forming an important part of the cryosphere. Recent studies have demonstrated that ice break-up dates, in particular, have been occurring earlier in many parts of the Northern Hemisphere over the last 50 years in response to warmer climatic conditions in the winter and spring seasons. The timing of lake ice phenological events (e.g. break-up/freeze-up) are useful indicators of climate variability and change. The Canadian Lake Ice Model (CLIMo) was used to simulate the contemporary and future lake ice conditions for the northern hemisphere, with a focus on North America. The contemporary climate simulations were driven by both ECMWF ERA-Interim and ERA-40 reanalysis data, while the future climate simulations were driven by the Canadian Regional Climate Model (CRCM5, provided by UQAM) and the CCCma Canadian Regional Climate Model (CanRCM4: CORDEX domain Nam-22, 1951-2100) with the RCP 4.5 and 8.5 emission scenario for the future climate conditions. The simulations were run for multiple lake depths to represent both shallow and deep lakes, and with and without snow cover to represent the effects of snow redistribution over the ice surface. The 30-year mean ice break-up, freeze-up, and thickness was compared between the scenarios for Canada for 1981 – 2010 and 2071 – 2100 to examine the possible changes to the ice cover regimes. Additionally, comparisons between the simulations and available in situ data for the contemporary climate were explored at selected locations. This work will examine the preliminary results from the modelled North American lake ice dataset under present day climate and projected future conditions.

Abstract ID: 34825

Final Number: H34B-0156

Title: Assessing the Sensitivity of the Soil Moisture and Ocean Salinity (SMOS) Observed Brightness Temperature for Soil Freeze- Thaw Detection during Wet Snow Conditions

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Abstract Body: The soil freeze-thaw cycle imparts a major control on the seasonal hydrology of cold regions. Understanding the soil freezing state is critical to accurately estimating runoff rates, water storage and predicting spring flooding. One of the most promising techniques for monitoring frozen soils is passive microwave remote sensing. Passive microwave satellites, like the Soil Moisture and Ocean Salinity (SMOS) satellite, offers the ability to capture the landscape soil freeze/thaw state. This L-band satellite is sensitive to the changes in the landscape dielectric which dramatically decrease from thawed to frozen state. Though it is widely accepted that L-band passive microwave satellites are sensitive to frozen soils, literature has indicated that the sensitivity may be hindered during wet snow conditions. This study was conducted during the winters of 2012 and 2013 in southern Saskatchewan. The study site, Environment Canada's Brightwater Creek Soil Moisture Network, is densely instrumented with 22 soil moisture stations over a 10x10km grid. The ability of the SMOS satellite to detect frozen soils was initially accessed by comparing passes with frozen and thawed soil. The results indicated that brightness temperature during frozen soil conditions was significantly ($p<0.05$) different from thawed soil. Following this comparison, periods with frozen soil and either wet or dry snow conditions were analyzed, using air temperature and snow albedo as an indicator of wet/dry snow conditions. The study found that the brightness temperature during wet and dry snow conditions was not significantly different ($p>0.05$). Polarization index was also examined, and it too indicated a significant difference between frozen and thawed soils but no significant difference during wet and dry snow conditions. These results suggest that L-band passive satellites like SMOS may be less sensitive to snow conditions in this region.

Abstract ID: 35003

Final Number: H34B-0157

Title: On Conceptualization and Routing Dynamics of a Glacierized Catchment

Presenter/First Author: Anna Chesnokova, Ecole de Technologie Superieure, Montreal, QC

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Co-authors: Francesca Pellicciotti, ETH Zurich, Zurich, Switzerland; Marco Carenzo, ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland

Published Material: This study was partly presented before during poster session of Alpine Glaciological Meeting, Innsbruck, February 2014.

Abstract Body: Assuming that glaciers can be represented as linear reservoirs that transform surface melt into runoff, we investigate their dynamic behaviour by rewriting the differential equation of linear reservoirs to derive the storage coefficients (Ks) from input and outputs to the reservoir system. We use hourly ablation rates simulated by a distributed energy balance model (input) and hourly runoff at the glacier snout (outputs) and study the system characteristics derived from the linear proportionality between the time derivative of runoff and the difference between input and output. We derive the storage coefficients from the relationship between measured runoff and known inputs to the system and investigate their seasonal and interannual variability. We compare the resulted Ks with those obtained from time series analysis. We use data from three ablation seasons with different characteristics (extensive snow cover throughout the ablation season in 2001, limited/absent snow cover in 2006 and a 'middle case' in 2010) from Haut Glacier d'Arolla, Switzerland. Storage coefficients exhibit a similar general pattern of decline over time with local peaks corresponding to snowfall events with higher absolute values for the season with extensive snowcover and lower for the season with limited snowcover. Given the observed temporal evolution in storage characteristics, we modify the conventional reservoir approach in two ways. In the first type of models, we explore multiple reservoirs (from 1 to 5) with constant in time constant storage characteristics, while in the second approach we use one reservoir with varying in time storage coefficients, parameterised as a function of snow covered fraction or of the snowpack water equivalent (SWE). In the first category, models that separate the contribution of snowmelt from the glacierised area from that over the non-glacierised areas perform better, especially when applied to season with limited snowcover. In the second category, models based on SWE of the snowpack have a higher performance.

Abstract ID: 35021

Final Number: H34B-0158

Title: Recent changes in glaciers within the upper Yukon River basin and their contribution to discharge at Whitehorse

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Abstract Body: Glaciers represent a significant source of stored water, and meltwater released during the spring through fall period provides runoff that can be regionally important. In the headwaters of the Yukon River above Whitehorse, YT, there is uncertainty on how much glaciers contribute to total discharge and how this will change in future under different scenarios of climate change. To begin to address these issues, we examined changes in glacier cover here based on remotely sensed imagery from various periods between 1948 and 2010, and estimated the current glacier volume by applying a volume–area scaling approach with locally derived parameters based on ice-thickness data collected in 2011. Glaciers in 2010 covered an area of 1002 km^2 and had an estimated total volume of 187 km^3; between ~1990–2010 glacier cover declined by about 6% overall, while some individual glaciers lost over 25% or more of their area. We set up the HBV-EC hydrological model over the upper Yukon River basin and some smaller tributary basins using the Green Kenue software tool, and forced the model using extrapolated observations from nearby climatic stations. The model was able to reliably reproduce the magnitude and timing of river discharge along with local snow accumulation, melt, and glacier mass balance. By separating glacial and non-glacial sources of simulated runoff, we estimated that snow and ice melt from glaciers has supplied an average of about 20% of the annual flow volume of the Yukon River above Whitehorse in recent decades, with 30% of this as a result of the net mass loss (i.e. wastage) of glaciers. The model also indicates that the region's largest glacier, the Llewellyn Glacier (433 km^2), was the single most significant contributor of glacially-sourced water, highlighting the importance of this ice mass. Further work will consider future climate scenarios and glacier dynamic modelling to project impacts into the remainder of the 21st century.

Abstract ID: 33992

Final Number: H34B-0159

Title: Spatial Variability of Snowmelt Rates at Scotty Creek, NWT

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Co-authors: William L Quinton, Wilfrid Laurier University, Waterloo, ON, Canada; Oliver Sonnentag, University of Montreal, Montreal, QC, Canada

Abstract Body: At high latitudes, snow has a significant influence on hydrological and atmospheric processes. Portions of these regions are dominated by evergreen coniferous forests which affect energy and mass exchanges between the atmosphere and the land surface. Beneath a forest canopy, energy budget dynamics are strongly influenced by the large spatial variability of radiative and turbulent fluxes. The spatial variation of shortwave irradiance to snow is important to quantify as it can affect the depletion of snow covered area and areal melt rates. Currently, the magnitude of this variation has been sparsely quantified by field measurements during melt and hence, limits the physical basis with which spatial distributions of melt can be estimated. This study was conducted in the high-Boreal zone of discontinuous permafrost at Scotty Creek, NWT for the purpose of addressing these discrepancies. The specific objectives were to 1) compute the snowmelt energy balance in a high-latitude forested environment; and 2) determine the relative importance of the energy balance terms with respect to controlling the spatial distribution of melt energy and partitioning of radiative and turbulent fluxes. Point measurements of snowmelt were used in combination with aerial remote sensing, including high-resolution LiDAR, and the Cold Regions Hydrological Model to examine the spatial distribution of snowmelt rates. Preliminarily analysis suggests that under most circumstances, net radiation provides the majority of melt energy below the tree canopy.

Abstract ID: 34844

Final Number: H34B-0160

Title: Lateral Variations of Ground Temperatures along Linear Disturbances in the Peatlands in the Regions of Discontinuous Permafrost

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Abstract Body: Lateral Variations of Ground Temperatures along Linear Disturbances in the Peatlands in the Regions of Discontinuous Permafrost

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In subarctic peatlands permafrost is found under peat plateaus, while fens and flat bogs remain permafrost free, thus creating heat source. In stable environment permafrost and permafrost free terrain are in thermal equilibrium, which is affected just by climatic fluctuations. At the same time, surface disturbance may initiate anomalous heat flow. In case of linear disturbance over peat plateaus, such as seismic lines, this flow is narrowly directed along the borders of the seismic line accelerating permafrost thaw. The objectives of this study was to assess the influence of the year round unfrozen water body (*i.e.* channel fen and flat bogs) on frozen peat plateau disturbed by seismic line, which was cut in winter 1985. The findings suggest that the presence of such heat source, such as channel fen and flat bog, in close proximity of the disturbed permafrost terrain has a profound effect on temperature distribution along the linear disturbance, causing accelerated thaw from the top as well as from the bottom of permafrost. The heat flux is coupled with mass flux and can be observed all year round, being on its peak during summer months.

The study was conducted in the Scotty Creek basin (at 61.31N and 121.30W), approximately 60 km SE from Fort Simpson, North West Territories. A number of geophysical surveys were performed to delineate permafrost, peat and mineral soil borders. Temperature and water level observations were carried out throughout two years period in order to understand the influence of heat storage on the temperature distribution along the seismic line and consecutive permafrost degradation.

Abstract ID: 34634

Final Number: H34C-0161

Title: Statistical and analytical approach for stream-aquifer interaction in the lower Nakdong River basin, Korea

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Abstract Body: Stream water (SW)-groundwater (GW) interaction demonstrated seasonal and areal changes in the vicinity of the upstream of the Changnyeong–Haman river barrage due to the construction of the river barrage. Statistical and analytical approaches examined the relationship of the stream water level (WL_S)–groundwater level (WL_G) and the electrical conductivity of GW (EC_G)–electrical conductivity of SW (EC_S) in the river barrage area of the lower Nakdong River basin from June 2011 until September 2014. The response time change of the SW-GW interaction by using the cross-correlation function (CCF) was verified by 1D unit step rise flood wave response model considering river resistance (R). The optimal value of the aquifer diffusivity (α) was obtained by pumping test analysis. The simulated groundwater levels were compared with the observed levels for verification. By the result of the statistical methods, the SWL-GWL and EC_S-EC_G response time showed an increase while CCF showed a decrease since the construction of the river barrage. Also, maximum CCF fairly well corresponded to the α of 5000 m^2/hour and R of 750-8000 m in analytical model. The values of R in observation well which distance of 500 m away from the stream has estimated to 1450 m (2011), 1000 m (2012), 750 m (2013), and 8000 m (2014), respectively. This result shows that the long-term operation of the river barrage can lead to weakening of the hydrologic stress propagation on the aquifer by decreasing of stream water level fluctuation and increasing of clogging on the bottom and walls of the stream-aquifer boundary.

KEY WORDS: Stream water–groundwater interaction, groundwater level, groundwater electrical conductivity, cross-correlation function, flood wave response model, hydrologic stress propagation.

Acknowledgement :This study was supported the research project of “Advanced Technology for GW Development and Application in Riversides (Geowater+)” in the “Water Resources Management Program (code 11 Technology Innovation C05)” of the Ministry of Land, Infrastructure and Transport (MOLIT) and the Korea Agency for Infrastructure Technology Advancement (KAIA).

Abstract ID: 35060

Final Number: H34C-0162

Title: Estimating Groundwater Inflows to Small Streams Using ^{222}Rn and Argon

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Abstract Body: Radon is a radiogenic isotope derived from the disintegration of ^{238}U. Dramatic loss of ^{222}Rn is produced when groundwater is discharged into rivers, where it rapidly degasses to the atmosphere. By measuring ^{222}Rn in the aquifer and in the river, it is possible to simulate groundwater-river exchanges if the radon degassing rate (a function of river width, depth and turbulence). Argon is a noble gas which is present in rivers in equilibrium with the atmospheric concentration. Performing argon tracing in the river could provide an estimate of its degassing rate to be used as a proxy for the ^{222}Rn degassing rate. The objective of this work was to quantify exchanges between groundwater and small rivers using the noble gases argon and radon as tracers of groundwater discharge processes. ^{222}Rn activities in groundwater and river water was analyzed during the 2013 and 2014 summers in two watersheds from the Centre-du-Québec and Vaudreuil-Soulanges regions of southern Quebec (Canada), i.e. the upper Nicolet River and the Raquette River respectively. Sampling in 2013 was dedicated to collect 130 groundwater samples. In 2014, the sampling focused on measuring ^{222}Rn in the two rivers. Groundwater ^{222}Rn activities show a relation with the local geology. Groundwater from the metasedimentary rocks of the Appalachians and in Grenvillian age magmatic rocks of Mount Rigaud show ^{222}Rn activities between 40 and 400 Bq/L while groundwater from the St. Lawrence Platform shows ^{222}Rn activities from 3 to 30 Bq/L. In the river, concentrations in ^{222}Rn are between 0.1 and 4 Bq/L. Localized groundwater inflows to the two rivers are shown by peaks of ^{222}Rn activities but exchanged flowrates need to be confirmed with a field-measured estimate of degassing rates Tests are currently under way to perform a laboratory-scale continuous argon injection that will help identify the required conditions for field-scale injections to be performed next summer

Abstract ID: 35061

Final Number: H34C-0163

Title: The Effect of Mine Dewatering and Peatland Form on the Pattern of Surface Recharge Around the Victor Diamond Mine, James Bay Lowlands

Presenter: Jonathan S Price, University of Waterloo, Waterloo, ON

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Co-authors: Pete N Whittington, Brandon University, Brandon, ON, Canada

Abstract Body: The Victor diamond mine requires substantial aquifer dewatering and depressurization of the limestone bedrock to keep the mine pit dry. Located in the James Bay Lowland, the dewatering has affected the pattern and rate of surface recharge through the peatlands that cover >90% of the area. The area is typified with domed bogs and fen water tracks; the fens act as the conveyors of water and connect with active stream. The surface recharge rate in the modelled watershed was simulated using HYDRUS 3D for the period of Jan 2005 to Dec 2012 (dewatering began Jan 2007), with two periods of two and six years in steady and unsteady state, respectively. The model was calibrated by using the daily water level in 20 observation wells, as well as observed total surface outflow and recharge of mine process water into the central quarry. The flow domain is 106 km² and extends to a depth of 300 m with 13 layers. The results shows that in pre-mining and mining conditions about 50,000 m3/day of water recharged through the surface mostly through the bogs that are the inter-fluvial areas between water tracks; the shallow peat along the fen water tracks conveyed most of this water out of the system as horizontal shallow surface and sub-surface flow. At the end of the simulated period for the mining condition (Dec 2012) when the dewatering rate approached 86,000 m3/day, ~ 25% of this water was derived from a 2-3 km radius around the mine. The model suggests recharge here was intensified because of a locally thinner or absent low permeability claystone layer (elsewhere ~50 m below the surface, separating upper and lower bedrock aquifers) and a thinner marine sediment layer. Simulation revealed that surface outflow along the fen water-tracks and dewatering of the mine are the two main components that control the surface recharge rates across the domain.

Abstract ID: 35062

Final Number: H34C-0164

Title: Surface-subsurface flow analysis of the Raquette River watershed (Vaudreuil-Soulanges, Quebec, Canada)

Presenter/First Author: Félix Turgeon, University of Quebec at Montreal UQAM, Montréal,

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Co-authors: Marie Larocque, Univ du Quebec - Montreal, Dorval, QC, Canada; Sarah Dorner, Université de Montréal, Montréal, Canada

Abstract Body: Located 50 km west of Montreal (Quebec, Canada), the Raquette River watershed covers an area of 133 km² and its main river is 34 km long. Groundwater resources are under pressure in this region, notably due to an important population increase in the past decades. These changes are expected to impact the hydrology of the entire watershed. The main objective of this research was to evaluate the relative contribution of surface and subsurface flow to the Raquette River using field data and the fully-coupled MikeSHE model. Upstream, the river flows through an agricultural zone on a thick clay deposit, where drained soils cover a sandy aquifer in a major bedrock depression. Towards its center, the river flows over the bedrock between Mount Rigaud and the Sainte-Marthe Hill (in the Sainte-Marthe channel). The river flows downstream over clay deposits and then over fluvioglacial sandy deposits towards the Ottawa River. Groundwater recharge is limited to Mount Rigaud and the Sainte-Marthe Hill. Low-flow measurements have shown that the main groundwater contribution to the river takes place on a 3 km long segment located in the Sainte-Marthe channel, where the river gains 35% of the flow measured at the outlet. The fully-coupled model is built with 10 layers and 165 870 cells (100 m x 100 m) and is run with a daily time step over two hydrological years. The spatial distribution of geological units in the surface layer was used to represent the spatial heterogeneity of parameters, such as the Manning roughness coefficients and the infiltration fractions. The calibrated model simulates adequately the measured heads, as well as the spatially variable flow rates and river-aquifer exchanges. The model shows that the stratigraphy and hydrogeological parameters in the Sainte-Marthe channel, as well as recharge rates over the Sainte-Marthe Hill control groundwater inflows to the river. Results from this study are also used to estimate the impacts of land use changes on the watershed hydrology.

Abstract ID: 35202

Final Number: H34C-0165

Title: The Hydrology of a “Spontaneously” Re-vegetated Vacuum-harvested Peatland, Eastern Manitoba

Presenter/First Author: Pete N Whittington, Brandon University, Brandon, ON

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Abstract Body: Peatlands cover over 38% of Manitoba’s land area and represent an important component of the natural landscape. Nearly 13% of Canada’s horticultural peat is produced in Manitoba in the southeastern part of the province. Vacuum harvesting requires the removal of all surficial vegetation and ditches to drain the peatland, lowering the water table. A consequence is that vacuumed harvested sites do not re-vegetate themselves naturally; active restoration efforts in eastern Quebec have been largely successful, though with considerable trial and error to get the ecohydrological processes correct.

The Moss Spur peatland was a large (~3 km diameter) domed bog, harvested from the 1940s and was abandoned in the early 1990s. With little intervention, the natural re-vegetation of the site has been remarkable, with over 90% wetland vegetation coverage and Sphagnum hummocks in a few locations, something that has not occurred naturally in Quebec. Preliminarily results suggest that the success of the re-vegetation is due to groundwater discharge under the site, which contradicts the ombrogenous requirement of bog hydrology. In areas with regeneration indicative of bogs (e.g., Sphagnum), hydraulic gradients of groundwater discharge averaged 0.02; in areas with more fen vegetation hydraulic gradients averaged 0.002; and in areas with no re-vegetation, hydraulic gradients averaged -0.1 (groundwater recharge). It is speculated that these groundwater flow reversals are occurring due to the lowered hydraulic head in the now abandoned former bog. This has been observed in other Western Boreal Plain peatlands in times of extreme drought, and thus peat harvesting may act as a surrogate extreme drought which causes groundwater flow reversals in large peatlands. Supporting this as a mechanism that aids restoration is that Moss Spur’s hydrogeomorphic setting is quite different than Quebec sites, as eastern boreal shield peatlands are more typically situated on a thin veneer of sediment over bedrock, thus precluding regional groundwater exchanges.

Abstract ID: 35149

Final Number: H34D-0167

Title: Quantifying the Increasing Impact of the Human Footprint on Water Quality in a Rural-Urban Kenyan Watershed: Can Upstream Stewards and Downstream Beneficiaries Find Common Ground?

Presenter/First Author: Kennedy Waweru Nganga, Consultative Group on International Agricultural Research (CGIAR), Nairobi,

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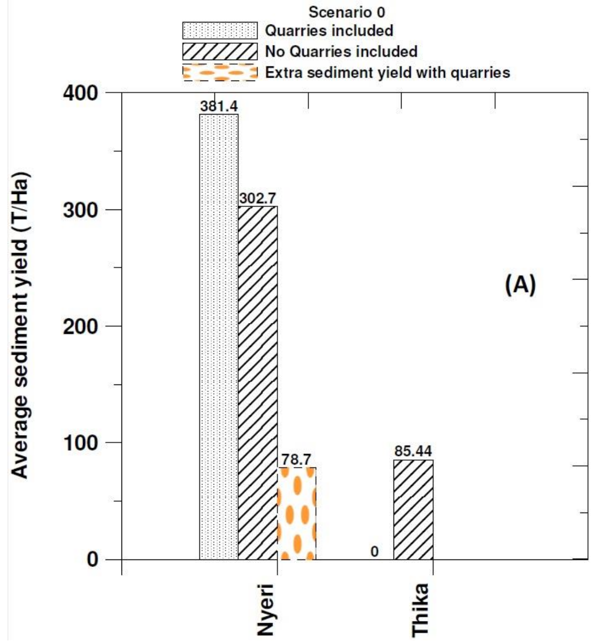
Co-authors: Fred Kizito, , , ; Deborah Bossio, , , ; Justine Cordingley, , ,

Published Material: Findings from this work were submitted to the CGIAR Research Program on Water, Land and Ecosystems in a technical report from the International Center for Tropical Agriculture in 2014. Findings have also been presented at the Global Landscapes Forum in 2014. Various aspects of this work have also been reported in traditional and social media by various organizations in 2014 including Reuters AlertNet, Water Land and Ecosystems website, as well as the Global Landscapes Forum and CIAT websites.

Abstract Body: Watersheds in rural Africa are facing new challenges from population growth and urbanization. As the anthropogenic footprint expands over the landscape (with population growth rates projected to rise to 4%), factors such as land cover changes driven by human activities and infrastructural development are increasing the severity of erosion and river sedimentation. Of particular importance are quarries that supply the material demanded by the growing construction industry, and the earth roads that feed to them. These quarries, many of which are unregulated, do little to mitigate their impact on the streams and rivers they border. Our assessments indicate that quarries and earthen roads (point sources) contribute up to 25% (79T/Ha) of the total annual sediment load in the watershed with the other 75% (302 T/Ha) contributed by agriculture as a non-point source. Both point and non-point sources combined have been found to significantly alter watershed characteristics and have modified hydrological responses in ways that are poorly understood. Our study findings monitored, modeled and quantified the importance of these new point sources and conventional non-point sources in the agriculturally dominated watersheds. We present a method for using remote sensing based techniques and scenario modeling to disaggregate the pollution sources and also present viable management options for mitigating the sediment problem. Finally the study demonstrates win-win solutions (that may have global relevance) on how upstream stewards and downstream beneficiaries can find common ground in these vulnerable rural-urban connected watersheds.



Abstract ID: 36081

Final Number: H34D-0168

Title: Temporal variability in phosphorus losses in tile drain effluent from agricultural fields

Presenter/First Author: Vito Lam, University of Waterloo, Waterloo,

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Co-authors: Merrin L Macrae, University of Waterloo, Waterloo, ON, Canada; Michael English, Wilfrid Laurier University, Waterloo, ON, Canada; Ivan O'Halloran, , , ; Yutao Wang, , ,

Abstract Body: Tile drains in agricultural fields have been identified as a significant source of phosphorus (P) to surface water bodies and have been identified as a potential contributor to algal blooms in Lake Erie. Tile-drains were monitored in two agricultural fields in southern Ontario (Lake Simcoe watershed) over approximately a 28-month period (year round sampling) to quantify runoff, P concentrations, mass and speciation, and, to determine if these varied with tillage practices. Discharge and P export were temporally variable and episodic in nature, with the majority of loss occurring in a relatively small number of events throughout the water year. Over the study period, 27 events were recorded. Events were highly responsive to precipitation events, snowmelt or a combination of both and were observed in every season. Tile drain hydrologic and biogeochemical responses did not vary with tillage practices. Rapid transmission of water from the surface into drainage tiles via macropores was not observed, and a threshold soil moisture was required to initiate runoff generation in tile drains. Consequently, antecedent moisture conditions, soil/crop conditions and seasonality led to differences between events, such as discharge magnitude, runoff-coefficients, and P concentrations and mass in tile drain effluent. As expected, tile drain responses were greatest following precipitation on bare, moist soils. Larger precipitation events and snowmelt events exported more runoff and P mass; however, the largest events did not always have the highest P concentrations in tile drain effluent, and, P supply limitation was apparent in the data set. Temporal variability in P mobilization in tile drain effluent is discussed and related to antecedent soil moisture conditions, event climate drivers and antecedent rainfall.

Abstract ID: 36613

Final Number: H34D-0169

Title: Waterlogged: The Case for Participatory Science in Investigating Water Quality Impacts

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Published Material: This project was briefly discussed in a Water Pop Up talk at the 2013 AGU. This talk was an overview of the project, and did not discuss the results and experience of the project, and thus represents a small percentage of the abstract presented here.

Abstract Body: The reference condition approach for investigating the impact of human activities in watersheds makes it necessary to study multiple sites that represent a range of disturbance. Gathering sufficient data to tease out human effects can be difficult due to the range of human disturbances and activities possible, as well as the variability in natural factors that contribute to water quality. Given this, we began a citizen science campaign to help investigate how land use change, like forest cover loss, affects the biogeochemical cycling of organic matter in stream and river ecosystems. We asked citizens to participate by collecting water samples in local watersheds around the Metro Vancouver area in British Columbia, Canada. Community-based samples augmented our sampling activity at sites chosen as either reference or disturbed sites. All researcher-collected and community-collected samples were analyzed for water quality parameters specifically related to organic matter, including dissolved organic carbon (DOC) concentration and quality through methods including high temperature combustion (DOC concentration) and UV-Vis absorbance and fluorescence spectrophotometry (DOC quality indices). Community-collected samples represented a high degree of variability in terms of disturbance, with the greatest number of samples collected from mixed-use watersheds surrounding Vancouver. All sample sites, and information related to water quality, were mapped in order to quantify types and severity of land uses upstream of sites, and these variables were evaluated relative to measured organic matter water quality parameters. Although not a replacement for sampling campaigns undertaken by researchers, participatory science can provide benefits beyond increased sample coverage and variability. Specifically within our experience, the presence of highly educated and active community groups within local watersheds presented an opportunity to augment the valuable environmental monitoring activities already occurring, and to draw from extensive knowledge regarding the histories of specific watersheds. Lastly, participatory science approaches serve as a means of directly engaging the community about the cumulative effects human activities have on environmental processes.

Abstract ID: 36829

Final Number: H34D-0170

Title: Apportioning Sources of Fine Sediment in an Agricultural Watershed Using Colour Fingerprinting

Presenter/First Author: David Allen Lobb, University of Manitoba, Winnipeg, MB

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Co-authors: Louise Barthod, , , ; Kui Liu, , , ; Philip N. Owens, University of Northern B.C., Prince George, BC, Canada; Nuria Martinez Carreras, CRP Gabriel Lippmann, Belvaux, Luxembourg; Alex Koiter, , , ; Ellen L Petticrew, Univ Northern British Columbia, Prince George, BC, Canada; Greg McCullough, University of Manitoba, Winnipeg, MB, Canada; Cenwei Liu, , , ; Leticia Gaspar, , ,

Abstract Body: The use of sediment color as a fingerprint property to determine sediment sources is an emerging technique that can provide a rapid and inexpensive means of investigating sediment sources. The present study aims to test the ability of color parameters to distinguish between potential sources of sediment and apportion their contributions within the South Tobacco Creek Watershed, MB, Canada (74 km^2). The results are compared with the findings from a conventional fingerprinting approach undertaken in the same watershed (i.e., geochemical and radionuclide fingerprints). Suspended sediment and potential source samples were collected at six sites along the main stem of the creek. Canonical discriminant analysis was used to determine the number of source groups. Sample color of sediments and source materials was quantified from diffuse reflectance spectrometry measurements and sixteen color coefficients were derived from several color space models (CIE XYZ, CIE xyY, CIE Lab, CIE Luv, CIE Lch, Landsat RGB, Redness Index). Experiments were undertaken to test the linearly-additive nature of the color coefficients and this was used to further refine the number of coefficients that were suitable for source apportionment. The discrimination power of the color coefficients was assessed using discriminant function analysis. The selected fingerprints were included in a Bayesian mixing model using Monte-Carlo simulation to apportion the contribution of the different sources to the sediment collected at each site. Consistent with the conventional fingerprinting approach, a switch in the dominant sediment source between the headwaters and the outlet of the watershed was observed. As the stream crosses and down-cuts through the Manitoba Escarpment, sediment is enriched with shale bedrock and stream bank materials from within and below the escarpment and depleted of topsoil and/or stream bank materials from above the escarpment.

Abstract ID: 35158

Final Number: H34E-0171

Title: Evaluation of Paleo-Hydrologic Extremes and Their Uncertainties

Presenter/First Author: Saman Razavi, University of Saskatchewan, Saskatoon, SK

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Co-authors: Amin A Elshorbagy, University of Saskatchewan, Saskatoon, SK, Canada; Howard S. Wheater, University of Saskatchewan, Saskatoon, SK, Canada; Dave Sauchyn, University of Regina, Regina, SK, Canada; Gonzalo Sapriza, University of Saskatchewan, Saskatoon, SK, Canada; Kwok Pan Chun, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: None of these have been previously published. Parts of the findings are currently under review in Water Resources Research for publication.

Abstract Body: Natural proxy records of hydroclimatic behaviour, such as tree-ring chronologies, are a rich source of information of past climate-driven changes and non-stationarities in hydrologic variables. They are typically directly related to available water in respective years, thereby providing a means to go beyond the limited observational records. In this study, we investigated the tree-ring chronologies that demonstrate significant correlations with streamflows, with the objective of identifying the spatiotemporal patterns and extents of changes and non-stationarities in climate and hydrology, which are essentially representations of past "climate changes". To this end, we developed a framework that also quantifies uncertainties around the reconstructions of paleo-hydrologic

extremes. The major headwater tributaries of the Saskatchewan River basin (SaskRB), the main source of surface water in the Canadian Prairie Provinces, are used as the case study. Results confirm that stationarity has never existed in the hydrology of the region, as the statistical properties of annual paleo-hydrologic proxy records across the basin, i.e., the mean and autocorrelation structure, have consistently undergone significant changes at different points in the history of the region. This study identified paleo-hydrologic extremes (e.g., severe droughts) in the past four centuries that are well beyond recorded hydrologic extremes in the observational period of this region. This presentation highlights the need to broaden the understanding of hydrologic extremes in the Saskatchewan River Basin beyond the limited observational records, as an improved understanding is essential for more reliable assessment and management of available water resources.

Abstract ID: 35328

Final Number: H34E-0172

Title: Sources of Uncertainty in Replicating Hydro-climatic Extremes

Presenter/First Author: Arelia T Werner, Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC

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Co-authors: Alex J Cannon, University of Victoria, Victoria, BC, Canada; Markus Schnorbus, University of Victoria, Victoria, BC, Canada; Rajesh R Shrestha, Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC, Canada

Abstract Body: Effective communication of projected hydrologic extremes starts with a discussion of uncertainty. We perform an analysis using 56 downscaled (2 x observations; 4 x reanalyses; 7 x downscaling methods) results to drive the Variable Infiltration Capacity hydrologic model. Performance of each method is tested for timing and distribution of 3-day peak flow, 7-day low flow and 26 ClimDEX indices. Downscaling methods include bias corrected constructed analogues (BCCA), double BCCA (DBCCA), climate imprint (CI), bias corrected climate imprint (BCCI), bias correction spatial disaggregation based on mean temperature (BCSD), BCSD based on minimum and maximum temperature (BCSDX), and BCCA bias corrected with BCCI (BCCAQ). NCEP1, ERA40, ERAInt and 20CR are the reanalyses downscaled and two separate observational datasets are used as the downscaling target. The ability to replicate the timing and distribution of ClimDEX indices depended on downscaling technique, reanalyses and gridded-observation in order of importance. The strongest method was DBCCA, while the weakest was BCSDX. 3-day peak flow performance was more dependent on reanalysis than downscaling technique. ERA40 results were strongest and NCEP1 weakest. In the case of 7-day low flow, results depended most strongly on downscaling method, CI failed to replicate the distribution, while BCSD and BCSDX failed to replicate the timing regardless of reanalyses; these poorly performing methods over estimated low flow volumes. BCCI and BCCAQ tied for best combined performance for 7-day low flow and 3-day peak flow. Uncertainty can be reduced by careful selection of downscaling methods for those metrics most sensitive to downscaling (7-day low flow), but can't be reduced where global climate model uncertainty plays a more important role (3-day peak flow).

Abstract ID: 35494

Final Number: H34E-0173

Title: Risk of Exceeding Extreme Design Storm Events under Possible Impact of Climate Change

Presenter/First Author: Chun-Chao Kuo, University of Alberta, Edmonton, AB

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Co-authors: Thian Yew Gan, University of Alberta, Edmonton, AB, Canada

Published Material: Kuo, C.C. and T.Y. Gan, 2015. Risk of Exceeding Extreme Design Storm Events under Possible Impact of Climate Change. *Journal of Hydrologic Engineering-ASCE*. (Under Review)

Abstract Body: In order to evaluate how the risk of intensive storms, which is the probability of exceeding certain storm intensity one or more times within a given number of years, is expected to change in central Alberta in the future. We proposed a new Risk Chart which represents the nonlinear relationship between storm intensity, design project life, and the risk of intensive storms being exceeded within the project life. First, a comparison between estimated Risk Charts of the past (1914–1995) and the present (1984–2010) for central Alberta shows that the risk of intensive storms occurring has increased for all storm durations in recent years, and the risk had been higher for storms of large return periods (≥ 50-yr). Given a design project life of 50-yr, the average increase in risk is 9 percentage points (pp). Second, the uncertainty associated with projecting the risk of intensive storms occurring in 2011–2100 was assessed by considering three Special Report on Emissions Scenarios (SRES) of four Global Climate Models (GCMs) of IPCC (2007) dynamically downscaled by a Regional Climate Model, MM5. Based on storms simulated by MM5 for central Alberta forced by SRES climate scenarios of IPCC for 2011–2100, the median risk for short-duration storms (≤ 1-h) of a design project life of 25-yr and 50-yr is projected to increase up to 37 pp and 38 pp, respectively. In other words, climate change impact could increase the vulnerability of central Alberta to the hazards of flooding by intensive storms in future. The proposed Risk Chart present the risk in a straightforward and meaningful way which will be useful for the long-term planning and engineering design of municipal infrastructure.

Abstract ID: 35608

Final Number: H34E-0174

Title: Renewal and Update of MTO IDF Curves: Defining the Uncertainty

Presenter/First Author: Eric D Soulis, University of Waterloo, Waterloo, ON

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Co-authors: Daniel G. Princz, University of Waterloo, Saskatoon, SK, Canada; John Wong, , ,

Published Material: Accepted, but not yet published, for journal publication by the Journal of *Water Managment Modeling*. Parts presented at the Ontario Climate Advisory Committee (OCAC) meeting #45. Preliminary finding were presented at CMOS 2012 and 2013.

Abstract Body: The University of Waterloo has been commissioned by the Design and Contract Standards Office of the Ministry of Transportation of Ontario (MTO) to update the intensity–duration–frequency (IDF) curves that are used to estimate design storms for drainage infrastructure. Environment Canada provides analyzed rainfall data for weather stations in Ontario. Project engineers determine the design storm parameters using a variety of methods. Thus, there is a need for a consistent interpolation procedure that can deal with the sparseness and unevenness of the Ontario station network. This presentation describes the procedures that form the basis for the MTO IDF Curve Lookup system. Confidence limits assist in the design process and allow comparison with other results. These were used to assess the spatial bias in the error fields. There appears to be none, but there is room for improvement where there are sharp changes in geography, such as the highlands west of Thunder Bay. Validation curves are presented for several Canadian stations and one American station.

Abstract ID: 34377

Final Number: H34E-0175

Title: Scaling Laws for Extreme Precipitations: Assessing the Impacts of Datasets Characteristics on Extreme Distribution Estimation.

Presenter/First Author: Silvia Innocenti, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Québec,

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Co-authors: Alain Mailhot, Institut National de la Recherche Scientifique, Québec, QC, Canada; Anne Frigon, Ouranos, Montreal, QC, Canada

Abstract Body: Characterizing extreme precipitations at small spatial and temporal scales is crucial in order to evaluate and predict the impacts of natural hazards on regional ecosystems. Available datasets, including climate model simulations and reanalysis products, still have many deficiencies related to their temporal and spatial resolution. Biases and uncertainties are also important, especially when considering extreme precipitations.

The present study aims at validating the use of scaling models for the description of the spatio-temporal structure of extreme precipitations in North-America. By means of scaling models, the statistical distribution of the extremes estimated at specific spatial and temporal scales is related to the distribution at other scales. It is therefore possible to assess extreme precipitation distribution at temporal and spatial scales which are only partially or not sampled. Hence, a consistent and parsimonious construction of IDF curves is possible.

The influence of datasets characteristics (e.g., their temporal and spatial resolution, or spatial coverage) on the scaling properties of sub-daily and daily precipitations is investigated through the comparison of different available datasets (station network series, NCEP Stage IV dataset, and reanalysis series). The range of validity, the magnitude, and the variability of the estimated scaling laws are compared among observed datasets and reanalysis having different spatial resolutions. The spatial distribution of scaling estimates is presented. The influence of climatic and geographic characteristics of Canadian region on scaling estimates is also evaluated. The objective is to validate the use of scaling models to estimate IDF curves for precipitation extremes over Canada. Preliminary results will be presented.

Abstract ID: 35381

Final Number: H41A-02

Title: Coupling System Dynamics and SWAT Models for Participatory Water Quality Management in the Du Chêne basin, Québec

Presenter/First Author: Jerome Boisvert-Chouinard, McGill University, Montreal, QC

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Co-authors: Azhar Inam Baig, McGill University, Sainte-Anne-De-Bellevue, QC, Canada; Jan F Adamowski, McGill University, Montreal, QC, Canada

Published Material: Partial results presented at the ASABE 2014 Annual International Meeting.

Abstract Body: The Québec Water Policy outlines the importance of stakeholder participation in water management processes, but in practice, there is a lack of meaningful engagement in water planning and implementation, and participation is often limited to public consultation and education. When models are used to support water planning, stakeholders are usually not involved in their development and use, and the models commonly fail to represent important feedbacks between socio-economic and physical processes.

This paper presents the development of a holistic model of the Du Chêne basin that simulates socio-economic and physical processes related to water quality management, and feedbacks between them. The model consists of two sub-components: a System Dynamics (SD) model, and a Soil and Water Assessment Tool (SWAT) model. The SD component was developed in collaboration with key stakeholders in the watershed. The coupled SD-SWAT model was used to assess the environmental and socio-economic impacts of different management scenarios proposed by stakeholders. The scenarios included different combinations of water quality improvement strategies such as planting buffer strips, replacing obsolete septic tanks, and putting in place economic incentives for sustainable agricultural management practices.

Our results indicate that a coupled SD-hydrologic model can be used as an effective tool for participatory water planning and implementation. The participatory modeling process provides a structure for meaningful stakeholder engagement, and the model itself can be used to transparently and coherently assess and compare different management options. In this case, the SD model was coupled with SWAT to address water quality, but a similar approach could be used to couple SD models with other physically based models to address different problems, such as water scarcity or soil salinity.

Abstract ID: 36168

Final Number: H41A-04

Title: PARAMETERIZATION AND VALIDATION OF SWAT MODEL FOR WHEAT YIELD AND CROP WATER PRODUCTIVITY UNDER RAINFED CONDITIONS

Presenter/First Author: Mukhtar Ahmed, Organization Not Listed, Rawalpindi,

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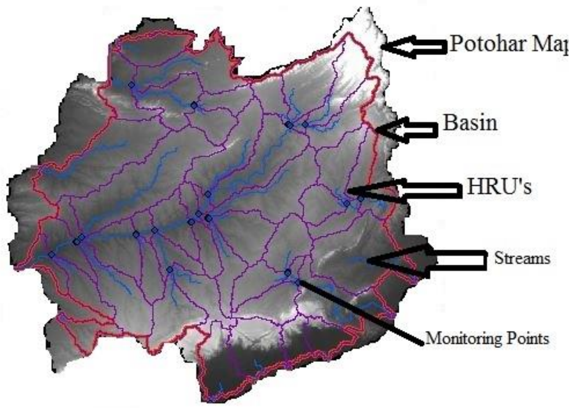
Co-authors: Atif Mehmood, PMAS Arid Agriculture University, Rawalpindi, Pakistan; Fayyaz ul Hassan, Comsats Institute of Science and Technology, Islamabad, Pakistan; Muhammad Aqeel Aslam, , , ; Muhammad Akmal, , , ; Muhammad Aslam, , ,

Abstract Body: The greatest challenge faced by the agriculture sector now days is production of more food from less available water. Increasing water productivity of the crops can help in facing this challenge. For understanding the relationship between water and food, a sound knowledge of crop water productivity (CWP) is important. Therefore, to achieve higher CWP under changing climatic conditions, increasing WUE (water use efficiency) could be an option by adopting mitigation strategies. These measures might be, adopting good management practices like optimizing the sowing date on long-term basis using simulation modeling as decision support tool. In the present study, Soil and Water Assessment Tool (SWAT) model was parameterized and validated to study the relationship between yield and crop water productivity of rainfed wheat. For this study, field experiment was conducted at three locations (Islamabad, University Research Farm, Chakwal Road and Talagang) with three wheat Cultivars (PAK-13, Chakwal-50 and Dharabi) and two sowing dates (20-30 October and 10-30 November). Data regarding soil moisture and grain yield were recorded from the field experiments. Crop water productivity was calculated by dividing the grain yield by evapotranspiration during crop growth cycle and was used for studying the relationship between available water, rainfed wheat yield and water productivity. Satellite based parameterization of study area for GIS mapping, topographic analysis, vegetation dynamics, land use, and soil

mapping was done by using different software packages like ArcGIS 10.1, Erdas Imagine, QGIS, and Swat-CUP. The SWAT model was used to simulate the processes related to the soil-crop-atmosphere interaction in the present study. Simulated results were compared with the observed values. Present study revealed that the changing climatic conditions significantly affect the rainfed wheat growth, yield and productivity. The simulated values for grain yield were close to the observed values with validation skill score of R^2 (0.827). Similarly, simulated values for crop water productivity were close to the observed values with validation skill score of R^2 (0.88).



Abstract ID: 35796

Final Number: H41A-05

Title: Assessment of SPEI as a Tool for Representing Drought in the Agricultural Landscapes of the Southern Canadian Prairies

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Abstract Body: Droughts have had a significant impact on the agricultural yield across the southern Canadian Prairies. This region is home for the majority of the agricultural land in Canada and therefore, any negative impact on the crops has a significant influence on the agricultural economy of Canada. Moreover, increasing economic activity and growing population in this region is increasing the demand for water resources and therefore influencing the vulnerability to drought. The future projections of increased climate variability resulting from climate change suggest an increasing likelihood of droughts in this region. Due to the complex interrelation between climate, hydrology and water demand, a comprehensive index to represent drought has been difficult to find. Measured meteorological and hydrological quantities are primary indicators of drought and various drought indices were derived by assimilating these measured quantities. The Standardized Precipitation Index (SPI) has been used to assess drought conditions in Canada however the Standardized Precipitation Evapotranspiration Index (SPEI) may better capture the evaporative stress associated with drought conditions. In this study, we compared the SPI and SPEI to understand which of the two indices best represent drought conditions across the southern Canadian Prairies. The initial results indicate no significant difference between the indices in assessing drought under observed climatic conditions. However, drought severity as projected by the future climatic projections from GCMs are captured best by the SPEI, which accounts for the loss of moisture through Potential Evapotranspiration. Our results indicate that SPEI would be a better measure of drought in this region with the projected increases in temperature.

Abstract ID: 33026

Final Number: H41A-06

Title: A hydrologic-based lumped method for stochastic internal dose calculation and the time evolution of the probability density distribution of radioactivity in the human body

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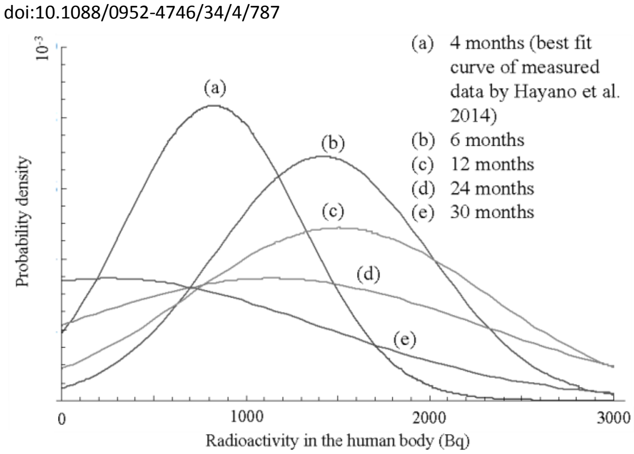
Abstract Body: In this report, we calculate the probability density function of the internal dose based on a hydrologic lumped method. The authors have been studied readily-understandable hydrologic-based lumped method to calculate the internal dose by treating the human body as a single vessel. In our previous research, the internal dose is calculated deterministically. However, radioactivity in the human body actually distributes by individuals stochastically. It is shown by the investigation of radiocesium by using whole-body counting [1]. The distribution emerges from some uncertain factors regarding the intake and excretion of radioactivity. Therefore, we suggest that the probability density distribution of the internal dose is appropriate to be discussed from the viewpoint of radiological protection of the public. The ingestion flux of radioactivity is including Gaussian white-noise fluctuations. Then, the continuity equation of radioactivity in the human body is formulated as the stochastic differential equation including the standard Wiener process. The stochastic formulation gives the time evolution of the probability density function of the internal dose as shown in the figure.

[1] R. S. Hayano, Y. N. Watanabe, S. Nomura, T. Nemoto, M. Tsubokura, T. Hanai, Y. Kumemoto, S. Kowata, T. Oikawa and Y. Kanazawa; “Whole-body counter survey results 4 months after the Fukushima Dai-ichi NPP accident in Minamisoma City, Fukushima”, *J. Radiol. Prot.* **34**, 787 (2014). doi:10.1088/0952-4746/34/4/787



Abstract ID: 34734

Final Number: H41A-07

Title: Effects of time series lengths on the design of hydrometric networks using Dual Entropy and Multiobjective Optimization

Presenter/First Author: Jongho Keum, Utah State University, Logan, UT

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Abstract Body: Recently, Dual Entropy Multiobjective Optimization (DEMO) has been developed and applied to design optimal networks for streamflow, precipitation, and soil moisture monitoring. While the previous applications to various hydrologic variables have shown versatility of DEMO application, it is still not clear how the length of input time series affects the optimization results and network designs. In this study, various time series lengths were applied to find the optimal streamflow and precipitation network designs. The study area is Hamilton, Halton and Credit Valley in southern Ontario, Canada. Numbers of the currently active streamflow and precipitation stations are 23 and 20, and the potential stations are 137 and 61, respectively. Three objective criteria were used in DEMO applications, including maximizing joint entropy, minimizing total correlation, and minimizing total costs. Five, ten, fifteen, and twenty-year of streamflow and precipitation data were used as input time series, respectively. The strong "hot- spots" (or high probability areas) were relatively constant for all four time series lengths. However, some areas with lower probabilities show some sensitivity to the length of the time series used. In summary, few years of time series (about 5-year daily series) can be used to determine "hot-spots" where additional monitoring stations are highly required.

Abstract ID: 36721

Final Number: H41A-08

Title: A Critical Look at Sensitivity Analysis of Hydrologic Systems Models: A New Framework for Global Sensitivity Analysis

Presenter/First Author: Saman Razavi, University of Saskatchewan, Saskatoon, SK

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Co-authors: Hoshin Vijai Gupta, University of Arizona, Tucson, AZ

Published Material: A part of it (mainly introduction and motivation part) was presented in AGU general meeting 2014 and is in review in Water Resources Research. This abstract is the next step of our work and contains significant additional materials.

Abstract Body: Sensitivity analysis (SA) is an important paradigm for effective understanding and modelling of hydrologic systems. Example essential functions of SA include (1) Uncertainty Apportionment - attribution of total uncertainty to different uncertainty sources, (2) Assessment of Similarity - diagnostic testing and evaluation of similarities between the functioning of the model and the real system, (3) Factor and Model Reduction - identification of non-influential factors and/or insensitive components of model structure, and (4) Factor Interdependence - investigation of the nature and strength of interactions between parameters/factors, and the degree to which factors intensify, cancel, or compensate for the effects of each other. However, despite the availability of a large body of literature on the development and application of various SA approaches, two issues continue to pose major challenges: (1) Ambiguous definition of sensitivity – Different SA methods are based in different philosophies and theoretical definitions of sensitivity, and can result in different, even conflicting, assessments of the underlying sensitivities for a given problem, (2) Computational cost – The cost of carrying out SA can be large, even excessive, for high-dimensional problems and/or computationally intensive models.

In this presentation, we first revisit the fundamental basis for sensitivity analysis and critically evaluate the existing approaches so as to demonstrate their flaws and shortcomings. Then we propose a new framework for 'global' sensitivity analysis that characterizes a range of important properties of metric 'response surfaces' encountered when performing SA on hydrologic models. We show how this framework embraces, and is consistent with, a spectrum of different concepts regarding 'sensitivity', and that commonly-used SA approaches (e.g., Sobol, Morris, etc.) are actually limiting cases of our approach under specific conditions. We show, through multiple hydrologic modelling case studies, that the new framework provides a fundamental understanding of the underlying sensitivities of hydrologic models, while requiring orders of magnitude fewer model runs.

Abstract ID: 36241

Final Number: H41B-01

Title: Revealing Multi-Variate And Multi-Scale Controls Of Soil Water

Presenter/First Author: Bing Si, University of Saskatchewan, Saskatoon, SK

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Co-authors: Wei Hu, University of Saskatchewan, Saskatoon, SK, Canada; Asim Biswas, McGill University, Montreal, QC, Canada

Published Material: Part of the presentation was given at Soil Science Society of America Annual meeting in 2014 and some material was submitted to WRR.

Abstract Body: Soil water varies spatially and temporally within the landscape. The variability is controlled by a complex suite of environmental factors and processes acting in different intensities over a variety of scales. While modeling approach has made progresses in this aspect, but its application has been hindered by the lack of detailed measurement of soil hydraulic properties and biophysical properties of land surface. There is a need for developing new statistical methods for revealing this multivariate, nonstationary, potentially nonlinear variability and its dominant controls at multiple scales in the landscapes. The objective of this study is to summarize recent progresses in methodology and a few recent applications of the methods on understanding of the soil water dynamics and the underlying processes causing the variability. Soil water storage (SWS) was measured down to 1.4 m (0.2 m depth interval) at 128 regularly spaced locations along a transect over five years from the Hummocky landscape of central Canada. The locations and the scales of the most persistent spatial patterns over time and depth were quantified using the wavelet coherency. The variability in SWS spatial patterns was controlled by different factors at different scales. Scale specific dominant controls were identified after using the Hilbert-Huang transform, structural equation model and multivariate wavelet coherency. The large scale macro-topographical control and medium scale landform control were much stronger than very large scale soil textural control on SWS. The scale-specific relationship with controlling factors improved the prediction of SWS.

Abstract ID: 36537

Final Number: H41B-02

Title: Joint multifractal analysis for three variables: Characterizing the effect of topography and soil texture on soil water storage

Presenter/First Author: Asim Biswas, McGill University, Montreal, QC

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Abstract Body: Multifractal analysis describes the variability and heterogeneity in the distribution of a variable by characterizing and summarizing the variability across scales. Joint multifractal analysis has been widely employed to characterize scale relationships between two variables co-existing along a single geometric support. In this study, the joint multifractal analysis was carried out for three variables coexisting in the same geometric support in order to describe the influence of topography (relative elevation) and soil texture (sand content) on water storage within the soil profile. Soil water storage was measured down to 1.4 m depth along a transect of 576 m long from the hummocky landscape of central Saskatchewan, Canada along with sand content and relative elevation. Joint multifractal analysis was conducted considering both the strange attractor formalism and the method of moments. The variability in soil water storage, sand content and relative elevation were scale dependent. The spatial variability in relative elevation was strongly reflected on water storage across analyzed spatial scales but the joint multifractal spectrum for sand content and water storage suggested a lower degree of correlation. The change in multifractality was also observed when both relative elevation and texture varied highly. This clearly demonstrated the capability of joint multifractal analysis to completely characterize the scaling behavior among three variables.

Abstract ID: 36582

Final Number: H41B-03

Title: Spatio-temporal Change Assessment Using Normalize Difference Vegetative Index and Spectral analysis techniques for vegetation cover on Wadi Auranah

Presenter/First Author: Gohar A Mahar, Federal Urdu University of Arts, Sciences and Technology, Karachi,

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Co-authors: Nassir Al Aamri, , , ; Omar Siraj Aburizaiza, King Abdulaziz University, Jeddah, Saudi Arabia

Published Material: the article has been published in Global Nest journal in December 2014.

Abstract Body: Abstract

Wadi Auranah is one of the potential wadis located on the western shield (Hijaz escarpment) of Saudi Arabia. A spatio-temporal change assessment of the wadi was conducted with the help of landsat data. The results of the spectral analysis and NDVI for vegetation changes assessment reveals a continuous increasing trend of land cover biomass in specific parts of the wadi. Geological review by enhancing geological map and field assessment of the study area showed this trend. About 73 km^2 of vegetation land cover has been created in the last 20 years. Treated wastewater is the main source of water supply that is used for afforestation and cultivation purpose.

Abstract ID: 36437

Final Number: H41B-04

Title: Multi-scale heterogeneous movement on hillslope solute transport toward surface water

Presenter/First Author: Suzanne Edith Allaire, Organization Not Listed, Quebec,

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Published Material: Some information submitted to the Plos One journal

Abstract Body: Surface water quality is controlled at the hillslope scale through a variety of processes occurring at different scales. Modeling efforts have significantly advanced but additional real field data over entire hillslopes is needed for studying relationship between these processes in time and space. The objective of this study concerns a field description of several preferential flow and matrix flow processes at different locations in a catena using different tracers. Tracer concentration was studied over two years in all three soils of the catena, in the buffer strip and in the creek of an agricultural site. The results indicate that each scale influenced solute transport toward surface water, but the connectivity between these vertical and lateral processes was most important. The processes occurring upslope were just as important on surface water quality as those close to the creek. Bypass of the buffer strip occurred due to different preferential flow processes within the buffer strip and uphill.

Abstract ID: 34270

Final Number: H41B-05

Title: Hillslope-Scale Spatial Variability of Snowmelt Runoff via Interflow in a Minnesota Forest

Presenter/First Author: Carl P J Mitchell, University of Toronto, Toronto, ON

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Abstract Body: In humid temperate catchments with permeable surface soils underlain by confining soil horizons, lateral interflow is an important runoff mechanism, particularly during the spring snowmelt period. Numerous physical and biological factors affect the spatial variability of interflow runoff. From a hydro-biogeochemical perspective, flow path (e.g. soil contact), residence time (affecting soil-water partitioning of chemicals), and magnitude of flow (controlling how much water or solute is delivered to a particular area) are important, but spatially-variable factors controlling downstream or down-gradient biogeochemical processing. To characterize the spatial variability of interflow across a north-facing forested hillslope, three separate 10 m wide interflow collecting trenches were dug to the confining layer across an approximate 75 m wide hillslope area. Continuous measurements of runoff, and spatially distributed perched water table elevations, soil moisture, and snowmelt rates were made through the spring snowmelt period. Stable isotope-based hydrograph separation was also applied to each of the hillslope plots to assess variability in event vs. pre-event water signatures. The runoff response to a rain-on-snow event (112 mm total input) varied from 40 to 72 mm. While hydrograph shapes and inter-site runoff amounts differed considerably during the rising limb, broad characteristics such as peak flow lag times were similar (45-47 hours). Hydrograph recession analysis revealed three distinct drainage periods; an early, relatively rapid draining of nearer-surface, high conductivity soils over a period of 15-30 hours, a middle recession ranging from 45 to 110 hours that was distinctively longest at the hillslope plot where toe slope soils were comparably deepest, and a longer draining component that is too ephemeral to be characterized as baseflow. Variability in the contribution of event water across the hillslope was high during the rising limb, but relatively low (~60 ± 20%) after peak flow. Overall, this work provides a needed baseline from which the uncertainty of future impacts can be quantitatively assessed and demonstrates the likelihood that small-scale differences in soil depth, particularly at the toe slope, are important to runoff response at this scale.

Abstract ID: 36597

Final Number: H41B-06

Title: *Field scale flow processes and soil water dynamics in seasonal wetlands of the Canadian Prairies*

Presenter/First Author: Dawn Keim, University of Saskatchewan, Saskatoon, SK

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Co-authors: Melkamu Ali, University of Saskatchewan, Saskatoon, SK, Canada; Andrew M Ireson, University of Saskatchewan, Saskatoon, SK, Canada

Abstract Body: *The Canadian Prairies are characterized by hummocky terrain containing numerous depressions and wetlands with complex hydrological systems. Quantifying hydrological processes is challenging as a result of the intricate relationships between surface flow, interflow and groundwater flow. Northern hydrology is further complicated by a seasonal freezing component that can lead to large variations of near surface and surface fluxes which dominate soil water redistribution in the unsaturated zone. We couple intensive field monitoring and numerical modeling to investigate the seasonal dynamics of soil water variability and groundwater flow direction at a wetland field site in the Saskatchewan Canadian Prairies. Soil water content, matric potential and soil temperature are monitored continuously within the top three meters of the unsaturated zone along a transect located between two terminal monitoring ponds. Water levels are monitored via nested piezometers located at the center of each of the terminal ponds and along the monitoring transect. We have used field observations to develop a numerical flow model based on Richards' equation coupled with a frozen soil infiltration algorithm to simulate unsaturated-saturated flow and examine the contribution of snowmelt infiltration in the spring. The interaction of subsurface flow and terminal wetland ponds along with observed water table responses is presented. This study provides valuable insights into field scale flow processes and soil water dynamics within the Canadian Prairies unsaturated zone.*

Abstract ID: 35700

Final Number: H41C-02

Title: A new impacts-driven approach to understanding climate vulnerabilities

Presenter/First Author: Julie A Vano, University of Washington, Seattle, WA

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Abstract Body: Extreme weather events have the biggest impact on society, yet are often the climate phenomena we understand least, especially in GCMs. Even though these understandings are limited, there are opportunities from a hydrologic perspective to use past weather events to better quantify conditions (e.g. extent, duration, and intensity of precipitation, snow pack, soil moisture) that caused those events. This will help identify how the character of simulated future events, as they continue to evolve, differs from those of the past. To explore this, this research works to develop an impacts-driven method that uses the same modeling framework as past climate change studies (global climate models, hydrological models, and impact assessment tools), but reverses the typical direction of information flow: first, resource managers identify a metric of concern, e.g., flow above X cfs at a certain gauge, then hydrologic factors that lead to the metric are diagnosed, and finally connections to climate drivers are quantified. This presentation will discuss the opportunities and challenges of this new approach in the Pacific Northwest region of North America. Floods in the Skagit River in western Washington, selected after numerous meetings with stakeholders throughout the region, will be highlighted as a test case for this impacts-driven approach.

Abstract ID: 36244

Final Number: H41C-03

Title: Ecological Flows for a Large Hydroelectric Reservoir Regulated River System: Will Projected Climate Change Bring About Beneficial Opportunities?

Presenter/First Author: Daniel L Peters, Environment Canada, Victoria, BC

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Co-authors: Rajesh R Shrestha, Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC, Canada; Markus Schnorbus, University of Victoria, Victoria, BC, Canada; Wendy A Monk, Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada; Donald J Baird, Enivironment Canada @ Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The Peace River in Western Canada has been regulated since 1968 with a large dam and storage reservoir for the production of hydroelectricity. The reservoir releases feed a run-of-the-river facility, and there are plans to add two more run-of-the-river dams downstream. Previous studies have found that flows emanating from the mountain headwaters have increased by ca. 250% during the winter low flow period and peak summer flows have decreased by ca. 35% - both associated with the introduction of hydroelectric operations. Although reduced by tributary inflow, this alteration in the flow regime was transferred more than a thousand kilometers downstream to the internationally important Peace-Athabasca Delta (PAD). The PAD ecosystem is influenced by occasional ice-jam and open-water flood events that recharge lake and wetland basins with varying degrees of connectivity to the main flow system. Reservoir spillage is a rare occurrence on this reservoir system. For instance, additional reservoir flow was released in the spring of 1996 to enhance natural hydro-climatological conditions in the lower watershed, conducive to the formation of ice-jams, and associated overland flooding in the Peace Delta. The Williston Reservoir was lowered by ~3m during the summer of 1996 in response to a sink-hole in the earth dam, generating near natural summer flows on the lower Peace River that helped raise the connected lake system into contiguous wetlands. Most recently, additional flow was released from the reservoir over the summer of 2012 in response to above average snowpack/rainfall and runoff in mountain headwaters. The objective of this presentation is twofold: i) examine the hydroclimatic drivers of these atypical historical flow releases; and (ii) examine the projected impacts of climate change on the timing and quantity of water available for hydropower generation. Based on our understanding of historical flow release events and projected climate change effects on streamflow into the Williston Reservoir, the goal of this study is to develop ecologically-relevant flow release recommendations that will contribute to the maintenance/sustainability of downstream deltaic ecosystem.

Abstract ID: 33940

Final Number: H41C-04

Title: Climate-Driven Trends in the Occurrence of Major Floods in North America and Europe

Presenter/First Author: Glenn A Hodgkins, US Geological Survey, Augusta, ME

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Published Material: Status and partial results from this project have been presented on posters at past AGU and EGU meetings. The project team is currently working on revisions based on journal review. We will resubmit to that journal after updates are complete. Resubmission will likely take place prior to the May Joint Assembly.

Abstract Body: We present an intercontinental assessment of historical climate-driven trends in major-flood occurrence—floods exceeding 25, 50, and 100 year return-period thresholds—using many diverse but minimally altered catchments. It is important to understand historical changes in major floods to help inform how floods may change in the future. To date there is very limited evidence of past changes in major-flood magnitude and occurrence. Many studies have analyzed annual-maximum flood trends (which primarily represent minor floods) and they have often not differentiated between trends influenced by human catchment alterations and those caused by climatic changes. Based on our results, there is no compelling evidence for consistent changes over time in major-flood occurrence across North America and Europe. Flood occurrence based on all 1206 gauges in our study increased from 1961 to 2010 but not significantly ($p<0.05$), driven primarily by European increases; there was no change overall in the occurrence of major floods in North America. Flood occurrence based on all 322 longer-record gauges increased from 1931 to 2010 but not significantly, this time driven primarily by North American increases. There were a few significant flood-occurrence increases and decreases for subgroups of gauges for both time periods, differentiated by catchment size, type of climate, flood threshold, and period of record. Significant increases from 1931-2010 in the occurrence of 25-year floods in North America appear to be driven by a relatively low occurrence of floods in the 1930s and 1940s. Past changes in major-flood occurrence are complex and future changes are also expected to be complex. International hydrologic networks containing minimally altered catchments will play an important role in understanding these complexities for both historical and future climatic conditions.

Abstract ID: 34356

Final Number: H41C-05

Title: Hydrologic Impacts of Projected Climate in the Athabasca Watershed: Implication on Water Availability in the Region

Presenter/First Author: Yonas B Dibike, Environment Canada, Victoria, BC

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Co-authors: Hyung-Il Eum, , , ; Terry D Prowse, University of Victoria, Vancouver, BC, Canada

Abstract Body: The potential impact of projected climate change on the hydrologic regime of the Athabasca watershed in Alberta, Canada, is examined using the process based and distributed hydrologic modelling system, MIKE-SHE. High resolution climate data statistically downscaled from the latest Coupled Model Inter comparison Project phase 5 (CMIP5) global climate projections was used as climate forcings to the hydrologic model. Analysis of the multiple climate change projections derived from six GCMs, two statistical downscaling techniques and two emission scenarios, showed an overall increase in projected temperature and precipitation in the region for all seasons except the summer that has shown both increases and decreases in temperature and precipitation, depending on the specific climate model and scenario considered. The watershed's response to these climate change scenarios is also assessed by computing hydrologic indicators that represent the magnitudes and timings of the hydrologic regime from the simulated discharges, to identify possible alterations between the baseline (1971-2000) and the two future periods (2050s, and 2080s). The results show overall projected decreases in mean monthly and annual maximum snow water equivalent (SWE) over the basin, with the biggest decreases in the upper reaches; and an overall increase in the actual evapotranspiration (AET) with the highest increases in the middle and lower reaches. The results also show future increases in winter and spring flows at most hydrometric stations considered within the basin, with relatively higher increases being projected for the stations located at the upper reach. On the contrary, summer flows are projected to decrease at most of the stations because of earlier snow-melt, increased evapotranspiration and no significant increase in summer precipitation. Implications of the projected changes in the hydrologic regime on water availability in the region are also identified.

Abstract ID: 35959

Final Number: H41C-06

Title: Climate Change Impacts on Extreme Wet and Dry Events for Southern California Water Resources

Presenter/First Author: Brianna Rita Pagan, Loyola Marymount University, Los Angeles, CA

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Co-authors: Jeremy S Pal, Loyola Marymount University, Los Angeles, CA; Moetasim Ashfaq, Oak Ridge National Laboratory, Oak Ridge, TN; Donald R Kendall, Loyola Marymount University, Los Angeles, CA

Published Material: To be presented at:2015 WateReuse California Annual Conference Los Angeles, CA March 15-17, 2015America Water Resources Associaton's 2015 Spring Specialty Conference *"Water for Urban Areas: Managing Risks and Building Resiliency,"* Los Angeles, CA March 30-April 1, 2015

Abstract Body: Southern California's lack of local water supplies has caused the region to extensively rely on imported sources originating from snowpack in the Sierra Nevada and Rocky mountains. This study evaluates how climate change will impact the interannual variability of runoff primarily generated from snowpack across all imported supplies of water to Southern California including 1) the Sacramento River basin, 2) the San-Joaquin River basin, 2) the Tulare Lake basin, 3) Mono Lake and Owens Valley basin and 4) the Colorado River basin. A 10-member ensemble of coupled global climate models are dynamically downscaled forcing one regional and one hydrological model resulting in a high-resolution 4.6-km output for the region. Greenhouse gas concentrations are prescribed according to the IPCC Representative Concentration Pathway 8.5 using the present-day period of 1966-2005 and future period of 2011-2050. Projected changes in average annual runoff across all basins are minimal. However, the likelihood of experiencing above or below average annual runoff increases. Supplies of water are further constrained under extreme dry conditions. Yet extreme wet years do not necessarily equate to an increase in water supply availability as the majority of precipitation occurs in the winter months and water must be released for flood control purposes. Significant water management problems can arise as the region currently does not possess enough surface water storage facilities to capture rising quantities of runoff.

Abstract ID: 35261

Final Number: H41C-07

Title: Projecting climate change impacts on streamflow extremes using nonstationary generalized extreme value analysis

Presenter/First Author: Rajesh R Shrestha, Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC

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Co-authors: Markus Schnorbus, University of Victoria, Victoria, BC, Canada; Alex J Cannon, University of Victoria, Victoria, BC, Canada

Abstract Body: Projecting nonstationarity of the streamflow extremes is crucial for managing river flooding in a changing climate. The objective of this study is to develop a statistical modelling framework for relating climate variables (i.e., precipitation and temperature) with streamflow extremes. The non-stationarity in streamflow extremes is represented by the variable parameter Generalized Extreme Value (GEV) distribution, with the Conditional Density Network (CDN) model used to evaluate the GEV parameters as a function of seasonal precipitation and temperature. The model was set up using an ensemble of 23 CMIP3 climate models derived precipitation and temperature, and simulated annual maximum streamflow from the Variable Infiltration Capacity (VIC) hydrologic model for the Fraser River Basin, Canada. Based on the model setup for the CMIP3 generation of GCMs, the CMIP5 precipitation and temperature will be used to derive the GEV distribution of annual maximum streamflow under CMIP5 climate change scenarios. Preliminary results indicate the flexibility of the GEV-CDN model to describe the non-stationarity of streamflow extremes. Future changes in streamflow extremes indicate increasing magnitude for a given return period. Such changes in the return periods could have major implications on flood risk, such as adequacy of the existing dikes in the lower Fraser region to offer long-term flood protection.

Abstract ID: 36790

Final Number: H42A-02

Title: A Novel Method for Extraction and Characterization of Porewater Chemistry in Low-Permeability Sedimentary Rocks

Presenter: Tom Anthony Al, University of New Brunswick, Fredericton, NB

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First Author Student?: Yes

Co-authors: Ian Douglas Clark, University of Ottawa, Ottawa, ON, Canada

Published Material: The method has been published in Applied Geochemistry. Some of the results will be presented at the 2015 Clay Conference.

Abstract Body: Measurements of spatial variability of naturally-occurring tracers in porewater from low-permeability rocks can provide insight into porewater residence time and the nature of solute transport. These system characteristics are required to assess the long-term stability of geologic systems for waste management. However, the measurement of porewater chemistry in low-permeability rocks is challenging because of small fluid volumes and the difficulty of extracting representative samples. Several techniques for porewater characterization are available, but the results they provide can be affected by ion exchange and mineral dissolution.

The objectives of this work are to develop and test a method of extracting representative samples of *in-situ* porewater from low-permeability rocks, and to accurately quantify solute concentrations in the extracted porewater. The method involves extraction of porewater by absorption into hydrophilic cellulosic membranes. *In-situ* porewater solute concentrations are obtained by normalizing solute mass, quantified by inductively coupled plasma - mass spectrometry (ICP-MS), to water mass, quantified by near infrared (NIR) spectrometry. Laboratory experiments confirm that the method is capable of providing porewater solute concentrations with precision and accuracy that are within the limits suggested by USEPA Method 6020A for analysis of saline water samples by ICP-MS.

A detailed description of the absorption method will be provided, followed by the results of porewater extractions from two field trials. The first trial was conducted on samples of low-permeability ($K < 10^{-12}$ m/s, porosity < 10 %) shale drill cores from the Michigan Basin in Kincardine. The second trial will examine porewater extracts from Opalinus Clay ($K < 10^{-12}$ m/s, porosity < 22 %) obtained from a deep borehole at the Mont Terri Laboratory, Switzerland. Concentrations of major ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Sr^{2+}, Cl^-, Br^-) will be quantified and compared to results from other methods.

Abstract ID: 36801

Final Number: H42A-03

Title: Transient electromagnetic investigations in the Ahmedabad region,central Cambay basin, Gujara, INDIA

Presenter/First Author: Yashavant Singh, Institute of Seismological Research, Gandhinagar,

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Abstract Body: We present the preliminary results of a time domain electromagnetic (TDEM) surveycarried out in the Bhavla region of the Ahmadabad district located in the central part of the Cambay basin to delineate shallow subsurface resistivity image of the region. Fixed in-loop TDEM soundings were made at 15 selected locations along N-S and E-Wlineswith 100 m sided transmitter loop. For each loop, the transmitter is operated for a sequence of data repetition frequencies ranging from 32 Hz to 1 Hz. Rate of change of secondary magnetic field produced due to the induced eddy current in the subsurface has been measured at every TDEM sounding site using a receiver coil. The data were processed to get apparent resistivity as a function of decay time.The subsurface electrical resistivity image obtained by combining the results of 1-D smooth inversion for 15 locations along a 10 km long N-S line indicates ingeneral at three-layered structure upto 160m. A 20-30m thick conductive channel of resistivity ~10 Ω.mat a depth of 20-25m, interpreted as saturated/unconsolidated rock, is overlain on another saturated rock (with possible content of sulfides, clay etc.) of comparably low resistivity. A fractured resistivity zone (20-25Ω.m) at a depth of 20m extending to entire depth section is observed at the north central part of the line. The results could be integrated with hydrogeophysical information for further characterization of the aquifer and the fractured zones observed in region.

Abstract ID: 35953

Final Number: H42A-04

Title: Spatiotemporal variability of heavy metals contamination of surface water: a case study in the Cordillera Blanca, Peru

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Abstract Body: The Rio Santa, Peru, drains the western slopes of the glacierized Cordillera Blanca and provides water resources at almost all levels of the watershed. As it flows away from the valleys of the Cordillera Blanca, the Rio Santa takes out pollution from numerous sources, including acid mine drainage and natural sulfide oxidation by-products. The Rio Santa dry season discharge decline that is projected to be a consequence of glaciers retreat will probably have implications for the evolution of water pollution. This threat makes the characterization of the actual contamination mechanisms of primary importance.

The present study focuses on the spatiotemporal variability of the heavy metal contamination across the entire Rio Santa Watershed. During the summer 2013, 36 points of the Rio Santa watershed were sampled for filtered water, suspended sediments and riverbed sediments and analyzed for heavy metals. In addition, 30 water samples were taken from a point next to the city of Huaraz at a frequency of once every 2 weeks and analyzed for trace metals. Results show clear spatial and temporal variability in metal concentrations in water and sediments. Elements like iron exhibit an increase in concentration in the liquid phase during the wet season when others like zinc or manganese show the opposite behavior. During the dry season, water in tributaries in the upper part of the watershed is contaminated with arsenic, zinc and aluminium. In that area, concentrations up to 360 ppb of arsenic were measured in tributaries situated downstream of mines while The Rio Santa water showed a decreasing concentration of 15 ppb to less than 6 ppb from south to north. This reduction in liquid phase concentration being simultaneous to an increase concentration in river sediments suggests that, during the dry season, a large part of the arsenic that reaches the Santa in an aqueous phase does not make it to the outlet but remains trapped in the riverbed.

Abstract ID: 36125

Final Number: H42A-05

Title: Water coverage and quality fluctuations of the Aral Lake tributary reservoir in Kazakhstan

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Abstract Body: Koksaray reservoir is one of the tributary reservoirs located on the Sur Darya River upstream of the Aral Lake in Kazakhstan. Sur Darya River has big seasonal fluctuations with a high amount of water release and flooding in the yearly spring and extreme shallow levels during the summer. Water coverage and quality fluctuations were studied over Koksaray by applying a combination of the Earth Observation Satellites (EOS) and field works in 2010-2014 years. High resolution German satellite RapidEye, Russians Recourse P and Meteor M satellite data were applied for this study. The water coverage fluctuations changes were traced from 457 to 44 km^2, or 10 times difference. Water pollution areas were also traced during these years. The future research work is planned with the data applications from EOS KazEOSat-1 and -2. The KazEOSat-1 is a high-resolution observation satellite, which was built by Astrium for the Space Company Garysh Sapary of the Republic of Kazakhstan. KazEOSat-1 satellite was launched in the first quarter of 2014 (KazEOSat-1 on 30 April 2014 and KazEOSat-2 is planned to be launched on 20 June 2015). KazEOSat-1 satellite provides high-quality panchromatic, 1 m, and four multispectral channels, 4 m, for a wide range of applications. KazEOSat-2 satellite provides medium-quality five multispectral channels, 6.5 m, for a wide range of applications. The current stage of the satellite's data applications for geomorphological research work is also to be discussed.

Abstract ID: 36435

Final Number: H42A-06

Title: Hydro-chemical studies of the Schuchinsk-Borovoye natural reserve, Kazakhstan

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Abstract Body: Schuchinsk-Borovoye natural reserve is one of the most popular resort area and national park in North-East Kazakhstan. Flora and fauna is has been impacted from the increasing numbers of tourists in the park in the last decade. Lakes are under anthropogenic pressure with increasing pollution and deterioration of aquatic ecosystems. Over the past 35 years, the water level of lakes of Burabay resort area has decreased to 1.5-2 meters. The new islands have appeared on lakes Shchuchye and Ainakol. The water receded from the shore in some places up to 100 meters. These reservoirs are still not subjected to the proper support as the national park zones, as recommended by the UNESCO Biosphere Reserve Sustainable Development (http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/asia-and-the-pacific/kazakhstan/). We have studied surface and groundwater of the catchment area and the hydro-chemical changes in Lake Schuchye of the Shuchinsk-Burabaynatural reserve (SCHBKZ) over the past five years on the basis of an accredited chemical laboratory for the lakes environmental monitoring. The organic, oil pollution, and non-organic, heavy metal (Cи, Zn, Hg, Cd, Pb, Sn, Fe, Mn, Ag, CrCo, Ni, As, Al) and their salts were analyzed. The maximum permissible concentrations of petroleum products for the spring of the year 2009-2013 has exceeded by 4.6 time. Results of the Hydro-chemical studies of the Schuchinsk-Borovoye natural reserve will be presented during the conference. The future research work is planned with the data applications from EOS KazEOSat-1 and -2. The KazEOSat-1 is a high-resolution observation satellite, which was built by Astrium for the Space Company GaryshSapary of the Republic of Kazakhstan. KazEOSat-1 satellite was launched in the first quarter of 2014 (KazEOSat-1 on 30 April 2014 and KazEOSat-2 is planned to be launched on 20 June 2015). KazEOSat-1 satellite provides high-quality panchromatic, 1 m, and four multispectral channels, 4 m, for a wide range of applications. KazEOSat-2 satellite provides medium-quality five multispectral channels, 6.5 m, for a wide range of applications. The current stage of the satellite's data applications for the Schuchinsk-Borovoye natural reserve also will be discussed.

Abstract ID: 35156

Final Number: H42A-07

Title: The Influence of Glacial Landforms on Subsurface and Surface Hydrology and Chemistry Across a Heterogeneous Boreal Plain Landscape

Presenter/First Author: Kelly J Hokanson, University of Alberta, Edmonton,

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Abstract Body: The Boreal Plains (BP) region of Canada is experiencing high levels of anthropogenic activity and is highly susceptible to climate change. The BP is characterized by heterogeneous glacial landforms with large contrasts in storage and transmissivity, which when coupled with a sub-humid climate, results in complex groundwater-surface water interactions. Predicting the impacts of land use change, climate change, and the future performance of constructed landscapes is currently not possible due to our limited knowledge regarding the natural variability of water table fluctuations, geochemistry, and salinity across the various glacial landforms in the BP. In this study, we test the influences of the interactions between landform, geology, and climate on local and regional groundwater flow, recharge, and storage as well as address the variation in landscape connectivity and overall salinity distribution. We have collected hydrogeological, geochemical, and isotopic data that spans from 1998 to present, which includes both wet and dry climate cycles. Data were collected from surface waters to a depth of 40m, along a 50 km transect encompassing pond-wetland-forestland sequences across the major glacial depositional types typical of the BP (coarse textured glaciofluvial outwash, fine textured stagnant ice moraine, and lacustrine clay plain). Within each landform, sites range from isolated headwater complexes to large regional discharge complexes. High spatial variability of water table fluctuations and salinity illustrate the strong regional controls that geology exerts over scales of groundwater flow between landforms and surface water bodies across the BP. Fifteen years of isotopic data delineate 'isotopic landscapes' with characteristic water storage and transmission properties.

Abstract ID: 36633

Final Number: H42A-08

Title: Regional nutrient export modeling of the South Saskatchewan River catchment using SPARROW

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Abstract Body: The South Saskatchewan River (SSKR) and the North Saskatchewan River forms the largest river system in western Canada. The SSKR catchment extension facilitates a variety of climates, topographies, soil types and land uses that form a highly heterogeneous environment. In the last years changes in the land use and new industrial developments in the South Saskatchewan River area have brought serious concerns about the future of water quality in the catchment and downstream waters. Agricultural activities have increased the supply of manure and fertilizer for cropping. Oil and gas exploitation has also increased the risk of surface water and groundwater contamination. The rapid population growth not only leads to increments in water consumption and wastewater, but in the construction of roads, railways and the expansion of new urban developments that impose hydraulics controls that affect the catchment hydrology and therefore the sediment and nutrient transport. Consequences of the actual anthropogenic changes have impacted Lake Diefenbaker aquatic ecosystem, where around 1229 tons yr^{-1} of nutrient are sequestrated. Although environmental agencies are constantly improving the mechanisms to reduce nutrient export into the river and ensure safe water quality standards, further research is needed in order to identify major nutrient sources and quantify nutrient export and also, with the aim of improve water quality sampling programs. The SPAtially Referenced Regression On Watershed (SPARROW) model is therefore implemented to assess water quality regionally, in order to describe spatial and temporal patterns to identify those factors and processes that affect water quality. The model is a suitable method to interpret monitoring data sets that suffer from network sparseness, bias and basin heterogeneity. Ultimately, the model will provide environmental agencies improved information for future water quality management practices and policies.

Abstract ID: 33851

Final Number: H42B-01

Title: Water Resource Futures Under Climate Change - Framing Uncertainty Within the Context of Vulnerability to Identify Risk

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Published Material: Mention can be found in the following three publications: (1) Nazemi, A. and H. S. Wheater (2014), Assessing the vulnerability of water supply to changing streamflow conditions, *Eos Transactions of American Geophysical Union,* 95(32), 288, doi: 10.1002/2014EOS320007. *(2)* Nazemi, A. and H. S. Wheater (2014), How can the uncertainty in the natural inflow regime propagate into the assessment of water resource systems? *Advances in Water Resources*, 63, 131-142, doi: 10.1016/j.advwatres.2013.11.009. (3) Nazemi, A., H. S. Wheater, K. P. Chun, and A. Elshorbagy (2013), A stochastic reconstruction framework for analysis of water resource system vulnerability to climate-induced changes in river flow regime, *Water Resources Research*, 49, doi:10.1029/2012WR012755.

Abstract Body: Estimation of potential impacts of climate change on water resources is of high societal importance, but conventional scenario-based estimation is subject to a cascade of models, each with high uncertainty. Uncertain socio-economic scenarios are used to drive uncertain global climate models, which are then downscaled to provide uncertain climate outputs at the scales of relevance for uncertain hydrological models, which can then be input to uncertain water resource systems models. Communication of the resulting overall uncertainty to water managers and other stakeholders is challenging; it is not unusual for not only the magnitude but also the sign of change in future resources to be uncertain. We present an alternative, and complementary, approach to the communication of risk. Analysis of the vulnerability of water resource systems to potential change is illustrated for a relatively complex, fully allocated water resource system in Alberta, Canada. Using a simple two-dimensional representation of potential changes in hydrology, water resource system vulnerability can be mapped onto a two-dimensional space, which clearly illustrates potential scenarios of concern. Conventional scenario-based estimates can be superimposed on the vulnerability map, to provide important insight into potential areas of future risk of system failure.

Abstract ID: 36491

Final Number: H42B-02

Title: Suppressed Convective Rainfall by Agricultural Expansion in southeastern Burkina Faso

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Abstract Body: With the 'green economy' being promoted as a path to sustainable development and food security within the African continent, the conversion to agricultural land is proliferating at a rapid pace often replacing natural savannah forests. Where agriculture is primarily rain-fed, the possible adverse impacts of agricultural land influx on rainfall occurrences in water- limited areas such as West Africa are investigated. . Using field observations complemented by model calculations in southeastern Burkina Faso, the observation of a 10-30% suppressed rainfall recorded over agricultural fields when referenced to natural savannah forests are explained. Measurements and simulations reveal that the crossing of the mixed layer height and lifting condensation levels, a necessary condition for cloud formation and subsequent rainfall occurrence, was 30% more frequent above the natural savannah forest. This increase in crossing statistics was primarily explained by a larger sensible heat flux above the savannah forest rather than differences in lifting condensation heights.

Abstract ID: 33914

Final Number: H42B-04

Title: Examining why trends in extreme precipitation should not be mistaken for trends in extreme discharge

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Abstract Body: It is firmly established in the hydrologic literature that flooding is dependent on both antecedent moisture and precipitation. One could possibly phrase this relationship even more directly as "heavy precipitation does not necessarily lead to high stream discharge", but studies are rarely formulated in such a way as to directly affirm this statement. However, we have observed a number of non-hydrologists mistake trends in heavy precipitation as a proxy for trends in flooding. If indeed the relationship between heavy precipitation and high discharge (or lack thereof) was more often explicitly presented, heavy precipitation would possibly be less often misinterpreted as a direct proxy for discharge. We undertake such an analysis by directly evaluating the frequency in which 99th percentile precipitation events result in 99th percentile discharge events for 300 watersheds spread across the contiguous U.S. We found that 99th percentile precipitation only results in 99th percentage discharge 30% of the time. However - not unexpectedly - when conditioned on soil moisture, 99th percentile precipitation results in 99th percentage discharge 51% of the time during wet periods and 8% of the time during dry periods. This study suggests that especially when one is interested in relating trends in heavy precipitation to hydrologic response, precipitation data should be segregated based on concurrent soil moisture. Taking such an approach for future climate predictions, we found that CMIP-5 GCM projections forecast an increase in concurrence of greater than median soil wetness and extreme precipitation in the northern half of the United States and a decrease in the southern half. This suggests that northern regions may see an increase in very high discharges while southern regions may see a decrease despite both regions having predicted increases in extreme precipitation.

Abstract ID: 34351

Final Number: H42B-05

Title: Novel Supervised Nonlinear Dimensionality Reduction Techniques for Improvement of Statistical Downscaling Processes

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Abstract Body: Statistical downscaling approaches relying on developing a statistical and quantitative relationship between large-scale atmospheric variables and fine scale hydro-climate variables at particular sites have gained popularity for predicting climate change impacts on hydro-climate variables. Due to the complexity of climate-associated processes, one of the main challenges in development of the statistical downscaling approaches for climate change projection is identification of predictor variables from high dimensional atmospheric variables conveying climate change information with respect to the hydro-climate variable of interest. Due to the inherent complexity, nonlinearity, and interdependency among explanatory large-scale atmospheric parameters, using conventional unsupervised linear dimensionality reduction methods leads to unsatisfactory predictive performance of data-driven models in statistical downscaling. To improve the performance of the machine learning-based models, the present paper proposes a new approach to supervised dimensionality reduction, which is called "Supervised Principal Component Analysis (Supervised PCA)" for regression-based statistical downscaling with high-dimensional input data. This method is a generalization of PCA, extracting the principal components of atmospheric variables along which the dependency between target hydro-climate variable and projectors is maximized. Moreover, a dual formulation is derived for supervised PCA, which significantly reduces the high computational complexity of iterative optimization procedures. To capture the nonlinear variability between hydro-climatic response variables and projectors, a kernelized version of supervised PCA is also proposed for nonlinear dimensionality reduction. The effectiveness of the proposed supervised PCA method in comparison with some state-of-the-art algorithms for dimensionality reduction is evaluated for precipitation under a statistical downscaling process using two soft computing nonlinear machine learning methods, Support Vector Regression (SVR) and Relevance Vector Machine (RVM). The results indicate a significant improvement over supervised PCA methods in terms of performance and computational efficiency.

Abstract ID: 36439

Final Number: H42C-01

Title: Subsurface hydrological processes and surface irrigation management

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Abstract Body: Increasing world food demand will result in a higher proportion of agricultural production surfaces to be irrigated. With an increasing risk of water scarcity, irrigation water use efficiency need to be continuously improved. Subsurface hydrological processes and pedological features influencing them (drainage, leaching, presence of a compacted layer, root development) act at different spatial scales and are generally neglected in managing irrigation at the whole field scale, in absence of adequate identification and quantification of their influence. Real time GPS equipped monitoring tools now allow us to identify the effect of capillary rise, compacted zones or differential crop water uptake on the surface water potential and the consequent irrigation needs acting at different spatial scales. Ongoing research taken from surface and subsurface irrigated crops (lettuce and cranberry) indicates that important water savings (30 to 80%) and gain in water and crop productivity (50%) can be achieved by implementing procedures that take into account subsurface processes in managing surface irrigation of crops. Given these results, long-term efforts should be put to implement such approaches at the farm scale.

Abstract ID: 36591

Final Number: H42C-02

Title: Characterization of Field-Scale Water Balance Components at A Heterogeneous Prairie Field Site

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Abstract Body: Understanding hydrological processes at different scales is essential for hydrological modeling, particularly in heterogeneous environments, such as the internally drained prairie basins, with high spatial variability in the snowpack and soil properties. A soil-weather monitoring system was installed at a pasture site in the Brightwater Creek sub-basin, near Saskatoon, Saskatchewan, Canada, to characterize field-scale water balance components during two continuous years with contrasting weather. In addition to traditional meteorological measurements, intensive transect surveys of snowpack, vadose zone soil water content and groundwater were conducted within the footprint of a flux tower (around 500 m). Through quantifying the field-scale water balance, some interesting results were found. During the snow accumulation period, snow redistribution happened at sub-field-scale and over-field-scale due to overcatch of patterned vegetation compared to surrounding stubble field. During the melt period, snowmelt and rainfall leads to surprisingly high infiltration into the vadose zone of glacial till. The features of spatiotemporal storage dynamics indicate existence of unique flow paths at the study site. These would of great interests for prairie hydrological modeling.

Abstract ID: 34374

Final Number: H42C-03

Title: Scale-classification of water table response in a low-gradient Prairie watershed

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Abstract Body: While shallow subsurface stormflow has been found a major contributor to runoff generation in many temperate, moderate to high-relief catchments, its importance in low-gradient environments remains unclear. Our objective was therefore to characterize the water table-runoff relationship in low-gradient, Canadian Prairie landscapes by (1) deriving a range of metrics of water table response, and (2) inferring the presence of various runoff processes from those metrics. The focus was on the Catfish Creek Watershed (Manitoba, Canada), which drains 642 km^2 of forest and agricultural land. Nine different riparian areas were selected to illustrate a range of land use conditions (e.g., forest, shrub or bare land cover), upslope accumulated areas and human landscape features (e.g., dykes). Each riparian area was equipped with three, 1.5 m deep water-table wells and paired with a stilling well in the adjacent stream, recording data every 15 minutes in 2013 and 2014. For each site, hydrological events were delineated and the stream response compared with the water table response. Specifically, several metrics of event-scale water table response were computed, notably the pre-event water table depth, the maximum water table rise, the rates of water table rise and recession, the time lag from the initiation of precipitation to the maximum well response, and an hysteresis index quantifying the delay in response between the water table and the stream. Preliminary analyses show that the metrics were highly variable among sites. The metrics also suggest different event conditions leading to either saturation-excess overland flow, local subsurface flow or more widespread translatory flow as the dominant runoff process in the riparian areas. Some of the metrics portraying hysteresis or recession characteristics were markedly different between short and longer events, thus reflecting a scale-dependence effect on soil hydrology.

Abstract ID: 36316

Final Number: H42C-04

Title: Recent Advances in Monitoring of the Unfrozen Soil Water in the Source Area of the Yellow River, China

Presenter/First Author: Dongliang Luo, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou,

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Abstract Body: Recent permafrost degradation in the Source Area of the Yellow River (SAYR) is obviously manifested by reduction in areal extent from continuous and discontinuous to sporadic and patchy, thinning of permafrost, and expansion of taliks. On this account, substantial transformation of surface and subsurface hydrological cycles have occurred. Therefore, the water yielding and runoff mechanism caused by ground ice-water phase change in permafrost is needed to be clarified. To investigate the trends in changes of climate, permafrost, and water resources in the SAYR, we built a monitoring network of permafrost-hydrology in the SAYR. This monitoring network includes three automatic meteorological stations, and ten active layer profiles. It is set up in consideration of elevation, landscape, and hydrology and vegetation conditions. The elevation of these sites range from 4320 m to 4720 m. The monitoring elements including the air temperature, air humidity, precipitation, radiation, and unfrozen soil moisture content, and soil temperature, and so on. Sensors with accuracy of 0.05 °C made and calibrated by the State Key Laboratory of Frozen Soil Engineering, Chinese Academy of Sciences, were set up to monitor the thermal regimes of the active layer at depths of 5 cm, 20 cm, 40 (50) cm, 80 cm, 100 cm, 120 cm, 160 cm, 200 cm, 250 cm, respectively. The CS616, with resolution of 0.1% v/v and accuracy of 3.0% v/v, were set up at comparable depths of soil temperature to monitor the unfrozen soil moisture content. All these observation elements were collected and recorded hourly or half-hourly by the CR3000 data loggers made by the Campell Scientific Inc. Additional field work including testing soil texture and measuring soil dry bulk density were carried out during the excavation of the profiles. Preliminary results demonstrate that yearly dynamics of unfrozen soil moisture content in the active layer strongly depending on the freezing and thawing processes of the soils, as well as infiltration of rainfalls and melting snow, particularly during the onset and finishing of the thawing and freezing periods. The content of soil moisture varied greatly with the diversity of ground surface condition and soil textures. These data could facilitate the research on evolutions of environments and response of permafrost to climate change in the SAYR.

Abstract ID: 33769

Final Number: H42C-05

Title: Groundwater Flow System in a Permafrost Area in the Upper Reaches of Heihe River

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Abstract Body: Heihe River is the second largest inland river in China, and the permafrost zone in the upper reaches is a main water flow producing region for Heihe River. However, few hydrogeological investigations were conducted and understanding about groundwater flow system in the source areas of major rivers reminds almost blank. This study aims to characterize the groundwater flow system in a typical permafrost zone at Hulugou catchment in the upper reaches of Heihe basin. A hydrogeological approach was used based on the integration of hydrogeological survey, field drilling, groundwater level and temperature data monitoring. In the summer of 2014, 21 boreholes were drilled at four sites, separately located at seasonally frozen zone and permafrost zone. At each site, 5 to 7 boreholes with different depth were drilled and the deepest one was as deep as 30m. Taking this method of drilling is to monitor subsurface ground temperature and take groundwater samples at different depth. Data shows that seasonally freezing zone mainly distributed in the piedmont plain of the catchment, where the altitude is below 3,400 meters above sea level. From June to October, groundwater flow system is mainly affected by the porosity and permeability of sediment layers at this area. Water within 2 meters below ground surface has become frozen in the winter and functioned as impermeable layer for infiltration recharge. Permafrost is mainly distributed in the mountainous area above 3,400 m above sea level. The temperature-log data shows that the depth between 2m and 17m below the surface is freezing layer and the depth between 0m to 2m is active layer, which leads to a weak hydraulic relationship between supra- and sub- permafrost water. The supra-permafrost water table in active layer is near ground surface in summer. During and after the precipitation events, the water table increases and reaches to the ground surface, and is likely to produce surface runoff. Unfrozen layer under the base of permafrost is with low soil moisture. More hydrogeochemical and isotopic data has been collected to further identify the origin of the sub-permafrost water, and groundwater and surface water interaction. The seasonal freezing and thawing process has significant impacts on groundwater flow and its contribution to Heihe River.

Abstract ID: 36572

Final Number: H42C-06

Title: Modeling the Impacts of Soil, Vegetation and Climate on Evapotranspiration and Groundwater Recharge during 2001-2010 on the Chinese Loess Plateau

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Abstract Body: Knowledge of spatio-temporal soil water balance over the Chinese Loess Plateau (CLP) is crucial to optimizing land uses for sustainable development. Daily evapotranspiration (ET) and groundwater recharge (GR) at 58 sites on the CLP during 1981-2010 was simulated using the HYDRUS-1D model. The impacts of soil, climate, and vegetation on annual ET and GR during 2001-2010 were explored. Both the annual ET and GR generally decreased from the southeast to the northwest, with annual ET ranging from 14.3 cm (105% of precipitation (P)) to 59.5 cm (82% of P) and annual GR from 0.0 cm to 14.3 cm (18% of P), respectively. The average simulated annual ET and GR were 39.0 cm and 2.4 cm over the CLP, contributing to 95.6% and 4.7% of annual P, respectively. Annual evaporation (E) was twice greater than annual transpiration (T) due to the sparse vegetation in most areas of the CLP. Spatial distribution of ET was dominated by P followed by leaf area index (LAI) and potential evapotranspiration (ETp). Specifically, LAI played an equivalent control on T as P did. Groundwater recharge was also dominated by P, while it was not affected by the ETp and LAI at the region scale. Soil hydraulic properties also influenced the distribution of ET and GR, but their effects were much smaller compared to the climatic forcings. This work highlights the dominance of P on water flux at the regional scale on the CLP, providing a basis for eco-restoration and groundwater use scheduling.

Abstract ID: 36469

Final Number: H42C-07

Title: Abundance of earthworm species is influenced by the proximity to the tile drainage

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Abstract Body: Earthworm burrowing affects water movement and nutrient transport in soil layers to a depth of more than 1 m, which is where subsurface tile drains are found. Subsurface tile drainage changes the soil moisture regime and is expected to alter the abundance as well as the composition of earthworm populations. The impact of tile drainage on earthworms will depend on soil properties, land use (cropping systems) and management. The objective of this study was to evaluate how earthworm abundance and composition was affected by the presence of subsurface tile drainage, and how the relationship was modulated by soil type and cropping systems at two farms in Southern Quebec. The spatial distribution of earthworms was considered in two 3m triangles located on top and between tile drain lines, which were the sampling points for earthworm collection by formalin extraction and hand sorting. We expect that earthworm species will respond differently to the presence of tile drain lines and anticipate an increase in earthworm populations above the tile drain lines, particularly of anecic species. The modulating effect of soil and land use on earthworm abundance and distribution gives us the opportunity to explain the spatial distribution pattern of earthworm species in this context. Knowledge about the number and distribution of earthworm species in relationship to tile drain lines permits us to draw conclusions about the potential contribution of earthworms to soil

porosity and solute movement in tile-drained fields, which could be important to avoid nutrient loss from agroecosystems with tile drainage.

Abstract ID: 33530

Final Number: H43A-01

Title: Quantifying the Impacts of 23-years of Warming and Drying Trends on Peatland/Upland Succession in Central Alberta

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Abstract Body: In this study we compare peatland ecosystem resilience (stability following climatic perturbations) using an index of evapotranspiration (ET) (EI) (actual ET/ precipitation) vs. dryness index (DI) (potential ET / precipitation)) and water yield within six heterogeneous upland/lowland catchments in the increasingly arid Central Boreal Plains (CBP) region of north-central Alberta from 1986-2009. The impacts of increased atmospheric drying over time within energy limited (DI < 1) and water limited (DI > 1) ecosystems and their resilience (or elasticity) is quantified using time series slope and residual analysis of the Normalize Difference Vegetation Index (NDVI) from Landsat TM combined with SRTM (Shuttle Radar) topographic positioning. This allows us to determine if ecosystems are experiencing long-term browning (declining NDVI trends), greening (increasing NDVI trends), resilience (recovery) or threshold (tipping point) change in boreal regions where NDVI is used as a spatio-temporal proxy indicator of ecosystem trajectory following annual atmospheric drying and catchment runoff. We find that catchments with low (detrended) topographic variability containing mostly peatland land cover types are highly resilient due to abundant water supply. Despite their resiliency, these catchments are characterised by declining water yield over the period of study and increased greening via succession of woody shrub and tree biomass into ~76% of peatlands. This indicates rapid loss and conversion to riparian/forest land cover types as peatlands dry. Meanwhile, catchments containing greater topographic variability have experienced increased water yields and declining NDVI trends during the same period. These catchments are typically water limited, highly sensitive to atmospheric warming and as such, have experienced significant browning (loss of chlorophyll, leaf cover) within 74% of upland treed and shrub peatlands with lagged recovery. A likely explanation for increased catchment yield coincident with reduced green foliage cover is a reduction in ET losses from upland land covers. The results of this study indicate that wide-spread browning trends observed in parts of the central boreal forest are complicated by energy-/water-limited systems, spatio-temporal lags and underlying geology.

Abstract ID: 34170

Final Number: H43A-02

Title: Hydroclimatic Controls on Peatland CO_2 Exchange Following Adjacent Forest Harvesting on the Western Boreal Plain

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Abstract Body: The Boreal forest of the Western Boreal Plains (WBP) is experiencing extensive land use changes from industrial expansion and deforestation. Potential alterations to surrounding hydrology and microclimate as a result of upland forest harvesting may threaten the ecosystem function of hydrologically connected-peatlands that are ubiquitous across the region, including the sequestration of greenhouse gases i.e. carbon dioxide (CO_2). Predicting the potential impact of deforestation on adjacent peatland CO_2 source/sink functionality requires comparison of peatland hydrology, microclimate and carbon exchange dynamics following tree removal relative to undisturbed ecosystems under natural climate variability. As such, the objectives of this study were to investigate: (1) Net Ecosystem Exchange (NEE) (i.e. CO_2) of undisturbed peatlands during the snow-free period; (2) the relative impact of upland forest harvesting on adjacent peatland NEE, including the hydrologic and microclimatological controls on this exchange; and (3) estimate the sustainability of WBP peatlands' functionality as a CO_2 source/sink in context of periodic land use disturbances. Growing season peatland CO_2 exchange was modelled in two neighbouring forest upland-peatland complexes over a four-year period (2005-2008) in the Utikuma Region Study Area of Alberta within the WBP. The forested upland area of one complex was harvested between 2007 and 2008, and the adjacent peatland was evaluated for potential shifts in NEE relative to the peatland in the undisturbed complex. These results, linked to changes in peatland hydrology (e.g. water table, soil moisture) and microclimate (e.g. wind speed, vapour pressure deficit, evaporation), as well as the implications for future forest harvesting in the region will be discussed.

Abstract ID: 34219

Final Number: H43A-03

Title: Trembling Aspen (*Populus tremuloides*) Transpiration and Recovery Post-fire Disturbance in the Western Boreal Plains of Alberta

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Abstract Body: The Western Boreal Plains of Canada (WBP) is characterized by a sub-humid climate where evapotranspiration often exceeds precipitation, highlighting the importance of the interactions between peatlands that hydrologically feed uplands. The connectivity between both land units can also be attributed to trembling aspen (*Populus tremuloides*) clones and rooting systems that aid in hydraulic redistribution, though this process has not been linked to aspen roots found in peatlands. The objectives of this study are: 1) to understand why aspen, an upland tree species, exist in peatlands post-fire, and 2) to determine the contribution of aspen roots in peatlands to the early recovery of burned sites in the WBP. Aspen leaf stomatal conductance was measured daily across a burned upland-peatland gradient in the Utikuma Research Study Area (URSA) in north central Alberta two years post-fire. Aspen transpiration (mm s^{-1}) in peatlands was particularly of interest since they are not known to establish in peat after disturbance. In the same plots, plant tissue and soil was also collected and analyzed for 18-oxygen ($\delta^{18}O$) and deuterium (δ^2H) composition to determine the water source for regenerating aspen. While usually stressed in waterlogged soils, the results showed that aspen transpiration did not significantly differ across each land unit regardless of differences in leaf area and soil moisture. Furthermore, $\delta^{18}O$/ δ^2H signatures of pore water and plant tissue of aspen found in peatlands indicate the uptake of peat water through aspen rooting systems and hydraulic redistribution to the adjacent land units. Although the long-term effect of aspen transpiration and water usage in peatlands remains unknown, this study demonstrates that aspen can

withstand wetland soils which aids in the hydrologic connectivity between peatlands and uplands needed during the early recovery of naturally and anthropogenically disturbed sites.

Abstract ID: 36041

Final Number: H43A-05

Title: Assessment of the evaporation rates of pools, strings and lawns of a boreal patterned fen

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Abstract Body: In northern landscapes, the hydrological budget is largely influenced by evaporation (*E*), particularly in boreal watersheds where peatland is a predominant land cover. To improve the hydrological modelling of boreal watersheds, a better estimation of this term is required. The summer *E* variability of pools, strings and lawns of a patterned fen (3.6 ha) was assessed using 26 small lysimeters. To investigate the impact of water table depth on *E*, direct (weighing lysimeters) and indirect (automated lysimeter) methods were used during the snow-free period (June to October). Results indicated that *E* rates from pools, strings and lawns did not vary significantly throughout the fen. At the peatland scale, atmospheric conditions seemed to govern *E* more than the type of land cover. These results suggest that discriminating each land cover in the *E* budgets is not required and a mean value may be sufficient. A significant impact of water table depth on *E* was observed in *Sphagnum* lawn. Indeed, a rapid decline in *E* was monitored in the first 100 mm of peat. This decline was in all likelihood due to limited upward fluxes of water from saturated layers, which was limited by the low unsaturated hydraulic conductivity of the peat layers. The monitored *E* was consistent with previous values and a depth-dependent *E* relationship could be used in future hydrological modelling. The findings of this field work further validated the use of the classical Priestley-Taylor equation for patterned fens and demonstrated the potential of using an automated lysimeter in remote locations.

Abstract ID: 36601

Final Number: H43A-06

Title: The Transport and Hydrological Response of Simulated Wastewater from a Continuous Point Source in a Northern Ribbed Fen

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Abstract Body: To minimize the discharge of wastewater contaminants from remote northern communities and mining operations, fen peatlands in sub-arctic regions are used for tertiary wastewater treatment to detain, transform, and remove these contaminants. However, there is a limited understanding of contaminant transport in fen peatlands, particularly in sub-arctic Canada. To better characterize contaminant transport in these systems, approximately 44 m^3 day^{-1} of simulated wastewater (concentrated custom-blend fertilizer and Cl^- diluted with water) was pumped into a small 0.5 ha sub-arctic northern ribbed fen continuously for 47 days (July 15th – August 31st 2015). Electrical conductivity (EC) of 3 similar northern ribbed fens varied between 15 (min) and 88 (max) µm cm^{-1} over the study period (May – September 2015). Water table quickly increased (~0.16 m in 6 days) nearest the point source (8 m down-gradient), resulting in rapid solute transport, as measured by electrical conductivity (EC) (20 to140 µm cm^{-1} in 11 days). This rapid transport was due to the large increase of hydraulic conductivity (~2 to180 m day^{-1}) as the water table rose. More gradual increases in water table (0.18 m in 13 days) and EC (140 µm cm^{-1} in 15 days) were observed farther (~50 m) from the point source; this delay was likely due to increased total storage capacity rather than differences in hydraulic conductivity. After 34 days the water table had risen on average 0.16 m across the site, but EC (113 µm cm^{-1} in 25 days) was limited to a final distance of 119 m. Northern ribbed fens have a large capacity to detain wastewater as illustrated by the conservative solute plume only travelling 49 % of the total site length (notwithstanding the large increase in hydraulic conductivity as the water table rose) and have the potential to significantly decrease wastewater contamination in northern aquatic environments.

Abstract ID: 35455

Final Number: H43A-07

Title: Analyzing the Impacts of Road Construction on the Successional Trajectory of a Poor Fen in Northern Alberta.

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Abstract Body: Roads that bisect wetlands can alter their hydrologic connectivity on a local or landscape scale. These impacts were studied in a poor fen located 45 km south of Fort McMurray, Alberta, where a raised road was built across the northern fringe of the fen in 1977. Examination of the fen's response to this impoundment provided insight into post-disturbance vegetation succession patterns and peatland development. The objectives of this study are to quantify the impacts of the road on fen vegetation composition and microtopography, and to predict its successional trajectory based on current vegetation and hydrology. To quantify the impact of the fen, vegetation cover along with several abiotic variables were measured in 281 1 m^2 plots. In sixteen 50 m^2 transects, recent moss growth was calculated by measuring the depth to the root crown of black spruce trees, as the root crown's position represents the original ground level at time of germination. Density and age of saplings were also measured in these transects. Analysis of vegetation reveals dominance of non-hummock forming species (such as *Carex aquatilis*) closest to the culvert (located in the NW corner). The average depth of recent moss growth was greater immediately up-gradient of the road (36.2 cm) compared with undisturbed areas (19.7 cm). There were no saplings near the culvert, very few within 220 m up-gradient of the road (12% of total trees), and many saplings in the transects furthest from the road (57%). These data suggests that periodic blockage of the culvert leads to flooding in the immediate area that encourages non-hummock forming species of sedge and moss, making an unfavourable environment for black spruce germination. This cycle of hydrologic disturbance may be preventing some areas of the fen from regaining the original vegetation structure, with implications for the system's development.

Abstract ID: 34946

Final Number: H43A-08

Title: Effective hydraulic properties of unsaturated sphagnum moss and peat

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Abstract Body: Twelve significant Ni-Cu-PGE occurrences are recognized in the Nancy magmatic feeder and subconcordant sills of the LKU. Mineralization occurs as disseminated to net-textured to massive sulfides hosted in ultramafic rocks and within the adjacent country rocks. The high metal tenors (>20% Ni and 20 g/t PGE) combined with the presence of MgO-rich komatiites that exhibit evidences of interaction and contamination with surrounding S-rich country rocks testify the potential of the VGB to host additional Ni-Cu-PGE mineralizations.

MINERAL DEPOSITS AND ORE MINERALS

Abstract ID: 35735

Final Number: MD12A-05

Title: Dating Layered Intrusions and Their Ore Deposits

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Published Material: Aspects of this work were presented as part of an invited review talk at the Geological Society of America Annual Meeting in Vancouver (Canada) in October 2014.

Abstract Body: Mafic layered intrusions preserve stunning rock records of the processes by which magma evolves in crustal magma chambers. They host major resources of Cr-Ni-Cu-V and platinum group elements (PGE), including the two world-class PGE reef-type deposits, the Merensky Reef in the Paleoproterozoic Bushveld Complex and the J-M Reef in the Neoarchean Stillwater Complex. Accurate and precise dates are needed to establish how different parts of layered intrusions are related to each other, including defining genetic relations with their contained ore bodies. Surprisingly, the classic layered intrusions in petrology (e.g., Stillwater, Bushveld, Muskox, Skaergaard) do not yet possess robust geochronological frameworks. Dateable accessory minerals, predominantly zircon, are typically present in minute quantities (10s to 100s of grains per 10-20 kg of sample), which is sufficient to provide high-precision geochronologic results. Heterogeneous textures and macroscopic evidence for interstitial minerals that crystallized from evolved interstitial melt at near-solidus temperatures are key criteria for selecting prospective samples. As part of larger chronostratigraphic studies of the Bushveld and Stillwater complexes, we have successfully determined the ages of a wide range of mineralized samples, including basal Ni-sulphide mineralization, chromitite horizons, and the PGE reefs. Our U-Pb geochronological results indicate that (1) these two major layered intrusions formed incrementally over millions of years, (2) distinct time gaps or magmatic hiatuses are recorded in their respective stratigraphic successions of cumulates, and (3) ages do not systematically decrease with increasing relative stratigraphic position (i.e., some older units are bounded by younger rocks). These extended magmatic time spans for large mafic-ultramafic layered intrusion and their associated ore deposits are remarkably similar to those recognized in intermediate to felsic plutonic and volcanic systems.

Abstract ID: 34846

Final Number: MD12A-06

Title: Extreme Variations in ɣOs, on the Thin Section Scale in Laurites from Chromite Layers from Stillwater Complex: Implications for the Origin of Laurite and the Representativeness of Whole Rock ɣOs.

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Abstract Body: The origin of massive chromite layers in large layered intrusions and their role in collecting Platinium-Group Element (PGE) is poorly understood. There have been a number of studies based on whole rock geochemistry and whole rock isotopic systems, including Re-Os, which conclude that contamination of a primary magmas with crustal component played a key role in the formation of the chromite layers.

The Re-Os isotopic system is particularly appropriate for examining the origin of PGE enrichment because Os is a PGE and is enriched in chromite layers. In the case of Stillwater Complex (Montana, U.S.A) chromite layers, the host of the Os is laurite which is generally enclosed in chromite. In order to eliminate contributions of alteration and metamorphism from interstitial phases, we applied a new approach based on Os isotopes in-situ analyses on laurite by LA-MC-ICP-MS. The ɣOs obtained are variable, from sub-chondritic to radiogenic, and are surprisingly variable at the thin section scale (ɣOs = -2 to 7) and raise question about the representativeness of ɣOs from whole rock studies. These results imply mixing between at least two components. The first is chondritic to subchondritic and indicates a mantle derived source. The second is supra chondritic and implies a crustal component.

Three models may explain these results: the laurites represent i) transported residual mantle xenocrysts, ii) phenocrysts that have crystallized from magma variably contaminated “en route” to emplacement, iii) the products of Os and Ru diffusion from chromite into base metal sulfides. In this latter case unradiogenic composition may reflect chromite-derived signature whereas radiogenic composition could represent a sulfide-dominated component.

Abstract ID: 34581

Final Number: MD12A-07

Title: Sulfide Distribution and Oxygen Isotopic Variation Within the J-M Reef, Stillwater Complex, Montana

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Abstract Body: The Stillwater Complex of Montana is host to one of the world's premier platinum-group element (PGE) deposits, the J-M Reef. The J-M Reef is found in what is known as olivine-bearing zone I (OB I) of the Lower Banded Series of the Complex. The Reef averages 1 to 3 m in thickness and occurs over 40 km of strike length (Todd et al. 1982). Rock types present within the Reef include dunite, troctolite, norite, and anorthosite. PGE concentrations strongly correlate with sulfide abundance. The origin of the J-M Reef remains controversial, and theories are broadly divided between those which favor downward collection of PGE-bearing immiscible sulfide liquids (e.g. Campbell et al., 1983) and those that favor an upward accumulation of PGEs controlled by magmatic hydrothermal fluids (e.g., Boudreau and McCallum, 1992). In addition to the very high concentration of Pd in the Reef, the distribution of PGE-rich sulfides remains enigmatic. We have examined interfaces between sulfide-bearing units of the J-M Reef and sulfide-poor units above, below, and within the Reef itself. PGE-rich and sulfide-rich lenses show vertical separation as well as horizontal discontinuities. The downward extent of the mineralization is defined by the presence of sulfide minerals and is not controlled by variations in host lithologies. Neither downward drainage of immiscible sulfide liquid through a fractionation/differentiation sequence nor upward fluid infiltration can readily explain these features.

Some of the distribution of sulfide minerals in the Reef and associated ballrooms may be a function of low-T hydrothermal fluid mobilization (e.g. Godel and Barnes, 2008). Oxygen and hydrogen isotopic studies show that the J-M Reef behaved as a horizon of relatively high permeability compared to other stratigraphic units in the Complex. The presence of plagioclase with $\delta^{18}O$ values as low as 4.0 ‰ and olivine with normal mantle values of 5.4 ‰ suppressed to 4.8 ‰ when partially serpentinized are indicative of kinetically controlled oxygen isotopic exchange between minerals and a low-temperature and low-^{18}O fluid. The elevated concentrations of Pd in pentlandite (5.6 to 9.8 wt. %) associated with the desulfurization of braggite and cooperite to isoferroplatinum-sulfide intergrowths indicates that Pd was transported within late-stage fluids.

Abstract ID: 35734

Final Number: MD12A-08

Title: Multiple Sulfur Isotope Studies of the Stillwater Complex, Montana

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Co-authors: Edward Ripley, Indiana University, Bloomington, IN; Chusi Li, Indiana University, Bloomington, IN

Published Material: I presented a portion of my data at the 11th International Platinum Symposium.

Abstract Body: Models for the genesis of the J-M Reef of the Stillwater Complex include magma mixing and the attainment of high R-factors to produce PGE-rich immiscible sulfide droplets (e.g., Campbell et al., 1983), leaching of trace sulfides in the Ultramafic Series and concentration at the level of the Reef by magmatic fluids (e.g., Boudreau and McCallum, 1992; Boudreau and Meurer, 1999), and the emplacement of PGE-rich magmas that had been upgraded via sulfide dissolution at depth (e.g., Keays and Lightfoot, 2013). In order to better evaluate the extent to which crustal sulfur was key for PGE enrichment we have initiated a multiple sulfur isotope study of the Complex. The work compliments the early S isotope studies of the Complex by Zientek and Ripley (1990), but the utilization of both ^{33}S and ^{34}S permits the detection of deviation from the terrestrial fractionation line that may be due to assimilation of S from Archean country rocks and was previously undetectable.

We have measured $\Delta^{33}S$ values for samples of country rocks and sulfides within country rocks, as well as rocks of the Reef Package in the area of the Stillwater Mine. $\Delta^{33}S$ values for both massive sulfides in country rocks and pyroxene-hornfels below the Basal Series range from 0 to 0.25 ‰. $\delta^{34}S$ values generally range from -1.3 to +1.3 ‰, with one massive sulfide sample having a value of 3.9 ‰ Samples of sulfides from the J-M Reef have $\delta^{34}S$ values from -1 to +1.5 ‰. J-M Reef samples have $\Delta^{33}S$ values from 0.005 to 0.05 ‰. The $\Delta^{33}S$ values of sulfides so far measured from the J-M Reef are not considered to be anomalous, however the range of sulfur isotopic values found in the metasedimentary country rocks does not preclude a contribution of country rock sulfur to the magmas that produced the Stillwater Complex. The relative uniformity of $\Delta^{33}S$ values in the igneous rocks of the Reef is consistent with no country rock contribution of sulfur, and exclusive incorporation of mantle S or, alternatively, contribution of country rock S characterized by similar $\Delta^{33}S$ values. A multi-component mixing process involving sulfur from various country rocks and that of mantle derivation remains feasible. Samples of Archean gneisses and other intrusive rock types are being analyzed to further constrain the involvement of country rock S in the formation of the J-M Reef.

Abstract ID: 33101

Final Number: MD13A-01

Title: Setting and Style of VMS Mineralization in the Eastern Goldfields Superterrane, Western Australia: Insights from the Ag-Zn-(Au) Nimbus Deposit

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Abstract Body: Economic VMS mineralization in the Archean Yilgarn Craton of Western Australia is largely restricted to two main zones of juvenile crust as revealed through regional (Nd, Pb) isotope variations (Huston et al. 2014). Interpreted as Archean paleo-rift zones, one of these runs N-S through the central Eastern Goldfields Superterrane and is associated with the high-grade Teutonic Bore, Jaguar and Bentley deposits, plus sub-economic VMS mineralization further south at Anaconda and Erayinia. The Nimbus Ag-Zn deposit (4.9 Mt at 149 g/t Ag-eq) is located approximately 265 km south of Teutonic Bore, near the margin of this paleo-rift zone and 17km ESE of Kalgoorlie. The local stratigraphy comprises a NW-trending and steeply-dipping bimodal-felsic package of volcanic rocks (i.e. FI affinity quartz-feldspar porphyritic dacite and lesser basalt, plus their autoclastic equivalents) with subordinate carbonaceous black shale, chert and polymict conglomerates. Primary sulfide mineralization occurs as a series of stacked plunging lenses which parallel a mineral elongation lineation. Early well-developed massive pyrite is underlain by 1) semi-massive, stringer and breccia-type Ag-Zn±Pb(Cu-Au) sulfides (including: pyrite, sphalerite, galena, pyrargyrite, marrite, boulangerite, arsenopyrite, chalcopyrite and tetrahedrite) associated with the autoclastic top of a thick unit of dacite; and 2) stringer and disseminated sulfides (dominated by pyrite and sphalerite) in largely coherent pseudo-brecciated dacite at depth. Hydrothermal alteration is characterized by extensive and pervasive quartz-sericite-carbonate which becomes more intense towards mineralization. Compared to other VMS occurrences in the Yilgarn Craton, the Nimbus deposit is unusual in terms of its tectono-stratigraphic position, the geochemistry of its host sequence (i.e. FI affinity felsic volcanic rocks, ocean-plateau like low-Th basalts), mineralogy (e.g. low Cu-Au through most of the deposit, abundance of Ag & Sb sulfosalts) and alteration assemblages (e.g. lack of chlorite, presence of kaolinite at depth). Classification of Nimbus as a shallow-water and low-temperature VMS deposit with epithermal characteristics (i.e. a hybrid bimodal-felsic deposit), is consistent with its position near the margin of this paleo-rift zone.

Abstract ID: 34542

Final Number: MD13A-02

Title: AURIFEROUS VOLCANOGENIC MASSIVE SULPHIDE, A NEW TYPE OF GOLD DEPOSIT IN THE GUIANA SHIELD?

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Abstract Body: In French Guiana, the “Montagne d’Or” gold mineralization (4.3 Moz Au at 1 g/t), property of Columbus Gold Corp., is hosted by the northern branch of the Proterozoic Paramaca Greenstone Belt (PGB). The PGB represents the remnant of a volcanic island-arc sequence formed between 2.18 to 2.13 Ga, during the Transamazonian orogeny. The main tectonic event has structured the two branches of the PGB, merging together along an E-W orientation, which there are surrounded by diverse intrusions and metamorphic complexes. The geological characteristics of the “Montagne d’Or” deposit contrast with those of other gold deposits of the area which comprise clastic-hosted, porphyry systems, shear zones, and lateritic enrichments.

The “Montagne d’Or” deposit is hosted by a bimodal volcanic and volcaniclastic sequence bounded to the south by a major E-W shear zone. These volcanic rocks are affected by a penetrative E-W trending and south-dipping regional schistosity. The rock sequence is facing south and is dominated by calc-alkaline felsic lithologies interbedded and interdigitated with tholeiitic mafic rocks cross-cut by transitional to calc-alkaline intrusives. Some mafic flows are pillowed and few graded felsic volcaniclastic sequences were found, indicating a submarine environment. The Au mineralization is associated with pyrite, pyrrhotite and chalcopyrite with minor sphalerite, magnetite and arsenopyrite. The sulphides show three distinct aspects, (1) stratiform disseminations, (2) stockworks or veinlets, and (3) structurally-transposed layers of semi-massive sulphides. Visible gold occurs within chlorite-sericite-rich zones and is spatially related to sulphides.

Based on these characteristics, the “Montagne d’Or” mineralization is thought to have a syn-genetic origin and is currently interpreted as the first occurrence of auriferous VMS in the PGB. However, remobilisation of sulphides may have occurred during metamorphism and tectonic deformation.

Abstract ID: 34247

Final Number: MD13A-03

Title: CONSONORM_LG: a new method of norm and alteration indexes calculation for low grade metamorphic rocks altered by VMS related hydrothermal systems

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Abstract Body: The CONSONORM_LG provides a standardised solution to approximate metamorphic parageneses as well as indexes for estimating chemical and/or mineralogical changes induced by hydrothermal alteration. These indexes are particularly performant for identifying and quantifying the Fe-Mg, K and CO2 alterations common in VMS systems (Volcanogenic Massif Sulphides).

The CONSONORM_LG is designed for silicate, Fe-Ti oxides and/or carbonate-dominated rocks that may contain sulphides, and it approximates the main parageneses of metamorphic rocks for three temperature-pressure conditions of the green schist and lower amphibolite facies (cf. 2SV350, 2SV450 and 2AMP575 facies of the norm). For each of the facies modelled, the norm calculates silicate assemblages using an Al-Ca-FeMg-NaK tetrahedron that is a convenient way to represent a large amount of silicate assemblages. In addition to silicates, the CONSONORM_LG calculates several accessory minerals from minor elements, Fe-Ti oxides, sulphides from analysed sulphur and/or from analysed metals and carbonates from analysed CO2 or from normative CO2 estimated from the LOI using the NORMAT method. The CONSONORM_LG also calculates several alteration indexes to estimate Fe-Mg (cf. chloritization), Ca (cf. propylitic alteration), Na and K alterations (cf. sericitization, phyllic alterations) and Al relative gains (cf. argilization for example). Carbonatation indexes are also calculated using the amount of normative minerals formed by this type of alteration, i.e. carbonates, chlorite and muscovite.

During this presentation, the calculation sequence of the CONSONORM_LG will be presented and validated using published whole rock analyses and petrographic descriptions. Then, the alteration indexes provided by this normative method will be tested using several natural samples of alteration halos associated with VMS-type deposits.

Abstract ID: 34952

Final Number: MD13A-04

Title: Geochemical Classification of Archean Volcanic Rocks in the Blake River Group, Abitibi Greenstone Belt, Québec

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Abstract Body: The Archean Abitibi Greenstone Belt is one of the best places in the world to explore for volcanogenic massive sulphide deposits (VMS), with 810 Mt of ore known so far. The Blake River Group (BRG) in the Rouyn-Noranda area includes two important mining camps, Noranda and Doyon-Bousquet-LaRonde, representing together about 374 Mt. VMS deposits are partially controlled by stratigraphy and, for the BRG, few regional marker horizons are known. Therefore, an improved knowledge of the volcanic stratigraphy would be valuable, and a chemo-stratigraphic

approach could help, especially if combined with the large high-precision U-Pb geochronology dataset now available.

We have compiled more than 2000 complete geochemical analyses (major and trace elements) for the Québec side of the BRG. With such a large database, multivariate statistical analysis is needed to utilize the data to its full potential. The BRG has been divided into a number of volcanic formations. We have so far focussed on two of these, the Noranda formation (hosting many VMS deposits of the Noranda camp) and the Reneault-Dufresnoy. For each formation we first split the data into mafic-intermediate and felsic samples, and discard a few outliers. Then we use hierarchical clustering analysis to place samples into groups. Examination of spidergrams and extensive tests leads us to use the elements Th, Nb, La, Ti, and Yb for the hierarchical clustering analysis. These elements (except La) are known to be largely immobile during hydrothermal alteration and metamorphism. The dendrograms shows the hierarchy of clusters, and we decide on the optimal number of groups based on (1) geological/geographical consistency of the groups; (2) maximizing the differences between groups; (3) maximizing the similarity within groups. We interpret those groups as volcanic units having different geochemical signatures, an interpretation consistent with the stratigraphic polarity and the U-Pb data.

Abstract ID: 36599

Final Number: MD13A-05

Title: Reconstruction and evolution of Archean intracaldera facies: the Rouyn-Pelletier Caldera Complex, Abitibi greenstone belt, Canada.

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Published Material: This presentation is a summary of a paper that is currently under revision by the Canadian Journal of Earth Sciences.

Abstract Body: The internal architecture of modern subaqueous volcanic edifices is rarely exposed and when visible, is difficult to access. Vertically-dipping Archean strata allow for the study of synvolcanic structures and the internal organization of subaqueous volcanic complexes. The Abitibi greenstone belt in Canada, and specifically the Blake River Group, hosts numerous subaqueous volcanic centres including the Blake River megacaldera complex (BRMCC). Within the BRMCC are three previously identified caldera complexes: the host Misema Caldera and the nested and overlapping New Senator and Noranda Calderas. Of particular interest is the southern sector of the New Senator Caldera (SNSC) and its close association with the 54 Mt Horne Au-rich volcanogenic massive sulfide (VMS) deposit.

Detailed mapping of volcanic and intrusive facies, along with site-specific geochemical and geochronological analysis at selected outcrop localities throughout the SNSC show that the stratigraphy of the sector is composed of mostly subaqueous effusive mafic volcanic sequences with intermittent felsic events. With the use of available structural data and the geometry of synvolcanic faults and dykes, volcanic and intrusive facies are grouped into facies assemblages. These facies assemblages compose a volcanic complex known as the Rouyn-Pelletier Caldera Complex. This study predominantly focuses on the Basal and Central Intracaldera Facies Assemblages (BIFA and CIFA respsectively) but also characterizes the other facies assemblages and places the Horne deposit within the context of the complex.

Facies of the BIFA represent the terminal stages of seamount construction and compose the first caldera floor. Following emplacement of those facies, a trapdoor collapse event occurred, allowing for the emplacement of the ponded lavas in the western CIFA. Piecemeal-type faulting follows this event and permits the extrusion and intrusion of facies of the eastern CIFA; forming yet another caldera floor. The caldera complex continues to build and shallows and a shift to more explosive activity occurs. This shift is interpreted to be one of the final phases of activity and is represented by the volcanic facies of the Horne deposit.

Abstract ID: 36222

Final Number: MD13A-06

Title: Volcanic Reconstruction of the Powderhouse Dacite in the Paleoproterozoic VMS Hosting Chisel Sequence, Snow Lake, Manitoba

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Abstract Body: The Chisel sequence is a 3 -5 km thick succession of voluminous felsic volcaniclastic rocks that hosts six known volcanogenic massive sulfide deposits (VMS) in the 1.89-1.88 Ga Snow Lake arc assemblage. The VMS deposits occur at the boundary between the upper and lower Chisel sequences. The Powderhouse dacite is the uppermost unit of the lower Chisel sequence and constitutes the stratigraphic footwall to the Chisel, Chisel North, Lost, Ghost, and Lalor VMS deposits. The Powderhouse dacite is laterally discontinuous and is localized to the extent of the overlying VMS deposits.

The stratigraphy and structure of the Powderhouse has been established through detailed surficial mapping (1:25 to 1:1000), core logging, lithogeochemistry, and petrographic analyses. The most distinctive lithofacies is a massive, feldspar crystal-phyric felsic tuff containing 5 -10 % lithic dacitic clasts and 10 -20% tectonically flattened dark lapilli, interpreted to be juvenile vitric clasts. The juvenile lapilli, voluminous clastic material, and massive to poorly graded bedforms suggests that the Powderhouse was emplaced subaqueously as a mass flow. Subsidence occurred during the emplacement of the Powderhouse dacite as indicate by abrupt truncation (restriction) of facies and localized heterolithic breccia beds intercalated with these massive tuffs. The uppermost lithofacies of Powderhouse dacite is a unit that consists of well stratified, heterolithic, block-rich breccia intercalated with beds of fine tuff or siliceous finely laminated tuffs without breccia. The stratified sub-unit represents a hiatus in voluminous massive flow deposition that is contemporaneous with the emplacement of rhyolite domes and formation of the VMS deposits. The Powderhouse dacite is interpreted to be a product of voluminous pyroclastic eruptions, which along with concomitant subsidence, preceded the formation of VMS deposits.

Abstract ID: 34501

Final Number: MD13A-07

Title: The Lower Lemoine Member of the Waconichi Formation, Abitibi Greenstone Belt, Chibougamau, Quebec: Implications for VMS Exploration

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Abstract Body: The Abitibi greenstone belt (AGB) is host to some of the richest volcanogenic massive sulphide (VMS) deposits in Canada. Only one VMS deposit, Lemoine, has been mined in the Chibougamau district thus far with 0.76 Mt of ore averaging 4.2 wt % Cu, 9.5 wt % Zn, 4.6 g/t Au and 83 g/t Ag. It is hosted in the Waconichi Formation (Roy Group). This MSc study aims at better constraining subunits within the Lemoine Member of the Waconichi Formation, identify emplacement processes and reconstruct its volcanic architecture through field mapping, core logging, petrography and geochemistry.

The study area encompasses the eastern sector of the NE-trending Lower Lemoine Member, where it comprises the intrusive Marelle QFP, the intrusive to extrusive Alpha Rhyolite, the extrusive Lemoine Rhyolite, the intrusive Coco Lake Rhyolite, and the extrusive Lemoine Dacite, Lemoine Andesite and Hangingwall QFP. The Lemoine deposit, 4 km SW of the study area, was located on top of the Lemoine Rhyolite and was overlain by the Hangingwall QFP.

Observations made in the 2014 field season have provided further evidence for the complexity of the volcanic architecture in the study area. For example, the the Alpha Rhyolite was emplaced in two pulses, a first effusive phase on the seafloor quickly overlain by the Lemoine Rhyolite, and a second phase intruding the Lemoine Rhyolite. The early, effusive (lobe-hyaloclastite flow) portion of the Alpha Rhyolite is characterized by a strong chlorite-sericite alteration whereas the intrusive portion is unaltered, showing the strong control of volcanic facies on alteration distribution. Facies mapping and thickness variations provide evidence for the location of possible volcanic vents in the study area,. The location of volcanic vents coupled with the spatial distribution of the hydrothermal alteration help better understand VMS systems and define new vectors for exploration in the eastern sector of the Lower Lemoine Member.

Abstract ID: 35345

Final Number: MD13A-08

Title: Contrasting the settings of seafloor massive sulfide deposits on the South Central Indian Mid-Ocean Ridge: Results of the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) INDEX 2013 cruise

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Abstract Body: The INDEX 2013 cruise mapped, in detail, four polymetallic seafloor massive sulfide (SMS) deposits located on the western (Sonne) and eastern flanks (Kairei, Edmond, Gauss) of the active, South Central Indian Mid-Ocean Ridge at water depths ranging from 2,440 to 3,300m; a fifth deposit (Score) was discovered along the latter. Altered sediments, hydrothermal crust, sulfide chimney debris and basalt talus cover the mound-like SMS deposits. Actively venting (up to 418˚C at Edmond) and extinct sulfide chimneys define “fields” on the mound surface; the deposits are typically copper-rich. Delicate, bladed Fe-Mn precipitates occur between pillows peripheral to the SMS deposits.

The active Kairei and Edmond, and inactive Gauss and Score SMS deposits occur on rift-parallel, fault-controlled ridges. The deposits formed on and are partly covered by deposits of coarse, blocky talus comprising blocks of fine-grained to aphanitic, olivine and plagioclase porphyritic basalt, typically mantled by centimetres of fine sediment; massive and pillowed basaltic lava are only exposed in fault scarp windows. There is no evidence of recent volcanism. The location of the SMS deposits along the flanks of structural ridges and their association with talus breccia devoid of glassy pillow components indicate that long-lived, ongoing tectonic unroofing of oceanic lithosphere along steep, ridge-parallel (and perpendicular) faults was accompanied by high-temperature hydrothermal activity, and that the faults acted as fluid conduits. In contrast, the hydrothermally inactive Sonne deposit occurs along the crest of an intact rift-parallel, pillow volcano. Variations in topography and bathymetry define two eruptive centres that attain their maximum height where they overlap immediately below the SMS deposit. Pillow lavas and glassy pillow-fragment talus without sediment cover indicate that the volcano is tectonically (volcanically?) active. The spatial coincidence of volcanic and hydrothermal vents at the Sonne SMS deposit is typical of ancient VMS deposits.

Abstract ID: 34332

Final Number: MD14A-0252

Title: *Importance of sample preparation, representivity, and reporting methologies for quantitative evaluation of precious metal mineralogy*

Presenter/First Author: Louis J Cabri, Cabri Consulting Inc., Ottawa, ON

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Abstract Body: It is essential to use quantitative methods in evaluation of precious metal minerals and determining precious metal deportment, well-known to process and applied mineralogist, but this approach is under-appreciated by many, especially for those unfamiliar with study of crushed and sized representative samples. The majority of economic geology publications are still only based on study of metallic minerals in polished thin sections (PTS) that cannot be representative of the ore being described, but are then used in conjunction with bulk chemical assays to arrive at so-called mass balances and metal deportment. Precious metal mineral abundances are still being reported in terms of frequency percent or volume percent based on approximate length x width measurements. The increased access to automated SEM-based imaging systems give a false sense of reliability unless these are used by knowledgeable operators based on careful sample preparation and representivity, as well as evaluated by reconciling to chemical assays. Sample preparation, measuring techniques, and reporting of data, has been the subject of continual improvement over the last few decades. The presentation will focus on platinum-group minerals (PGM) and platinum-group elements (PGE), such as occur in mafic-ultramafic magmatic deposits.

Abstract ID: 33801

Final Number: MD14A-0253

Title: Experimental confirmation of high temperature silicate liquid immiscibility in multicomponent ferrobasaltic systems

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Published Material: These findings are still under review by American Mineralogist (Minor Revision).

Abstract Body: Here we report the results of an experimental study aimed at testing the existence of stable, super-liquidus immiscibility between silica-rich and Fe-rich multicomponent melts at temperatures above 1100 °C. Four pairs of the potentially immiscible compositions were tested in a one-atmosphere gas-mixing furnace (Ar/H_2-CO_2 gas mixture) at 1150 and 1200 °C and at the oxygen fugacity corresponding to that of the QFM buffer. Pre-synthesized pairs of the silica-rich and Fe-rich starting compositions were loaded in Pt wire loops, fused separately at 1300 °C, then brought in contact and kept at constant experimental temperature for more than 24 hours. Three pairs of compositions out of four used in this study did not mix. Some temperature-dependent chemical re-equilibration was observed in the Fe-rich liquid phase but, in the cases of immiscibility, the two liquids remained compositionally distinct and showed sharp compositional gradients at contacts. One pair of liquids crystallized some tridymite, whereas the other compositions were clearly above the liquidus. Overall, the results of the experiments are in good agreement with the earlier centrifuge study and confirm the existence of stable, super-liquidus immiscibility in some Fe-rich basaltic-andesitic compositions at temperatures up to 1200 °C.

Abstract ID: 34039

Final Number: MD14A-0254

Title: Solubility of the assemblage Pt-PtAs(melt) in basalt with implications for Pt-As complexing and As speciation

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Published Material: All findings were reported during a seminar for Undergraduate thesis presentations, hosted at the University of Toronto in March of 2014.

Abstract Body: Given the evidence in nature for a strong Pt-As association in magmas, we evaluated the effect of arsenic on platinum solubility in molten silicate. Two different approaches were employed. In the first, vacuum-sealed quartz tubes contained a synthetic basalt analogue with Pt metal +/- arsenide melt encapsulated in a natural chromite crucible. Oxygen fugacity (fO_2) was fixed using solid oxide buffers, corresponding to log fO_2 of -11.65, -7.72 and -4.10, respectively. Experiments were done at 0.1 MPa, 1200º C for 1 to 4 days, then quenched in water. It was found that As was volatilized from samples and began to contaminate the oxygen buffer, leading to a systematic decrease in Pt and As solubility with time. To mitigate this problem, a second series of experiments (type 2) first equilibrated the basalt sample with (initially) pure Pt in a gas-mixing furnace, with the sample then sealed in a silica ampoule along with arsenide melt, but without the solid oxide buffer. The fO_2 in these experiments was checked using partitioning of vanadium between chromite and melt. All experiments contained Pt-Fe alloy + Pt-arsenide melt, except some type 2 runs in which the Pt-Fe alloy was absent. The dissolved As content of the silicate melt increased significantly with fO_2, varying from 10 to 10,000 ppm, over the fO_2 range investigated. The average Pt content of the As-bearing glasses produced at log fO_2 of -7.72 and -4.10 are 0.16 ppm and 0.18 ppm, respectively, compared to 0.02 ppm and 0.14 ppm Pt in As-free glasses. At log fO_2 of -7.72, the As content of the silicate melt is ~400 ppm, in which the Pt solubility is enhanced by 8-fold. Hence, the molar As/Pt required to affect this "excess" Pt solubility is ~7400. The As content of typical primitive basalts is ~0.1 ppm, compared to 1-10 ppb Pt, resulting in molar As/Pt of ~300-30; this suggests the solubility enhancement by As complexing will be insignificant in natural systems. Importantly, despite high levels of As in two experiments which were saturated in Pt-arsenide melt (60-80 at% Pt), but not Pt metal, each contained Pt contents of <0.01 ppm. Results therefore imply that the Pt level required for Pt-arsenide saturation in molten silicate is low, possibly leading to crystallization of such phases as sperrylite ($PtAs_2$) in sulfur-poor, As-bearing magmas.

Abstract ID: 33422

Final Number: MD14A-0255

Title: Characterizing the mineralogy of orthomagmatic Fe–Ti–V (± P) oxide mineralization hosted in Paleoproterozoic anorthosite in the Cape Caribou River Allochthon, Grenville Province, Southeast Labrador

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Abstract Body: The Cape Caribou River Allochthon (CCRA) is a thick lobate thrust slab located in the Grenville Province of south-eastern Labrador. It consists mainly of Paleoproterozoic anorthosite-mangerite-charnockite-granitoid rocks. The uppermost unit of the CCRA is the North-West River Anorthosite (~1625 Ma), a heterogeneous unit containing rocks ranging from anorthosite to gabbronorite, which are host to Fe–Ti–V (± P) oxide mineralization. Exploration activity in the CCRA has been sparse, despite several known mineralized areas. Ongoing research is investigating the mineralogy, geochemistry, and mineral chemistry of oxide mineralization to understand the origin of mineralization, and to provide insights into exploration potential of the CCRA and similar geological settings; amenability of oxides to beneficiation is also explored. Preliminary results are presented herein.

Fe–Ti–V (± P) oxide mineralization in the CCRA is abundant and widespread, and has four modes of occurrence: (1) pods of semi-massive to massive oxide (apatite-poor and -rich); (2) oxide veins (with straight or irregular contacts with host rocks); (3) disseminated oxide (mineralization occurring on its own or associated with orthopyroxene); and (4) alternating oxide bands having sharp contact with host rocks. All mineralization occurrences consist of spinel series (ulvospinel-magnetite solid solution) and trigonal series (ilmenite-hematite solid solution) Fe-Ti oxides, and are associated with pyrrhotite, chalcopyrite and pyrite. The mineralization exhibits complex mineral associations between oxides, apatite, silicates and sulfides, and within each mineral group; complex and variable exsolution textures within oxide minerals (magnetite, ilmenite, hematite and hercynite) are abundant. These mineral relationships will be used to determine the oxide mineral paragenesis, the partitioning and residence of Ti and V, the physiochemical conditions of oxide formation, and the processing route for oxide concentrate.

Abstract ID: 35009

Final Number: MD14A-0256

Title: Genesis of Co-Ni mineralizations during serpentinisation process in Bou Azzer ore deposits, the Neoproterozoic ophiolite of Bou Azzer El Graara (Central Anti-Atlas, Morocco)

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Abstract Body: The neoproterozoic Bou Azzer inlier central Anti Atlas Mountains, southern Morocco represents a geological window into the Precambrian basement. It's surrounded by a discordant Phanerozoic cover. It is interpreted as the boundary between the northern margin of West African Craton (WAC) and dismembered parts of the Anti-Atlas Pan-African orogenic belt commonly known as Bou Azzer ophilite. In Bou Azzer two main phases of serpentinization at Bou Azzer was pointed out (Wafik, 2001) : i) an oceanic syn-rifting pseudomorphic serpentinisation stage with antigorite and two continental tectonic serpentinzation stages during tectonic setting of ophiolite with ii) syn-collision extensional stage lizardite and iii) post-collision extensional stage chrysotile filling veins and faults. After this author, Serpentinite is initial reserve of Ni-Co mineralization in Bou Azzer, where is reconcentrated by tectono-magmatic events that took place later.

The genesis of Co-Ni arsenides resulted from hydrothermal and tectono-magmatic processes. A primary paragenesis of magmatic origin with pentlandite, chromospinelle, and cobaltiferous and nickeliferous magnetite has been highlighted in Ambed massive where the serpentinization of ultramafic rocks is partial, and it is probably associated with Fe sulphides. However, the mineralogical assemblages identified in Aghbar and Bou Azzer East massive where serpentinization is total are composed on secondary minerals of polydymite cobaltiferous, millerite cobaltiferous, orcelite and magnetite cobalti-nickeleferous. These mineralizations could come during serpentinization from mutation of a primary mineral pargenesis formed on olivine and pentlandite+pyrrhotite aggregates. The genesis of cobaltiferous hydrothermal mineralizations is basically related to the serpentinization process. In tectonical term, serpentinization modify serpentine plasticity and provide doming phenomenon and has important contribution on genesis and structural context of Bou Azzer mineralized corps. In chemical level, serpentinization control the mobility of nickel and cobalt exist in primary ultramafic minerals which marked in arsenides, sulfides and iron oxides.

KEYWORDS: mineralizations, hydrothermal, cobalt, nickel, arsenides.

Abstract ID: 35283

Final Number: MD14A-0257

Title: Sulphur isotopic studies of Cu-PGE mineralization in the Coldwell Complex, Ontario: Implications for mineralizing processes

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Abstract Body: The Marathon and Geordie Lake Cu-PGE deposits are hosted by the Two Duck Lake (TDLG) and Geordie Lake (GLG) gabbros of the Coldwell alkaline complex, respectively. The TDLG intruded Archean metavolcanic rocks and the GLG occurs within syenite of the Coldwell Complex. The role of sulphur contamination from country rocks in the genesis of these two deposits is a point of debate.

All sulphide $\delta^{34}S$ (V-CDT) values for both Marathon and Geordie Lake mineralization fall between -2.0 and +2.0 ‰. There are no significant or consistent differences between different minerals at Marathon, although slight differences exist between some textural variants. Py from the country rocks at Marathon exhibits a wide range of $\delta^{34}S$ with an average of 0.2 ‰. At Geordie Lake, Po exhibits a distinctly lower range of $\delta^{34}S$ values (<-1 ‰) than other sulphides. At Marathon, there is no systematic variation in $\delta^{34}S$ with distance from the Archean country rocks, however, $\delta^{34}S$ values of Cpy from mineralized samples at Geordie Lake decrease with increasing distance from the syenite.

Analyses of multiple sulfur isotopes of representative samples from mineralized zones in the Marathon deposit show evidence of mass-independent fractionation, with negative $\Delta^{33}S$ values for most samples (total range = -0.91 to 0.0 ‰). There is a negative correlation between $\Delta^{33}S$ and $\Delta^{36}S$ with a slope of ≈ -1, which is characteristic of Archean surficial sulphur. In addition, $\Delta^{33}S$ values approach magmatic values of ≈0 systematically with increasing distance from the country rocks.

These results support genetic models that involve locally derived sulphur for both deposits. In the case of Marathon, this likely reflects crustal contamination and assimilation of during emplacement of the TDLG, whereas at Geordie Lake, sulphur was likely added to the gabbros through subsolidus volatile transport.

Abstract ID: 35634

Final Number: MD14A-0258

Title: Stratigraphy and distribution of chromite in the Black Label deposit, McFaulds Lake greenstone belt, Superior Province, Ontario, Canada

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Abstract Body: The Black Thor Intrusive Complex (BTIC) is a semi-conformable sill-shaped intrusion that can be subdivided into: 1) a *lower ultramafic series* of basal olivine websterites and lherzolites, interlayered dunites and lherzolites with minor interstitial chromite, and overlying websterites, 2) a *middle ultramafic series* characterized by a lower chromitite horizon (Black Label), olivine websterites, lherzolites and dunites, and an upper chromitite horizon (Black Thor), and 3) an *upper ultramafic to mafic series* of websterites, mela/meso/leucogabbros and lesser anorthosites. A late pyroxenite composed primarily of websterite intruded the lower and middle ultramafic series and locally brecciated Black Label chromitites. Unbrecciated chromite-bearing rocks in Black Label have been divided into 6 textural facies: 1) massive, 2) semi-massive, 3) matrix-textured, 4) net-textured, 5) heavily-disseminated, and 6) lightly-

disseminated. Lithologies, textures, contacts, and bedding are similar within the unbrecciated SSW and NNE parts of the horizon, but distinct within the central brecciated part. Massive and semi-massive textures are more abundant near the feeder zone, whereas disseminated and net-textured are more abundant away from the feeder zone (NNE and SSW parts), and disseminated textures are more abundant in the NNE than in the SSW parts. It is possible to confidently make correlations of massive chromitites within the SSW parts over distances of up to 300m, and possibly up to 900m, but correlations are difficult in the NNE part as the chromite layers are very thin. The total amounts of chromite (integrated massive chromite equivalent) are greatest near the feeder, decrease away from the feeder, and are lowest in the NNE part. Mineralogical and geochemical investigations are in progress to establish whether the concentration near the feeder is attributable to mechanical sorting from a slurry or preferential in-situ crystallization.

Abstract ID: 35821

Final Number: MD14A-0259

Title: Platinum-Group Minerals in the Black Thor Mafic-Ultramafic Intrusive Complex, McFaulds Lake Greenstone Belt, Ontario

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Abstract Body: Several styles of Ni-Cu-PGE mineralization occur within the Black Thor Intrusive Complex and

PGMs have been characterized in 20 samples from 7 zones containing sulfide mineralization: 2 basal contact zones (AT-12 extension, basal contact), 3 magmatic breccia zones (NW breccia, Unnamed, F2), and 2 stratiform chromite horizons (Black Label, Black Thor). Host rocks include dunite, peridotite, chromitite, and granodiorite (footwall). The PGMs in contact zones are froodite with lesser michenerite, sperrylite, and unidentified Pd-Bi telluride, Pd-Bi-Sb, Rh-Ru-Ir sulfarsenide, Pt-Ir arsenide, and Rh-Ir sulfarsenide. Most PGMs are enclosed within pyrrhotite-pentlandite-chalcopyrite-cubanite, but are also associated with amphibole-chlorite-serpentine and occur along sulfide-silicate boundaries. Euhedral shapes, large grain sizes (>20µm), and the strong association with sulfides suggest a magmatic origin. The PGMs in the brecciated zones are paolovite, sperrylite, michenerite, and Hollingworthite with lesser unidentified Pt-Rh-Os sulfarsenide, Rh-Pt-Pd-Os sulfarsenide, and Rh-Pt-Ir arsenide. Most of the PGM occur within sulfides, some along sulfide-silicate boundaries, and only minor amounts within silicate phases. The associations suggest that they are magmatic, but anhedral habits and occurrences in high strain zones suggest post-magmatic mobilization. The PGMs in Black Label are paolovite associated with chalcopyrite with lesser froodite, michenerite, sperrylite, hollingworthite, and telluropalladinite in both sulfides and silicates. The PGMs in Black Thor are stibiopalladinite, arsenopalladinite, isomertieite, palladoarsenide, and majakite, with lesser sperrylite and polkanovite, all of which are enclosed in silicate phases. Many Pd-bearing PGMs in Black Thor occur in carbonate veins, suggesting that Pd was mobile during carbonate alteration, but the low but uniform abundances of PGEs in both stratiform zones suggest that they were also originally magmatic.

Abstract ID: 35833

Final Number: MD14A-0260

Title: Hybridized Ultramafic Rocks in the Black Label Hybrid Zone of the 2.7 Ga Black Thor Intrusive Complex, McFaulds Lake Greenstone Belt, Ontario, Canada

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Published Material: Geology section at SEG Keystone 2014

Abstract Body: The Black Thor Intrusive Complex (BTIC) is a sill-shaped, semi-conformable, layered intrusion that is composed primarily of dunite, lherzolite, Ol websterite, websterite, and chromitite overlain by lesser mela- to leucogabbro, and anorthosite. After emplacement but before complete crystallization, a Late Websterite Intrusion (LWI) reactivated the feeder conduit and transected the basal part of the BTIC, including the Black Label chromitite horizon. Detailed core logging shows that the injection of LWI magma leads to the incorporation of inclusions and production of a 1-10m thick marginal zone of heterogeneous, interfingering brecciation defined as the Black Label Hybrid Zone (BLHZ). The BLHZ contains dunite/lherzolite/chromitite enclaves of variable sizes (1-50 cm) with subangular to amoeboidal geometries, sharp to diffuse contacts, and significant amounts of disseminated to patchy net-textured Fe-Ni-Cu-(PGE) sulfide mineralization. The core of LWI is typically an inclusion-free, medium-grained, Opx-rich adcumulate with accessory Chr or Ol, however, inclusion-rich intervals of the LWI contain more Ol and Chr produced by disaggregation and partial assimilation of ultramafic units. There are two types of interclastic hybrid groundmass, one containing xenocrystic Ol and one containing xenocrystic Chr+Ol of varying proportions. Geochemical signatures of the hybrid rocks reflect the partial assimilation and brecciation of dunite/lherzolite/ chromitite sequences and addition of Ol+Chr in hybrid rocks. Similar Th-U-Nb-Ta-LREE patterns suggest that the LWI is related to the remainder of the BTIC, presumably representing a more fractionated magma from deeper in the system. Further characterization of the hybrid rocks and inclusion variability is in progress and will help to establish the range and variability of processes involved within the BLHZ, and their influence on the nature and distribution of brecciated chromitite and associated Fe-Ni-Cu-(PGE) sulfide mineralization.

Abstract ID: 35925

Final Number: MD14A-0261

Title: Base Metal Sulphide Minerals in the Upper Critical Zone (UCZ) of the Bushveld Igneous Complex (BIC)

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Abstract Body: We report on the distribution and textures of base metal sulphide minerals in mafic cumulates of the Upper Critical Zone of the western Bushveld Complex. Samples from a 828 m section of a single exploration borehole on Turffontein Farm 34 km east of Rustenburg were examined in the petrographic microscope and with scanning electron microscopy (SEM) with energy dispersive X-ray fluorescence spectroscopy for point analysis and mapping. Primary sulfide melt inclusions hosted by silicate primocrysts were not observed in any samples, but pockets of sulfide minerals associated with late-crystallizing interstitial phases including quartz, albite, biotite, rutile, and apatite are common. The samples include orthocumulate textured pyroxenite and chromitite, and

meso- to adcumulate textured norite, gabbronorite, and anorthosite. Two principal generations of sulfide minerals are recognized, based in part on the identities of the associated silicate minerals. In those instances where sulfide minerals occupy positions apparently interstitial to the magmatic silicate minerals with pristine textures, the sulfide mineral assemblage is pyrrhotite + chalcopyrite + pentlandite mainly associated with anhydrous minerals (quartz, pyroxene, albite, plagioclase). However most occurrences show hydrothermal overprints, being associated with pyrite, millerite, galena and commonly showing disseminated halos of chalcopyrite within zones of hydrous alteration (actinolite/tremolite, chlorite) of the host silicate minerals. Rare platinum group minerals (sperrylite, cooperite) were observed in samples from the Merensky Reef and the UG2, UG3, and MG4 chromitite layers. Other occurrences of sulfide minerals were hosted by grain boundaries and cleavage fractures of silicate minerals, indicating local transport and redeposition of sulfur and base metals during alteration. A possible interpretation of the observations is that later hydrothermal fluids may have potentially affected the origin of sulphide mineral inclusions.

Abstract ID: 36477

Final Number: MD14A-0262

Title: Geological Setting of the Marbridge Mine: Komatiite Hosted Ni-Cu Ore Deposit

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Abstract Body: The Marbridge Mine is located in the southeastern part of the Abitibi Sub-province, at the base of the Malartic Group within the La Motte-Vassan Formation (2714 Ma). The mine was in operation from 1962 to 1968 with a production of 700,000 tonnes of ore at 2.28% Ni and 0.17% Cu, from four lenses associated with komatiites. The study area is surrounded by various plutonic rocks (Preissac pluton; 2681-2660 Ma; La Corne pluton; 2680-2642 Ma and La Motte pluton; 2647 Ma). Regional metamorphism reaches the amphibolite grade and surrounding rocks are part of an intense deformation zone which is characterized by L-tectonites. The main schistosity (S1) is commonly oriented NW-SE and is overprinted by a subvertical crenulation cleavage (S2) generally EW associated with Z-shaped P2 folds. The lithogeochemical analyses of the various units has allowed to recognize two distinct suites: (1) a calc-alkaline suite consisting of andesitic, dacitic, rhyolitic units and various associated volcanic rocks; and (2) a tholeiitic suite, consisting mainly of komatiitic flows, basalts and ultramafic intrusions. The presence of intense sericitic and chloritic alteration in felsic volcanic units and strong epidote alteration in mafic volcanic units is compatible with an early “VMS” hydrothermal system in this sector. Finally, these data will be used to reconstruct the sequence of geological events that have affected the Marbridge mine area. This reconstruction will allow the definition of exploration tools in such metamorphosed ultramafic-mafic environments.

Abstract ID: 36746

Final Number: MD14A-0263

Title: Platinum Group Element Enrichment and Mobilization in the Mesamax and Expo Ni-Cu-PGE Magmatic Sulfide Deposits, Cape Smith Fold Belt, New Quebec

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Abstract Body: The Expo and Mesamax Ni-Cu-PGE magmatic sulfide deposits are hosted within the Expo Intrusive Suite (EIS). The EIS consists of rocks of dunite to gabbronorite composition which have been metamorphosed by the Trans-Hudson orogen to the greenschist facies dominated by tremolite-actinolite, serpentine and chlorite. Both deposits consist of lenses of massive sulfides mainly composed of pyrrhotite-chalcopyrite-pentlandite-magnetite overlain by net-textured and disseminated sulfides. Palladium and platinum are significantly enriched at the vicinity of the contact between the net texture and the massive sulfide (Pt content as high as 236.1 ppm) and also in association with late talc-carbonate alterations. The scope of this study is to investigate PGE enrichment and mobilization mechanisms occurring in both deposits. Samples from the inner and outer zone of Mesamax and Expo were selected for geochemical assays at the onsite lab (Au, Pt, Pd, Ag, Rh, Cr, Cu, Fe, Mg, Ni, Co). A second selection was made for petrography, SEM, X-Ray mapping and LA-ICP-MS, based on the texture (massive sulfide, net texture, veins or alteration zones) and the PGE/ Cu+Ni ratio. From the preliminary results, there is an association between PGEs and carbonate alteration which suggests that CO2-bearing fluids mobilized PGEs during later events.

Abstract ID: 35581

Final Number: MD14B-0264

Title: Study of multiparameter data on exploration drill core from the McLeod VMS deposit, Matagami mining district, Quebec

Presenter/First Author: Nathalie Schnitzler, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Québec,

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Abstract Body: The INRS mobile laboratory for the physical, chemical and mineralogical characterization of rocks acquires multiparameter data on exploration drill cores. The laboratory can measure nearly simultaneously and non-destructively the density, magnetic susceptibility, geochemistry and mineralogy of drill core, directly on their storage sites. This data supplements the visual core description made by the geologist and helps to discriminate spatially the lithologies and alterations related to the emplacement of VMS (or other) deposits.

The Bracemac-McLeod mine is located in the Matagami VMS district, in the northern part of the Abitibi Subprovince, Quebec. Three exploration drill cores were analyzed in summer 2014 and seven more are planned for summer 2015, for a total of over 6000 m spread over the McLeod deposit and up to 1 km to the east. Measurements are taken at 20-30 cm intervals, at specific spots determined by the geologist.

The large amount of data (several thousand measurement spots, over 20 variables) requires the use of statistical multivariate analysis methods to simultaneously interpret all data. In previous studies at Matagami (Fresia, Ross, Gloaguen & Bourke), cluster analysis was used to group the data point into classes (corresponding to the various lithologies defined by the geologist), on the basis of their physical and geochemical signatures. Also, Principal Component Analysis (PCA) helped determine the alteration zonation along the drill core and spatially between the studied drill cores. As part of the new MSc project, we will propose other multivariate

methods, and attempt to develop exploration vectors using the composition or concentration of some mineral groups derived from near-infrared spectrometry.

Abstract ID: 34960

Final Number: MD14B-0265

Title: Metamorphosed Hydrothermal Alterations of the Auriferous Lalor VMS Deposit and Relations with Ore Styles

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Co-authors: Patrick Mercier-Langevin, Geological Survey of Canada, Québec, Canada; Pierre-Simon Ross, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec City, Canada; Shamus Duff, , , ; Mark D Hannington, University of Ottawa, Ottawa, ON, Canada; Benoît Dubé, Geological Survey of Canada, Québec, Canada; Simon Gagné, , ,

Abstract Body: The Paleoproterozoic Lalor auriferous volcanogenic massive sulphide deposit in Snow Lake, Manitoba, is hosted in a complex volcanic succession referred to as the Lalor volcanic succession. The deposit consists of stratigraphically and structurally stacked Zn-rich, Au-rich and Cu-Au-rich ore lenses. The volcanic rocks that host the deposit were affected by intense and laterally extensive ore-related synvolcanic hydrothermal alteration. These altered rocks were subsequently subjected to syn-deformation amphibolite-grade metamorphism that resulted in the development of distinct minerals and metamorphic mineral assemblages of varying composition in response to variably altered precursors. Five distinct alteration- and metasomatism-related chemical associations (K, K-Mg-Fe, Mg-Fe, Mg-Ca and Ca) were defined based on the mineralogy (mineral assemblages) and geochemistry of the altered zones. Mapping of the host volcanic rocks and ore-related mineral assemblages and chemical associations at Lalor indicate that: 1) the bulk geochemistry of the ore-related alterations has largely been preserved despite metamorphic processes, and the primary alteration styles can be inferred, 2) the Zn-rich massive sulphide lenses are preferentially associated with the low- to high-temperature K and Mg-Ca alteration zones, 3) the Zn-rich massive sulphide lenses formed at two distinct stratigraphic positions as a result of protracted seafloor/sub-seafloor hydrothermal activity, 4) the Cu-Au-rich zones at depth are associated with transposed discordant high-temperature Mg-Fe altered rocks and presumably represent footwall feeders, and 5) the precious metals were in part locally remobilized into low-strain sites during the main deformation event and consequently are not currently spatially associated with one chemical association in particular.

Abstract ID: 35296

Final Number: MD14B-0266

Title: The Coulon volcanogenic massive sulphide deposit, Northern Quebec: context, structure, alteration and zonation

Presenter/First Author: Rose Anne Bouchard, Université du Québec à Chicoutimi, Chicoutimi, QC

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Co-authors: Vital Pearson, Mines Virginia Inc., Quebec, QC, Canada; Réal Daigneault, Centre d'études sur les Ressources minérales (CERM), Chicoutimi, QC, Canada

Abstract Body: The Coulon volcanogenic massive sulphides deposit (14 mt @ 1.3% Cu and 3.9% Zn), located in Northern Quebec, has been strongly deformed and metamorphosed in high grade conditions, and its primary characteristics have been modified. Within the study area near lenses 08, 9-25, 44 and 16-17, five lithological units have been recognized: amphibolite, and sillimanite-, cordierite-sillimanite-, cordierite- and cordierite-anthophyllite-bearing schists. The schist that contains porphyroblastic sillimanite corresponds to the main unit and is characterised by a well-developed planar fabric. However, proximal to the sulphide lenses, cordierite and anthophyllite porphyroblasts overprinting the structural fabrics are observed; and these minerals are likely the metamorphosed equivalent of minerals formed by chloritization (cf. Mg-alteration). Using the TiO2 vs Zr diagram to characterize the main groups of volcanic rocks, basaltic, andesitic and two types of rhyolite were discriminated. The area is characterized by a steeply dipping foliation associated to a D1 event overprinted by regional and local folds related to a D2 event. The main fabric (D1) strikes north-south in the northern part of the study area and is NE-SW trending in the southern portion. A steep stretching lineation is especially visible in the southern area, but is completely obliterated by metamorphic recrystallization in the northern portion. The massive sulphide lenses exhibit a pyrite-pyrrhotite-chalcopyrite-sphalerite-galena paragenesis. Generally of metric to decametric thickness, lenses extend up to 300 meters horizontally and to 700 meters vertically. The project investigate the geometrical and textural changes that the orebodies underwent as a result of metamorphism and deformations, with particular focus on the remobilisation problematics in the perspective of adjusting exploration guides.

Abstract ID: 36215

Final Number: MD14B-0267

Title: Deciphering the hydrothermal evolution of a VMS system using trace elements in pyrite by laser ablation ICP-MS: an example from the Bracemac-McLeod deposits, Abitibi, Canada and implications for exploration.

Presenter/First Author: Dominique Genna, Université du Québec à Chicoutimi, Chicoutimi, QC

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Abstract Body: Textural and chemical characterization of pyrite was used to reconstruct the hydrothermal evolution of the Bracemac-McLeod archean VMS deposits in the Matagami district, Abitibi, Canada. The mineralization is divided into a 1) zinc-rich zone, concordant to the Key Tuffite - a marker horizon at the district-scale, 2) a copper-rich zone and 3) some localized magnetite-rich zones replacing sphalerite and pyrite. Petrographic and LA-ICP-MS studies of whole pyrite grains from the Key Tuffite and from the different ore zones of the deposits provided the opportunity to investigate the distribution of trace elements in pyrite over a wide range of sulfide assemblages related to temperature. The study has revealed five pyrite types. Nodular pyrites (I) in the Key Tuffite and pyrites from the low temperature (250°C) zinc-rich zone (II) have the same chemical signature (significantly enriched in Sb and Tl) suggesting that both precipitated from similar physicochemical conditions. Pyrites from the copper-rich zone (III) have a different signature, enriched only in Se ± Co. These pyrites are related to later higher-temperature fluids (300°C). Pyrite preserved during a later magnetite-replacement (>350°C) stage (IV) are also characterized by enrichment in Se, but are depleted in all other elements. Similar signature is found in idiomorphic metamorphic pyrite (V), which occurs at the district-scale. During recrystallization of pyrite IV and V, only Ni, Co, As and Se are preserved whereas other base metals are expelled from the pyrite structure. Consequently, only Ni, Co, As, Se, Sb and Tl are useful to reconstruct the hydrothermal evolution of the VMS system and used to build a suite of discrimination diagrams. Specifically, the ratio Se/Tl can discriminate pyrites from mineralized Zn-rich zone

(Se/Tl<10), from pyrites associated with Cu-rich zone (10<Se/Tl<10000) and pyrites from non-economic parts of the deposit (replaced by magnetite or metamorphogenic; Se/Tl>10000).

Abstract ID: 35615

Final Number: MD22A-01

Title: Physical Rock Properties - The Quantitative Link Between Geophysics and Geology

Presenter: Vince Gerrie, DGI Geoscience Inc, Toronto, ON

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Co-authors: Patrick Hooker, , , ; Roxanne Leblanc, , , ; Pamela Patraskovic, , ,

Abstract Body: Comprehensive physical rock property measurements provide the critical quantitative link between geology and geophysics, thereby improving 3-D geologic modelling.

Machine learning, cluster analysis, and classical statistics are used to classify the rock into petrophysical (physical rock properties) domains and benefits of this classification scheme are discussed. Traditional lithological classification schemes, i.e. visual core logging, are compared to the rock property domains and methods to link geology to geophysics are explored. In addition, establishing relationships between petrophysical data and geometallurgical, geochemical, and geotechnical parameters to create proxy relationships are investigated and select case studies presented.

Additionally, in-situ structural measurements combined with structural analysis can aid in the development of structural models. Understanding the distribution of fault zones and their relationship with mineralization, can lead to better exploration targeting, and decreased operational risk.

Abstract ID: 35264

Final Number: MD22A-02

Title: INTEGRATING BOREHOLE GEOPHYSICAL, GEOLOGICAL AND GEOPHYSICAL DATA - PAST AND PRESENT

Presenter: Philip Hawke, Wireline Services Group, Perth,

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Abstract Body: In the past twenty five years, integration of surficial geological, geochemical and geophysical data has led to new mineral finds. Final success, however, is driven by drill results which provide key information used to define and delineate deposits. But integration of borehole geological, geochemical, and geophysical data is not routine. Here, we look at a case history including integrated results acquired at a strategic copper-cobalt deposit in Central Montana, U.S.A. Basic methods for working with different data are presented. We then advance forward to today's exploration environment and examine some of the developments in technologies that can now add even more to key drilling investments.

Geological, geochemical and geophysical logs were made available by BHP and under the supervision of a geologist and a consulting geochemist. One challenge was to find a means of handling this huge volume of data – one approach which is presented here. Geophysical logs were lightly filtered and integrated with geological logs, and a cross-section was derived totalling 700 m in length. Results concurred with the geologist's interpretation of stacked sulphide plates in a complex framework of thrust faults. Next, the geochemical data were brought into play by integrating irregularly sampled geochemical data with regular geophysical logs. Geophysical and geochemical data were then combined in a Factor Analysis study which derived factors to evaluate and map trends across the deposit.

Today, these tasks are easier with enhanced computing power and other evolutions. Now, new geophysical tools are available, including borehole radar and televiewers which map structure in situ. New processing techniques now enable high-end calibration of gamma logs in uranium exploration. And, logging is now possible past the end of drill rods, for faster and more economic results.

In summary, we provide a detailed look at how integrated borehole geology, geochemistry, and geophysics can provide a fresh look at deeper geology such as is being encountered more routinely today. With an enhanced look at the 3rd and most important dimension in mineral exploration, namely the drill hole, we can learn from the lessons of the past while thinking ahead to the next discoveries and the new technologies and approaches that can drive them.

Abstract ID: 35702

Final Number: MD22A-03

Title: Borehole Geophysical Logging During or just after Drilling : The developing technology of downhole Shuttle Probe survey systems

Presenter/First Author: Alan Robert King, Geoscience North, Sudbury, ON

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Abstract Body: A shuttle type borehole (BH) probe is a downhole geophysical logging system with sensor(s), on board memory, and battery power supply all together in the downhole tool. This configuration permits operation of the tool in a drill hole with no electrical or data connection to surface. Data is measured and stored downhole and is dumped from memory when the tool is returned to the surface.

This method of deployment inside the drill rods has a number of significant advantages including: -

- Elimination of loss of borehole probes. This is especially critical for expensive probes like BH televiewers or tools with small nuclear sources such as density probes.

- No more blocked holes. This is a problem in any area of unstable rock, but particularly in tropical environments where deep weathering often makes for an unstable interface between the drillhole casing through the overburden and the open hole in bedrock.

A number of groups around the world are working on a new generation of shuttle tools including:

DMT GmbH & Co. KG in Germany

- The Australian Deep Exploration Technologies Commonwealth Research Consortium (DET CRC)

- other industry groups

The available BH shuttle tools and current developments in the field will be reviewed with the goal of alerting potential users to the value of these systems as well as encouraging the development of practical, multi-sensor tools so that multiple key surveys can be done in a single pass on completion of every drillhole. Also potential applications to BH sensing systems other than those currently under development will be discussed.

BH Shuttle technology has the potential to provide most geophysical logs in most drill holes at little additional cost in money or time. The full development and deployment of these systems would be a tremendous step forward in our exploration and mine development process as well as in other geoscience fields including groundwater, petroleum and general earth imaging

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Abstract ID: 33388

Final Number: MD22A-04

Title: A New Logging-While-Drilling Approach for Natural Gamma Spectroscopy with Diamond Drilling

Presenter/First Author: Ida Hooshyari Far, Curtin University, Perth,

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Co-authors: Anton Kepic, CURTIN UNIVERSITY, Perth, Australia; Andrew Greenwood, , , ; Anna Podolska, , ,

Abstract Body: Spectral gamma ray logging has been desired, but not been adopted in slim-hole drilling, especially in hard-rock environments. The common drawbacks of conventional wireline approaches are either a lack of natural gamma radiation verses wireline pull-rate, or the use of a radioactive source, in order to develop an adequate gamma ray spectrum. Using a radioactive source allows measurements such a rock density or heavy mineral concentration. However, the isotopic radioactive source used in such measurements is undesirable due the possibility of losing the source.

This issue encouraged Researchers at Curtin University within the Deep Exploration Technology Commonwealth Research Centre to develop “Shuttle”, a novel approach to logging while coring, in diamond drilling. This new tool can measure natural gamma ray activity during drilling process. The data is retrieved when the rock core is pulled out periodically. Thus, the spectral data is retrieved every 1.5-3 m of drilling. Since drilling is a long process it provides adequate time for the Shuttle to collect data. Thus, high quality natural gamma ray spectroscopy can be performed as the spectrum for a 1m segment typically results from millions of gamma rays analysed. Obtaining a high quality gamma ray spectrum is highly important; since analysis is based upon the different types of gamma scattering can lead to better identification of rock types and underground formations.

We have used a prototype spectral gamma sensor using BGO crystal on a wireline to simulate the data that will be collected by a shuttle system to demonstrate the data quality anticipated as well as laboratory tests on concrete blocks with different materials to test data analysis techniques. Our preliminary results indicate that spectral data collected by the Shuttle will allow us to reliably measure K, U and Th concentrations plus indicate the presence of heavy minerals. The high quality spectra obtained opens the possibility of identifying other lithological properties just with natural radioactivity.

Abstract ID: 36220

Final Number: MD22A-05

Title: Decomposing the Electromagnetic Response of Magnetic Dipoles to Determine the Geometrical Parameters of a Dipole Conductor

Presenter/First Author: Jacques Kontak Desmarais, University of Saskatchewan, Saskatoon, SK

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Co-authors: Richard Stuart Smith, University of North Carolina at Chapel Hill, Chapel Hill, NC

Published Material: This presentation deals with two papers that were submitted to Exploration Geophysics. Both papers are currently under review.

Abstract Body: Interpretation of airborne electromagnetic (AEM) data is hampered by effects of system and survey configuration, and is often a challenge for experienced interpreters, particularly in situations when the conductor is off-line or not striking perpendicular to the flight line. Consequently, it is often difficult for explorationists to define the position and orientation of conductors and hence correctly locate and orient drill holes from AEM measurements. These difficulties associated with geophysical data interpretation may be surmounted using automatic data transformation or interpretation algorithms. These algorithms convert measurements of geophysical fields into physical properties of the ground through the application of simplifying assumptions. This study presents a novel automatic data interpretation algorithm for modelling airborne electromagnetic (AEM) data acquired over resistive environments, where the position and orientation of a dipole conductor is allowed to vary in three dimensions. The algorithm assumes that the magnetic fields produced from compact vortex currents are expressed as a linear combinations of the fields arising from dipoles in the subsurface oriented parallel to the three orthonormal Cartesian axes. In this manner, AEM responses can be represented as 12 terms. The relative size of each term in the decomposition can be used to determine geometrical information about the orientation of the subsurface conductivity structure. The geometrical parameters of the dipole (location, depth, dip, strike) are estimated using a combination of a look-up table and a matrix inverted in a least-squares sense.

Tests on synthetic models and field examples show that the algorithm is capable of extracting the correct geometrical parameters of a dipole conductor using a three-component receiver and one-component transmitter system. The algorithm is unstable when the conductor approaches axial-symmetry with respect to the traverse line. In light of this observation, we design a novel multicomponent-transmitter-receiver system capable of predicting the correct parameters for all conductor geometries.

Abstract ID: 34895

Final Number: MD22A-06

Title: Maximizing Subsurface Information Using a Multi-Parameter Airborne Survey Platform

Presenter/First Author: Peter Tschirhart, Sander Geophysics Ltd, Ottawa,

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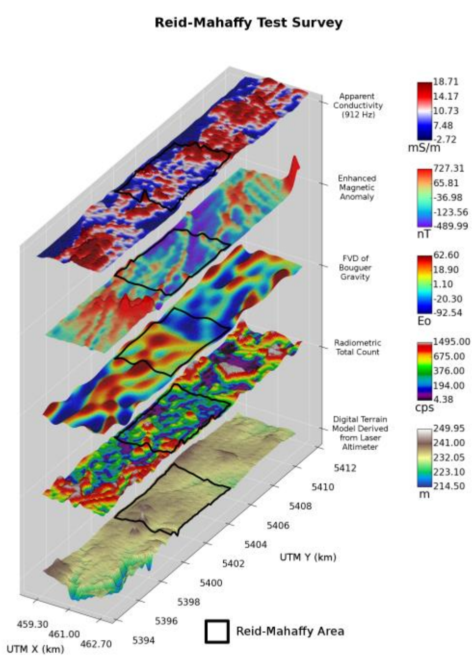
Co-authors: Luc Lafrenière, Sander Geophysics Ltd., Ottawa, Canada; Malcolm Argyle, Sander Geophysics Ltd., Ottawa, ON, Canada

Abstract Body: Sander Geophysics owns and operates a DHC-6 Twin Otter survey aircraft that is capable of acquiring multiple geophysical parameters simultaneously. Several complementary geophysical techniques including frequency domain electromagnetics, gravity, magnetics and gamma-ray spectrometry are used together to maximize subsurface information. Associated aircraft GPS data as well as radar and laser altimeter data are also recorded. The electromagnetic data is provided by SGL's SGFEM system, which is designed for high resolution, relatively shallow mapping, and consists of a four frequency (912, 3,005, 11,962, and 24,510 Hz) transmitter mounted in a wingtip pod and a receiver mounted in a pod on the opposite wing. Gravity data is provided by AIRGrav, a total field gravimeter designed and built by SGL specifically for the airborne environment, which is mounted inside the aircraft cabin. A total field magnetometer mounted in a rigid tail stinger provides the magnetic data, and a gamma-ray spectrometer with up to 3 boxes (50.4 litres downward facing, 8.4 litres upward facing) of sodium iodide crystals provides the radiometric data. A survey using this multi-parameter system was flown over the Reid-Mahaffy geophysical test site in Ontario to demonstrate the system's capabilities over a typical mineral exploration target with known geology and good depth control. Using a primary (traverse) line spacing of 200 m, a total of 315 lkm were flown over the test site and surrounding area at a speed of 90 knots (167 km/h) and at an altitude of 52m. The electromagnetic data have been reprocessed using new tools and techniques thereby significantly improving target details. An analysis using the electromagnetic data along with gravity, magnetic and radiometric data is presented and compared with forward models to illustrate the capabilities of this system.



Abstract ID: 36834

Final Number: MD22A-08

Title: Mining data from the mining industry: advice and possibilities for academic researchers

Presenter/First Author: Mark Shore, Magma Geosciences Inc, Nepean, ON

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Abstract Body: Cooperation between academic researchers and mineral exploration companies has been a productive avenue in many areas of economic geology, geophysics, and geochemistry. Over the past decade, structural changes in the mining industry and (at times severe) financial pressures on companies from small mineral exploration 'juniors' to giant integrated multinational mining companies has reduced the number and scope of such collaborative efforts.

However there are still opportunities for useful interchange between industry and academia. Some of the data available (much of which could be classified as 'grey' data or literature) will be described and strategies to identify, locate and obtain it will be described.

Mineral exploration often generates vast amounts of data that may be examined intently by a small corporate group for a very specific purpose over a short period, then set aside. Such data may be of great value to other potential users. Typical examples include airborne geophysical surveys collecting data on the Earth's magnetic field, gravity, conductivity and radioactivity, which can be invaluable in mapping bedrock or surficial deposits over large areas and delineating large and small scale faults and folds.

Other data may include large-scale surveys of soil, water or lake sediment geochemistry and whole rock or trace element analyses of rock in outcrop or drill core. Samples may be collected from otherwise inaccessible or very costly sites, such as in remote field areas, in deeply weathered or glaciated terrain, underground mines, or deep drill holes.

Researchers must recognize the limitations of such data. Analytical work may not be performed to the levels of accuracy expected in research, samples collected for one purpose may not be entirely suited for another, and timetables and goals may be very different between a company exploring for a mineral deposit and a Ph.D. candidate working on a thesis project. I will describe strategies to minimize such conflicts.

Abstract ID: 36581

Final Number: MD23A-01

Title: Economic aspects of Terrestrial Impact Structures

Presenter/First Author: John G Spray, University of New Brunswick, Fredericton, NB

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Abstract Body: Impact structures on Earth have played a significant role in the creation and preservation of economic deposits, including metal ores and hydrocarbons. In Canada, well-known structures include Sudbury, renowned for its world-class Cu-Ni sulfides and associated platinum group element deposits; Manicouagan for facilitating a ~6000 MW hydroelectric generating capability; and Steen River for multizone oil and gas potential, along with numerous buried craters within the Williston Basin (e.g., Viewfield, Sakatchewan). Key processes associated with economic deposit development include (1) fusion of crustal rocks to create a melt body that fractionates and so concentrates immiscible and/or dense phases that are rich in metals; (2) creation of fractured, permeable rock volumes to act as reservoirs for hydrocarbons; (3) creation of basins that can preferentially accumulate hydrocarbons; (4) formation of traps and seals through generation of impact melt sheets and/or impermeable frictionally-fused fault systems; (5) creation of hot rock-water hydrothermal systems that can precipitate economic volumes of metals (e.g., within the Onaping Formation at Sudbury). Critical to exploiting the economic potential of impact craters is to understand their internal structure, especially in terms of syn- to post-impact tectonics. Many of the larger surviving craters on Earth have been modified since their formation, making the distinction between impact-generated features and subsequent overprinting effects challenging. This presentation will review examples of terrestrial impact structures exhibiting economic potential; both proven and pending. Key structural controls will be reviewed as a guide to exploration rationale for both metals and hydrocarbons, as well as other uses (e.g., waste storage).

Abstract ID: 35896

Final Number: MD23A-02

Title: Structural evolution of the Otish Basin: a Paleoproterozoic polymetallic-uranium rich meteorite impact structure, Québec, Canada

Presenter/First Author: Normand Goulet, University of Quebec Montreal, Montreal,

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Co-authors: Serge Genest, , Crabtree, QC, Canada; Francine Robert, Groupe Omegalpha Inc, Crabtree, QC, Canada

Abstract Body: The evolution of the Palaeoproterozoic sedimentary Otish Basin (OB), located in northern Québec, was mainly developed on the southeastern margin of the Superior craton. The OB lay unconformably on the Archean basement, covering an area of about 5200 km², averaging a thickness of 2,4 km and sitting north of the Mesoproterozoic Grenville province. The evolution of the OB has been disturbed by a major meteorite impact responsible for a widespread gabbro emplacement at around 2.1Ga. Shocked derived material (glass and PDFs) are observed in the sediments under the gabbro sheet and inside the large enclaves found in the gabbro itself that could be interpreted has a melt/breccia sheet. The gabbro has been emplaced in an extrusive manner according to their distribution and their physical relationship with the sediments.

A regional brittle-ductile deformation, possibly related to the Hudsonian orogeny (1.85 Ga), affected all the units of the OB. The main stress component was oriented NW-SE producing folding and overthrusting to the NW. The OB is an overturned syncline with a shallow plunge to the SW and later offset by NW and NNE conjugate faults. A correlation with the timing of the deformation of the Sudbury structure could possibly be proposed. The major deformation is pre-Grenvillian and post-Archean. Major faults and fractures were developed or reactivated along some ring or radial dykes formed during the meteorite impact. The morphological oval shape of the OB combine with the arc shape of the Mistassini Basin (MB), adjacent to the SW, with shatter cones of uncertain age, lead us to consider the MB as an element of our puzzling huge structure for which the postulated radius of the relevant structure is well over 250 km.

Mineralised hydrothermal fluid rich in uranium (1.7 Ga) and polymetallic (Cu, Au, Pb, Ag) deposits are filling early Proterozoic fractures and faults zones affecting both the OB and the Archean basement.

Abstract ID: 35384

Final Number: MD23A-03

Title: Meteorite Impact Related Uranium Occurrences in the Otish Basin, Quebec, Canada.

Presenter/First Author: Serge Genest, , Crabtree, QC

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Co-authors: Francine Robert, Groupe Omegalpha Inc, Crabtree, QC, Canada

Abstract Body: The Proterozoic Otish Basin is well known for its uranium potential. Although the unconformity model has been used for prospection since its beginning, the main bodies discovered within the basin are obviously derived from strong hydrothermally driven enriched fluids. The Lavoie uranium ore body defined in 1985 and its neighbouring Epsilon showings clearly show a structural pattern relevant to a tangential tectonic transport towards the northwest. The surrounding rock units have suffered strong and pervasive alterations. The alteration pathways were mainly controlled by the capping of the sedimentary rock pile by a thick gabbroic unit. The presence of a carbonate unit reaching locally 50 meters in thickness favoured the stacking northwesterly. For many decades the tectonic modelling was founded around the hudsonian event as well as the Grenville Front because of its proximity to the basin. The exploration in this area now faces new facts. The recent discovery of planar deformation features (PDFs) must be taken into account for enlightening the mechanics involved in ore genesis in the Otish basin. PDFs have been found within the sandstone units in the eastern half of the basin up to 1000 meters in depth. The distribution of those PDFs in sandstone seems to be limited to the west by a major N010°-N020° faulting zone, i.e. the Indicator discontinuity. PDFs have also been observed in a large plurimetric enclave observed at the base of the overlying gabbroic unit. This later unit is interpreted here as a melt sheet related to a major meteorite impact event which is tentatively dated at 2,1 Ga, an interpretation also supported by the absence of feeding dykes noted throughout the basin as well as by its spatial relationship with the PDFs distribution in the underlying sandstone units.

Abstract ID: 35335

Final Number: MD23A-04

Title: A Meteorite Impact Origin for the Chibougamau Formation, Québec, Canada: towards a New Interpretation of the Chibougamau-Mistassini Mining Camp.

Presenter/First Author: Francine Robert, Groupe Omegalpha Inc, Crabtree, QC

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Co-authors: Serge Genest, , Crabtree, QC, Canada; Guillaume Courtois, , , ; Normand Goulet, University of Quebec Montreal, Montreal, Canada

Abstract Body: The Chibougamau Formation (CF) is an assemblage of conglomerate, arkosic sandstone, graded laminite and diamictite resting unconformably on the Archaean basement. The main outcrops of the CF occur around the Chibougamau area. They are bounded by SW-NE faults in a kind of semi-grabben. The upward movement of the southeastern compartments has been related to a subsequent tectonic event. The CF has been firstly described as a mixture of sediments with an igneous component such as diabase. Later, it has been compared to the Gowganda Formation (GF, Cobalt Group, Ontario) and interpreted as a glaciogenic rock. Because of the correlation between the GF and the CF, and the lack of carbonate fragments, the CF has been dated pre-Mistassini Group (which is rich in dolomite). Glaciogenic tenant searchers have never found a striated fragment or a specific iron-shaped one. While participating to a field trip organized by the CIM in 1984, the second author noted some sedimentary incongruities within the diamictite. Since then, the CF has been the subject of studies by our group and subsequently interpreted as a meteorite impact fallout. More recently, a master thesis work dealing with petrography on three sites of the CF has been performed by the third author in order to validate the new interpretation. Results cannot be more

conclusive: shock metamorphism has affected numerous large fragments and micro-fragments in the matrix (planar deformation features (PDFs), maskelinite and glass). Further studies of the CF yielded more information: up to 3 sets of PDFs in feldspars, quartz and other minerals, ballen texture, toasting on feldspars and quartz, brown glass fragments, some of calcitic origin, and some spherules. Moreover, a large outcrop observed in the Mt Radar area shows micro-breccias associated with flowing glass in a carbon-rich fine grain matrix. The finding of well expressed black carbonate fragments in the CF is of interest. Did the CF postdated the Mistassini Group?

Abstract ID: 36045

Final Number: MD23A-05

Title: Progress in the Search for a Major Meteorite Impact Structure in the Palaeoproterozoic Kisseynew Domain and Flanking Volcanic Belts, Manitoba, Canada

Presenter/First Author: Eckart Buhlmann, Organization Not Listed, Flin Flon,

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Abstract Body: Central Manitoba is underlain by the Kisseynew Domain, a basinal structure flanked by the Palaeoproterozoic Flin Flon- and Snow Lake volcanic belts to the south and the Lynn Lake and Leaf Rapids volcanic belts to the north. The volcanic belts are important present and past metal producers from VMS type copper-zinc-gold deposits. Lithogeochemical data of host rock to VMS ores were examined. It was found that the Flin Flon and Lynn Lake deposits have a strong magmatic component. Tholeiitic volcanics and gabbros pre-concentrate copper and produce copper-rich hydrous fluids. The open question is the source of the thermal energy to create large volumes of iron-rich magma. Meteorite impacts would deliver sufficient energy to generate the required temperatures and melt volumes. Some indirect pointers to a major crater were observed: In the Palaeoproterozoic Kisseynew basin at several locations outliers of Ordovician limestone are noted, suggesting local depression. Several VMS deposits along the boundary between underlying Amisk volcanic and overlying Missi clastic sediments show large scale signs of fluidization. This is expressed in major pegmatoidal bulges of pegmatized and dispersed ore along the otherwise sheet like ore horizons. Many graphitized fault zones can be traced for tens of kilometers and suggest possible remnants of a transient crater. The VMS deposits derive their copper from mafic volcanic and gabbroic rocks. A large impact would have created the necessary volume of high temperature melt. The various signs observed lend support to the hypothesis for a major impact as the energy source. Future work will benefit by using the impact hypothesis to refine our understanding of the process. This will lead to defining targets of higher potential for future ore searches.

Abstract ID: 36227

Final Number: MD23A-06

Title: Impact-Generated Hydrothermal Systems and Associated Mineralization: A Case Study at Manicouagan

Presenter/First Author: Sarinya Paisarnsombat, University of New Brunswick, Fredericton, NB

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Abstract Body: Impact-associated hydrothermal alteration is manifest in various locations within the Manicouagan structure of Quebec, Canada. Major hydrothermal systems are developed in the east of the structure, where associated mineralization is manifest as veins, vugs, and geodes. This work focuses on zeolitization (the predominant hydrothermal activity) and SiO_2-phase mineralization. Within the central uplift (comprised of anorthositic gneiss), thomsonite and natrolite (Thm-Ntr) have been deposited as veins (thickness of ~2-3 cm) in more intact host rocks, and as more pervasively distributed occurrences in more fractured rocks. Analcime is mainly associated with shock veins, which locally pervade the central uplift. Thm-Ntr is also commonly developed as veins within basal suevite (melt-bearing brecciated rock) as a result of labradorite alteration occurring beneath the impact melt sheet; IMS (i.e., between the IMS and footwall rocks). SiO_2 phases occur as colourless and purple (amethyst) varieties at different locations within the IMS. Fluid inclusion and oxygen isotope determinations reveal that mineralization of SiO_2 phases occurred at ~225 to 430°C. High salinity fluids (14-26 wt% NaCl eq.) in the absence of salt (NaCl) crystals suggests Ca^{2+}-rich hydrothermal activity (with more limited Na^{+} mobilization). The $\delta^{18}O$ values indicate that magmatic fluid was involved in the production of SiO_2 phases within the upper unit of the IMS ($\delta^{18}O_{fluid}$ range from +0.81 to +7.67‰), while fluids involved in geode formation at the base of the IMS were derived from metamorphic origins ($\delta^{18}O_{fluid}$ range from +17 to +23.17‰). Both formations appear to be closed systems, and are not connected; which suggests low permeability of the IMS body. Based on the $\delta^{18}O$ results, there is no evidence of meteoric water being involved in the hydrothermal phases at Manicouagan.

Abstract ID: 35882

Final Number: MD23A-07

Title: Deformation and Structural Controls at the Broken Hammer Deposit: Sudbury, Ontario

Presenter/First Author: Marshall Francis Hall, Laurentian University, Lively,

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Co-authors: Bruno Lafrance, MERC, The Goodman School of Mines, Laurentian University, Sudbury, ON, Canada; Harold Lorne Gibson, MERC, Department of Earth Sciences, The Goodman School of Mines, Laurentian University, Sudbury, ON, Canada

Abstract Body: In the Sudbury District, Cu-Ni-Platinum Group Element (PGE) footwall deposits are hosted by the basement rocks underlying the ca. 1.85 Ga Sudbury Igneous Complex (SIC). The SIC is interpreted as a differentiated impact melt sheet, which was flattened into its present elliptical shape during the 1.85 Ga – 1.80 Ga Penokean Orogeny. Footwall deposits are subdivided into "sharp-walled" vein and "low-sulphide" PGE-rich mineralization, the latter expressed by thin sulphide veinlets and disseminations. The Broken Hammer deposit, which is located in Archean rocks in the North Range of the SIC, is a hybrid footwall-type deposit containing sharp-walled massive sulphide vein and low-sulphide PGE-rich mineralization. It contains an indicated resource of 259, 500 tonnes grading 0.88% Cu, 0.1% Ni, and 12.14 g/tonne total precious metals (TPM). The deposit is mined as an open pit operation, which provides a unique opportunity to study the 3D geometry and the emplacement of the veins. The veins range in thickness from 1 to 50 cm and are composed primarily of chalcopyrite, millerite and platinum group minerals. The dip on the veins ranges from steep (>60°) to moderate (40° to 50°) and the veins are typically thicker where they change orientation to more shallow dips. The veins have three main strike orientations: 070°, 130°, and 190°. The intersection of all these veins is coincident with the trend (220°) and plunge (30°) of the main ore body, suggesting that the veins formed during a single deformation event. The latter corresponds either to the collapse of the floor of the Sudbury structure during the modification stage of the impact, to the Penokean orogeny, or to a combination of both occurring simulataneously.

Abstract ID: 34241

Final Number: MD24A-0268

Title: Magnetotelluric and Controlled-Source Electromagnetic Study of Aquistore CO_2 Sequestration Site, near Estevan, Saskatchewan

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First Author Student?: No

Co-authors: Ian J Ferguson, University of Manitoba, Winnipeg, MB, Canada

Published Material: Preliminary results of this research were included in a poster presentation at the EMIW meeting in Weimar, Germany, August, 2014

Abstract Body: Pre-injection magnetotelluric (MT) and controlled-source electromagnetic (CSEM) surveys at the Aquistore carbon sequestration site, Estevan, Saskatchewan are being used to determine the capability of surface electromagnetic (EM) methods for monitoring an injected CO_2 plume. MT is being used to characterize the background resistivity structure of the Williston Basin and local EM noise conditions, and CSEM is being tested for its ability to delineate the target and the overlying resistivity structure. There are a number of challenges in imaging the CO_2 plume with surface EM techniques, including the > 3 km depth of the storage complex, conductive Mesozoic rocks above the target, and the high EM noise environment. Analysis of pre-injection MT data from surveys conducted in 2013 and 2014 demonstrates the ability to measure accurate MT responses across the site, defines a dominantly 1-D resistivity structure, and delineates a period band (0.125 to 6.667 s) of strong EM noise. Theoretical modeling shows that for a colinear electric-dipole transmitter and receiver configuration, and offsets of < 10 km, the CSEM response is sensitive to shallow (<1 km) resistivity but provides limited resolution of a resistive plume at the injection depth. Analysis of CSEM data collected at the site in 2013 using frequency-domain and time-domain methods shows that the signal from a 0.5 Hz, 29400 A.m bipole source can be accurately detected to offsets of at least 4 km.

Abstract ID: 36221

Final Number: MD24A-0269

Title: Combining Spatial Components and Hilbert Transforms to Interpret Ground-Time-Domain-Electromagnetic Data

Presenter/First Author: Jacques Kontak Desmarais, University of Saskatchewan, Saskatoon, SK

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Co-authors: Richard Stuart Smith, University of North Carolina at Chapel Hill, Chapel Hill, NC

Published Material: This is a presentation which deals with a paper that was submitted to GEOPHYSICS. The paper is currently under review.

Abstract Body: We present a method for displaying or imaging data from a ground-time-domain-electromagnetic system and for extracting the geometrical parameters of a small conductor. The parameters are determined directly from the data using combinations of the spatial components of the secondary fields and their Hilbert transforms. The position of the target coincides with the peaks of the Energy Envelope or the T-component of the response. Here, the Energy Envelope is the square root of the sum of the squares of the three spatial components and their Hilbert transforms, whereas the T-component response is an analogous quantity that excludes the Hilbert transform terms. Studies on synthetic models indicate that the T-component response is sharper than the Energy Envelope in the majority of possible target orientations. Once the position of the body has been determined using the peak of the T-component response, the dip of the target can be quantified using the ratio of the full width at half magnitudes of the T-component response and the T-component Hilbert transform response, which is analogous to the Energy Envelope, but excludes the untransformed quantities. Finally, once all other geometrical parameters have been determined, the depth of the target can be evaluated using the full width at half magnitude of the T-component response. The proposed modeling method was tested over an anomaly acquired at the Coulon field site during an InfiniTEM survey in the Abitibi greenstone belt of Quebec. The extracted geometrical parameters are consistent with the available geological information.

Abstract ID: 34030

Final Number: MD24A-0270

Title: Tools Used in Mineral Exploration for Measuring the Conductivity and the Resistivity in Drill-Holes and on Drill Core: Observations on Their Range of Sensitivity.

Presenter/First Author: Richard Stuart Smith, University of North Carolina at Chapel Hill, Chapel Hill, NC

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Co-authors: Devon Parry, , , ; Omid Mahmoodi, , ,

Published Material: This paper has been submitted to Exploration Geophysics and is undergoing revision

Abstract Body: A study has been undertaken to acquire conductivity data using the EM39 low-induction-number conductivity tool. Measurements were taken in three holes in the Sudbury, Ontario, area: at Victoria in the south west part of the Sudbury structure; at Levack, in the North Range; and at the Lady Violet deposit near Copper Cliff. These data were compared with pre-existing data acquired using other tools and measurements taken on core extracted from the holes. The comparison shows that each tool has a finite range of sensitivity. The resistivity tool used by DGI is sensitive to conductivities in the range 0.01 to 100 mS/m; the EM39 is sensitive to conductivities in the range of ~30 mS/m to 3000 mS/m and the IFG to conductivities greater than 30 mS/m. In the sub-ranges where the ranges of two instruments overlap, one might expect a good correlation between the measurements derived from the two tools. However, this is not always the case, as the instruments can have a different volume of sensitivity: the EM39 has a coil separation of 50 cm and will see material greater than 20 cm away from the hole; whereas the IFG conductivity tool seems to have a smaller spatial scale of sensitivity due to its 10 cm coil separation. The handheld instruments used to log the conductivity of the core are sensitive to more conductive material (greater than about 1 S/m). The scale of the sensors of these handheld instruments is a few cm, so they are focussing on a very local estimate. The spatial characteristics of the handheld instruments are similar to the IFG tool, so there is a reasonable linear correlation between the conductivities derived from these three different instruments. However, the slopes are not unity; for example, the GDD instrument giving values three times greater than the KT-10. When selecting tools for measuring the resistivity and conductivity, ensure that the values that you expect to measure fall within the range of sensitivity of the instrument and that the features sought are comparable in size to the volume of sensitivity.

Abstract ID: 36728

Final Number: MD24A-0271

Title: Empirical Discrimination Between Graphitic And Sulfide-Rich EM Conductors And Application To VMS Exploration In Abitibi, Québec

Presenter/First Author: Silvain Rafini, CONSOREM, Chicoutimi, QC

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Abstract Body: For historical reasons, the exploration of VMS in Abitibi always focused on the bimodal-mafic type, such that strategies were restricted to isolated EM anomalies and coexisting mafic and felsic volcanics. EM anomalies located along formational or structural linear conductors into sedimentary and mafic environments, which constitutes 90 % of Abitibi volcanics, hence were occulted and their potential for less conventional pelitic and mafic-pelitic VMS ignored.

In these environments, a major exploration problem is to detect the occurrences of massive sulfide bodies embedded into graphitic formations. Two avenues are investigated in an attempt to solve this issue:

Numerous MEGATEM anomalies that are caused by conductors of known geochemistry and/or mineral composition were compiled in order to empirically analyze the correlations between the attributes of these anomalies and the graphite vs sulfide component of the conductor, using advanced statistical methods. This led to the introduction an original index, I1, equal to the ratio of *ontime* on *offtime* early channels. I1 is statistically shown to encompass most of the total variability of EM responses and to have a potential for graphite/sulfide discrimination.

The second avenue consists in analyzing the EM longitudinal variations along some graphitic linear conductors into which massive sulfides occurrences are known from drillholes, in the aim of constraining their EM signature in such highly conductive environment. The hypothesis tested here was that the superposition of vortexes induced separately by graphite and the massive sulfides should generate a sudden increase of the EM response, exceeding the background longitudinal variations caused by progressive changes of the graphitic or primary sulfides component. This theory turned to be remarkably validated. The known massive sulfide bodies were very confidently identified by abrupt changes in three parameters: the total energy envelope at channel 12, the decay constant TAU, and the I1 index.

This demonstrated that massive sulfide bodies along graphitic conductors can be detected by analyzing the 1D longitudinal variations of EM responses which, in other words, simply comes to raise the base level. The original methodology was hence used to generate numerous first class exploration targets in Abitibi.

Abstract ID: 34124

Final Number: MD24A-0272

Title: Delineation of Extension of Uranium Mineralization using Noise Assisted Empirical Mode Decomposition of VLF EM data

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Co-authors: Shashi Prakash Sharma, Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur, India

Abstract Body: The Beldih open cast mine of the South Purulia Shear Zone (SPSZ) in Eastern India is well known for apatite deposits associated with Nb–rare-earth-element–uranium mineralization within steeply dipping, altered ferruginous kaolinite and quartz–magnetite– apatite rocks with E–W strikes at the contact of altered mafic–ultramafic and granite/quartzite rocks. A detailed Very Low-Frequency Electromagnetic (VLF-EM) study has been carried out around South Purulia Shear Zone to investigate the lateral extension and depth extent of the subsurface structures associated with uranium mineralization. The VLF-EM data in the study area was contaminated by non-stationary and nonlinear noises (mainly power line disturbances) where the noises could not be removed by conventional filtering methods. Therefore, to recover signals with considerable geologic information is must. For this purpose present work used empirical mode decomposition (EMD) technique. With the help of this data processing technique, the VLF-EM data was enhanced toward quantitative inversion results with satisfying accuracy. The analyses have been accurate in depicting the possible structures associated with uranium mineralization. Accuracy of the present data processing technique is also demonstrated on synthetic data. In the present work actual current density has been optimized at actual depth using a new computational procedure.

Abstract ID: 34059

Final Number: MD24B-0275

Title: Lithological and Structural Control of the Emerald Occurrences South of Singhbhum Shear Zone within the Singhbhum Crustal Province, Eastern Indian Craton

Presenter/First Author: Shreeram Suman Sahu, Indian School of Mines, Dhanbad,

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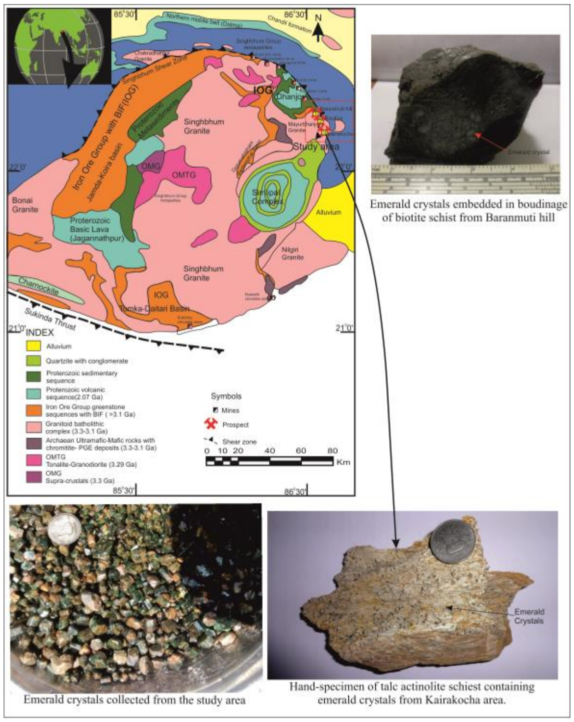
Co-authors: Sahendra Singh, , ,

Abstract Body: Emerald is the chromium and vanadium bearing variety of beryl (Be3 Al2Si6O18) with a "grass green" primary hue and a slender yellow or blue secondary hue. Globally, this gem variety is known to be hosted by Pegmatites, schists with or without pegmatites and within veins and breccia of black shale. In this work we have reported new area of emerald occurrences, where mineralization occur within the schist with or without pegmatities as intrusive, along a north-south oriented 25km long belt near Singhbhum Shear zone within the Eastern Indian Craton. Emerald occurrences in the study area is confined within biotite schist, talc-actinolite schist and show evidences of lithological and structural control. The detailed microstructural and chemical analysis of beryl, emerald, amphibole, mica, tourmaline, quartz and chlorite indicate that the syn to post tectonic mineralization may be correlated with magmatic activities, post-magmatic hydrothermal activities and regional-metamorphic event. These rocks contain 3000–5000 ppm Cr, and behave as source rocks to supply the Chromium for the crystallization of emeralds. The basement rocks within the area is an ensemble of migmatised gneisses, mica schists, granite gneisses and amphibolites along with widely scattered small bodies of ultramafic rocks, intensely invaded by pegmatite and quartz veins. This work reveal that regional metamorphism and tectono-metamorphic processes during shear zone deformation might have played a significant role in the formation of emerald deposits. The Singhbhum shear zone provides an ideal condition for emerald crystal growth, where the beryllium bearing hydrothermal fluid interacts with chromium bearing mica schist or ultramafic rocks.

Key word: Emerald, Pegmatites, Singhbhum, Lithology, Structure, Singhbhum Shear Zone



Geological map of Singhbhum Crustal Province, showing Emerald occurrences

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Abstract ID: 36077

Final Number: MD24B-0276

Title: Geology and Initial Resource Estimate of the Zoned, Complex-Type, Li-rich Pakeagama Lake Pegmatite, Northwestern Ontario, Canada

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Co-authors: Garth L Drever, Raven Minerals Corp., Toronto, ON, Canada; Peter J Vanstone, , , ; T Kurtis Kyser, Queen's University, Kingston, ON, Canada

Abstract Body: The Pakeagama Lake pegmatite is a zoned, Li-Cs-Ta (LCT) pegmatite located 175 km north of Red Lake, Ontario. The pegmatite occurs near the margin of the Pakeagama Lake granitic pluton, which intruded proximal to the Bearhead Lake Fault Zone that separates the Sachigo and Berens River domains of the Superior Province. More than 2,400 metres of drilling in 14 drill holes and 21 channel cuts have revealed a significant Li deposit, with an inferred resource estimate of 6.8 Mt averaging 1.56% Li_2O, 105 ppm Ta_2O_5, and 0.30% Rb_2O.

Mineralogically similar to the Tanco pegmatite in southeastern Manitoba, the Pakeagama Lake pegmatite displays intermittent wall zones and three main intermediate zones, which are the Upper Intermediate Zone (UIZ), Central Intermediate Zone (CIZ), and Lower Intermediate Zone (LIZ). The UIZ is dominated by spodumene + quartz intergrowth (SQUI) after primary petalite with lesser grey K-feldspar + mica, and represents the highest grade Li zone within the pegmatite (including 4.2% Li_2O over 18 m). The CIZ consists of predominantly coarse (up to 0.5 m in length) K-feldspar with lesser quartz and mica. Significant portions of this zone display replacement of K-feldspar by a dark to purple-coloured lithian mica + quartz assemblage which hosts euhedral blue apatite. These micaceous zones also contain pollucite (the primary ore mineral of Cs) blebs and the highest Ta grades found to date in the pegmatite (including 236 ppm Ta_2O_5 over 19 m). The LIZ comprises the bulk of the exposed pegmatite and contains predominantly K-feldspar, Na-feldspar, SQUI, lithian muscovite, and rare pollucite. Based on electron probe microanalysis (EPMA), spodumene throughout the pegmatite contains low concentrations of impurities such as Fe, making the ore suitable for use in the manufacture of specialty glass and ceramic products. Lithian micas contain high Rb contents based on EPMA, with concentrations as high as 2.75 wt.% Rb_2O.

The pegmatite has an elongated oval shape striking in a northwesterly direction and dipping steeply to subvertical to the southwest, and is in contact with metasediments along the footwall. Initial indications are the pegmatite represents at least the second intrusion event along a linear structure that had previously been intruded by tantaliferous (up to 1350 ppm Ta_2O_5 in a grab sample) banded sodic aplite.

Abstract ID: 36099

Final Number: MD24B-0277

Title: Feldspar and Quartz Crystals Unveil the Petrogenesis of the Lithium-rich Moblan Pegmatite (Quebec)

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Published Material: Experimental evidence for the supersaturation of pegmatite-forming melts in Li-aluminosilicates was presented in the GSA meeting in Vancouver in October 2014 and the GAC-MAC conference in Fredericton in May 2014. Part of the findings summarized in this abstract have been submitted for publication to the journal Contributions to Mineralogy and Petrology.

Abstract Body: The main sill of the Moblan spodumene-pegmatite in Quebec is characterized by simple aplite and albite-rich wall zones that surround a central core rich in quartz and spodumene. The Li concentration of the core is estimated at approximately 13000 ppm with feldspar and quartz crystals from various zones of the pegmatite incorporating up to 350 ppm Li. The simple mineralogy and restricted dimensions of the wall zones, the elevated Li concentration of quartz and feldspar crystals and the unusually high Li content of the core suggest extreme enrichment of the pegmatite-forming melt in Li prior to emplacement.

The Li concentration of the main minerals from different zones of the Moblan pegmatite is used in combination with experimental results in order to evaluate the Li enrichment of the granitic melt that generated the central sill. The Li concentration of the melt that coexisted with Li-rich feldspar and quartz crystals can reach up to ~7000 ppm, suggesting supersaturation of the pegmatite-forming melt in Li-aluminosilicate phases. In addition, the uncommon geochemical signature of Li in feldspar can be used as a useful exploration tool for the identification and targeting of Li-rich pegmatites.

Abstract ID: 36584

Final Number: MD24B-0278

Title: Location and Characterization of Pegmatites in the Southern Baffin Island Region, Nunavut: Field and Satellite Observations

Presenter/First Author: Alia Bigio, University of New Brunswick, Fredericton, NB

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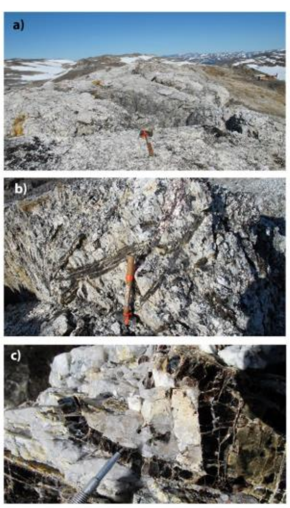
Co-authors: David Richard Lentz, University of New Brunswick, Fredericton, Canada; Paul Budkewitsch, , ,

Published Material: The paper on which this poster is based will have been published by the time the conference occurs, in the Summary of Activities 2014, Canada-Nunavut Geoscience Office.

Abstract Body: A number of granitic pegmatite dykes intrude the country rock on Hall Peninsula, southern Baffin Island, Nunavut. The aim of this project is to study the distribution, composition and petrogenesis of a select number of these pegmatites and evaluate their metallogenic potential. We anticipate that this research will highlight any rare metal, rare-earth element, and/or gem potential in pegmatites on Hall Peninsula, to companies that are interested in those commodities, with an emphasis on Sn, Li, Cs and Ta in particular.

This project will also include an examination of the source of parent melts, relative paragenesis, timing with respect to late orogenic evolution, and absolute ages of emplacement. Lithogeochemical and mineral-chemical analysis of the pegmatites is being done using whole-rock geochemistry and laser-ablation, multiple-collector, inductively coupled plasma–mass spectrometry (LA-MC-ICP-MS). In-situ field analysis of pegmatites for higher-than-background radioactivity also took place using a GR-135 Plus spectrometer in order to prioritize pegmatites for geochronological work.

A broader regional context has been added to this project through the use of pegmatite samples obtained from both the Cumberland and Meta Incognita peninsulas. As pegmatites are not generally large targets, and can be easily overlooked in larger scale mapping projects, an attempt is being made to develop an approach that can identify them using various remote sensing methods.



Abstract ID: 33661

Final Number: MD31A-01

Title: Platinum-group Element and Associated Trace Elements Distribution in Pyrrhotite, Pentlandite, Pyrite and Chalcopyrite - Implications for the Formation and the Exploration for Magmatic Nickel and PGE Deposits.

Presenter/First Author: Sarah-Jane Barnes, Université du Québec à Chicoutimi, Saguenay, QC

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Published Material: Contribution Mineralogy Petrology 06, Chemical Geology 08, Economic Geology 11, 12, 13 Mineralium Deposita, 10, 11, 12 Canadian Mineralogists, 13

Abstract Body: In order to fully exploit the vast potential of the LA-ICP-MS analysis in studying Ni and Platinum-group element (PGE) ore deposits it is necessary to understand which mineral is controlling the element of interest. This is particularly important for the PGE as they can be present both in sulphide minerals and in platinum-group minerals (PGM). With the aim of establishing which minerals control which PGE we have studied well characterized samples from type-examples of Ni and PGE deposits. By considering: the petrography, the whole rock composition, and the trace element content of the sulphide minerals we can calculate a mass balance and deduce which mineral is controlling each element and try to deduce which process was important in the controlling each element.

Pyrrhotite, pentlandite and pyrite host most of the Re, Os, Ir, Ru and Rh, except if As is present, in which case Ni, Co, Ir and Rh arsenides or sulfarsenides form. Pentlandite contains 20-40% of the Pd present in most deposits, with the balance in PGM. Almost all of the Pt is present as Pt minerals, although some can be present in pyrite. Pyrite also contains most of the elements that pyrrhotite contains. Chalcopyrite contains very little of the PGE budget. These results are consistent with collection of the PGE by a magmatic sulphide liquid followed by partitioning of Re, Os, Ir, Ru and Rh into the first sulphide mineral to crystallize (MSS). MSS exsolves to form pyrrhotite and pentlandite at lower temperatures and the minerals inherit the PGE that were present in MSS. Platinum and Pd generally concentrate into the fractionated sulfide liquid and crystallize as PGM from this liquid. Pyrite replaces pyrrhotite and in some case pentlandite in some deposits.

The distribution of the PGE among the sulphide minerals and PGM can also used in exploitation of the deposits, in particular the importance of pyrite as host for Rh has not been fully recognized. Although sulphide minerals do not survive transport very well if they are present in a heavy stream or glacial mineral separate then high Rh contents in pyrite would be a good indicator of the presence of a nearby Ni or PGE deposit. Similarly if pentlandite or pyrrhotite are present and they contain Os, Ir, Ru, Rh and, in the case of pentlandite, Pd this is a positive sign for a Ni or PGE deposit.

Abstract ID: 34499

Final Number: MD31A-02

Title: The Use of Pentlandite and Pyrite Compositions for Exploration

Presenter/First Author: Charley Duran, University of Quebec at Chicoutimi UQAC, Chicoutimi,

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Co-authors: Sarah-Jane Barnes, Université du Québec à Chicoutimi, Saguenay, QC, Canada; John Corkery, , ,

Abstract Body: We have analyzed pentlandites and pyrites of sulfide-rich pods from the Lac des Iles Pd-deposits (Western Ontario, Canada) using LA-ICP-MS. In comparing our data with those from the literature, we noticed that pentlandites from primary PGE deposits are significantly enriched in Pd and Rh relative to pentlandites from Ni-Cu sulfide deposits. We also noticed that pyrites found in magmatic Ni-Cu-PGE deposits are enriched in Co and Se and depleted in Sb and As relative to pyrites found in low-temperature hydrothermal deposits (e.g. orogenic gold deposits and volcanogenic-hosted massive sulfides). A plot of Pd vs Rh in pentlandite appears to be effective at distinguishing pentlandites from primary PGE deposits to those from Ni-Cu deposits. In addition, a plot of Co/Se vs Sb/As in pyrite allows to distinguish pyrites from magmatic settings to those from hydrothermal settings. In detrital rocks such as tills, pentlandite and pyrite can be found in the heavy mineral fraction. Therefore, the two plots that we developed can be used in exploration to fingerprint potential targets. Furthermore, we identified that the primitive-mantle normalized patterns of pentlandites derived from primitive magmas (e.g. layered intrusions, flood basalts, and ultramafic intrusions and flows) are different to those of pentlandites derived from evolved magmas (e.g. andesites). Thus, the geochemical signature of pentlandite may be used to infer the nature of its parental magma. This result can be of key importance to adapt exploration strategies.

Abstract ID: 34040

Final Number: MD31A-03

Title: Platinum-group Elements and Au in Mantle Sulphides and their Contribution to Porphyry Cu-Au Deposits

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Abstract Body: The geochemical characteristics of many porphyry Cu-Au deposits reflect mantle contributions. One such characteristic is a relatively high content of PGE compared to Au-poor porphyry deposits. PGE in porphyry deposits consist mainly of Pd with lesser amounts of Pt. In porphyry Cu-Au deposits, the average Pd+Pt content of ore varies from 1 to 100 ppb. Pd to Pt ratios are typically >1 and range as high as 70. Iridium-group PGE (IPGE: Ir, Os, Ru and Rh) generally occur at very low levels and are rarely reported.

Sulphides are the major repository for PGE and Au in the mantle. Primitive mantle averages about 15 ppb Pd+Pt and 1.7 ppb Au. In contrast, Pd+Pt contents of mantle sulphides range from 500 ppb to nearly 300 ppm and Au contents vary from 30 ppb to 300 ppm. Mantle sulphides form two distinct populations. One consists of spherical Fe-Ni monosulphide solid solution (mss) inclusions primarily in olivine. These tend to be rich in IPGE and depleted in Pd relative to Pt. The second population consists of irregular-shaped, intergranular Cu and Ni sulphide grains that are Pd-rich and relatively depleted in IPGE.

Cu- and Ni-rich mantle sulphides are crystallization products of a Cu-Ni-rich sulphide melt that coexisted with mss. During partial melting in the upper mantle, mss globules remain trapped within restitic rocks, whereas the Cu-Ni sulphide droplets are entrained in mantle-derived magmas that can ascend to higher levels in the crust. If these hot mafic melts are injected into colder felsic magma, they can vesiculate as they cool, producing mafic foam of reduced bulk density that contributes to convection in the felsic magma (Eichelberger, 1980). Examples of mafic foam occur in the McGerrigle Complex in the Gaspé Peninsula. Supercritical aqueous fluids generated by vesiculation destabilize the sulphides and concentrate the metals and sulphur. These fluids are the most likely source of Pd and Pt, and also much of the Cu, Au and sulphur, in porphyry Cu-Au deposits.

Abstract ID: 35569

Final Number: MD31A-04

Title: Contrasting Os, Ir, Ru and Rh Content between Volcanic and Plutonic Chromites: Petrogenetic and Provenance Tools

Presenter/First Author: Philippe Pagé, Sciences de la Terre, Université du Québec à Chicoutimi (UQAC), Chicoutimi,

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Co-authors: Sarah-Jane Barnes, Université du Québec à Chicoutimi, Saguenay, QC, Canada

Abstract Body: The introduction of a new generation of LA-ICP-MS allowed us to analyze the Os, Ir, Ru and Rh (IPGE) contents of chromite from samples representative of different geological settings including MORB, boninites, komatiites, Hawaiian tholeiite, continental flood basalt picrite, and from chromitites of podiform type deposits from ophiolitic mantle section and of stratiform type deposits from large layered intrusions including Great Dyke, Stillwater, Black Thor and Bushveld complexes. In addition, chromites from ultramafic sills of the Bushveld Complex have also been analyzed as well as disseminated chromites from komatiitic massive sulfides. Our results confirm that chromite acts as an important phase in controlling the whole rock budget of Ru, but this role is generally shared with other phases like laurite (RuS2). However, chromite only plays a minor role on the fractionation of Os, Ir and Rh, accounting for < 50% of their whole-rock budgets. Other Os, Ir and Rh phases are needed to account for whole rock Os, Ir and Rh concentrations. Most primitive mantle normalized IPGE profiles of chromite show RuN>RhN with the exception of boninite and arc lavas which tend to show RuN<RhN. The chromite from each different setting has distinctive PGE normalized profiles that can be used to identify parental magma. For example the chromite from the chills of the Bushveld lies between komatiites and picrite rather than boninite. Also, sulfide segregation prior to chromite saturation has a dramatic effect on the concentration of the chalcophile elements (Os, Ir, Ru, and Rh) which preferentially partition into the sulfide melt leaving a IPGE-poor silicate melt from which chromite crystallize. The use of IPGE content of chromite as a diagnostic provenance tool is of great interest to determine geological settings and the sulfide mineralization potential of ultramafic - mafic rock assemblages of uncertain origin, and of detrital chromites from covered terrains.

Abstract ID: 35336

Final Number: MD31A-05

Title: Fe-Ti Oxides Composition in Archean Fe–Ti–V–(P)-bearing Mafic-Ultramafic Intrusions of the Superior Province: a Geochemical Evolution Tracer

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Co-authors: Michel G Houlé, Laurentian University, Sudbury, ON, Canada

Abstract Body: The concentration of trace elements in magnetite and, to lesser extent, ilmenite is controlled by their environment of formation, which makes Fe-Ti oxides useful petrogenetic tracers and suitable indicator minerals for exploration.

We report magnetite and ilmenite composition from two Neoarchean Fe–Ti–V–(P)-bearing intrusions of the Superior Province, the Big Mac mafic intrusion (McFaulds Lake area, Ontario) and the Pyroxenite de baie Chapus (James Bay, Quebec). In both intrusions, the chemical composition of Fe-Ti oxides in compatible (*e.g.*, Al, Mg, V, Ni, Cr) and incompatible elements (*e.g.*, Ti, Mn, Zn) in mafic magmas shows a strong geographic-control,

independently of the lithologies and the proportion of Fe-Ti oxides, that tracks efficiently the magmatic fractionation and indicates the way up of each intrusion. These results are also supported by lithofacies distribution, geochemistry, and silicate mineral chemistry. All together, these data help to constrain the internal stratigraphy and thus to target the most prospective areas to host Fe-Ti-V mineralization.

Furthermore, the magnetite from these intrusions has significantly lower Ti+V contents than expected and plots within the hydrothermal deposits field in the Ni/(Cr+Mn) *vs* Ti+V and Ca+Al+Mn *vs* Ti+V discrimination diagrams rather than within the Fe-Ti-V deposit field. Considering that this Fe-Ti-V deposit field was mostly defined based on Fe-oxides hosted within Proterozoic and Phanerozoic Fe-Ti deposits, preliminary results highlight the possible existence of a distinctive Archean signature of magnetite from the Fe-Ti-V oxides-bearing intrusions. In the light of these results, further investigations are needed to better understand which factors control this distinctive Archean signature of magnetite and to constrain the use of these discrimination diagrams for magnetite to fingerprint the mineral deposit types.

Abstract ID: 36822

Final Number: MD32A-01

Title: Applications and implications of trace element chemistry and elemental mapping of ore minerals to hydrothermal ore deposit discrimination and genetic models

Presenter/First Author: Daniel Kontak, Mineral Exploration Research Centre, Sudbury, ON

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Published Material: some components of this havd bee presnted at previous meetings, but the overall theme of the talk has not been presented and in that context original.

Abstract Body: Hydrothermal ore systems are the end products of thermal anomalies and fluid fluxes that result in local chemical anomalies (i.e., ore deposition and alteration zones). The magnitude and duration of these thermal anomalies vary among ore systems with, for example, orogenic gold deposits having greater longevity than magmatic driven ore systems, which also implies longer fluid flux. The advent of *in situ* micro-analysis of minerals using LA ICP-MS has provided the means to not only determine the abundances of a wide range of trace elements to low detection limits, but to also examine elemental coupling-decoupling and elemental paragenesis, the latter best portrayed with element maps. In the Chemical Fingerprinting Lab at Laurentian University, multiple projects have generated mineral-specific databases which provide the basis for: (1) assessing minerals as potential ore-deposit discriminators; and (2) interpreting the origin of elemental coupling-decoupling and paragenesis in a variety of ore minerals and deposit settings. The trace element data for chalcopyrite and scheelite, both of which have inter-deposit uniformity, are used to illustrate their ability to chemically discriminate multiple ore systems due to intra-deposit variance (e.g., orogenic gold, porphyry Cu(-Au), vein Sn-W, VMS, IOCG). In contrast to the general uniform chemistry of chalcopyrite and scheelite, that of arsenopyrite and pyrite, in particular from orogenic gold deposit settings, record large elemental variance, elemental decoupling, and complex elemental zoning. These latter observations provide indirect evidence of ore-system longevity and complexity. This new technology has provided, therefore, the means to not only geochemically discriminate ore systems using single mineral phases, but to also decipher another aspect of ore deposit models, this being their longevity and involvement of single or multiple reservoirs.

Abstract ID: 35715

Final Number: MD32A-02

Title: Scheelite chemistry and its use as an indicator mineral for hydrothermal ore deposits

Presenter/First Author: Rémy S. Poulin, Laurentian University, Sudbury, ON

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Co-authors: Daniel Kontak, Mineral Exploration Research Centre, Sudbury, ON, Canada; Andy McDonald, Mineral Exploration Research Centre, Sudbury, ON, Canada; Beth McClenaghan, Geological Survey of Canada, Ottawa, ON, Canada

Abstract Body: Scheelite occurs in a variety of ore-deposit settings, including Cu-Mo-W porphyries, skarns and polymetallic veins. Furthermore, as it is resistant to both chemical and physical weathering and has a high specific density, it is often encountered in tills. As part of a comprehensive crystal-chemical study testing its use as a pathfinder and ore discriminator, scheelite from 34 deposits was examined using a variety of methods (e.g., trace elements, $\delta^{18}O$, SEM-EDS, cathodoluminescence (CL)). Despite using an extensive element list, only Mn, As, Sr, Y, Mo and the REEs showed regular and significant levels of enrichment above their LOD. Results indicate scheelite is chemically complex with broad ranges in the investigated parameters: (1) crystal zonation (absent to normal, oscillatory. discordant); (2) minor-element chemistry: Mn (≤LOD to 531 ppm, As (≤LOD to 2320 ppm), Sr (14 to 11480 ppm), Y (≤LOD to 1370 ppm) and Mo (≤LOD to 99500 ppm). This chemistry shows a small intra-deposit variance, but a large inter-deposit variance; (3) REEs data which indicate: (i) a lack of apparent correlation between REEs and the type of CL observed despite previous suggestions to the contrary; (ii) considerable variation in ∑REEs from ≤LOD to 5306 ppm; (iii) a single chondrite-normalized (CN) pattern, for a suite, but rarely a second pattern is noted; (iv) similarity of CN REE patterns (i.e., flat, convex, concave) among deposit types; and (v) both positive and negative Eu anomalies (≤ 0.1 to > 50); and (4) $\delta^{18}O$ values from -4.6 to +9.1‰. The dataset, the most comprehensive for scheelite, suggests that there is a large variation in the parameters examined and considerably expands the data base for this mineral compared to that in the present literature. This dataset may also provide insight into the fluid evolution of ore deposits possessing a complex paragenesis and will serve to establish a basis for further applied crystal-chemical studies of this mineral phase.

Abstract ID: 34263

Final Number: MD32A-03

Title: Hydrothermal Influence on Zircon from the Kiruna IOA Ores - A Comprehensive Geochemical Study of Zircon Crystals from the Kiruna Iron Apatite Ore District in the Norrbotten Region of Northern Sweden

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Co-authors: Anne Westhues, Memorial University of Newfoundland, ST. John's, NL, Canada; John M. Hanchar, Memorial University of Newfoundland, St John's, NL, Canada; George R Rossman, Caltech, Pasadena, CA

Abstract Body: The iron deposits located in the Norrbotten (Kiruna) region of northern Sweden are the type-locality of apatite iron oxide (IOA) deposits. The origin of these deposits has been debated for several decades. There are two current theories of the ore genesis of the Kiruna deposits: 1) iron oxide extracted from an immiscible silicate liquid-iron oxide melt; or 2) iron oxide transported and subsequently emplaced by hydrothermal fluids. Zircon grains were separated from the Kiirunavaara ore, adjacent hanging wall and footwall host rocks, and spatially related syenite and granite intrusions. BSE and CL images of the ore zircon reveal

xenocrystic cores that are overgrown by "spongy", inclusion-rich hydrothermal rims. Zircon crystals from the syenite intrusion contain veins and patchy zones resembling alteration and resorption textures. Zircon from the host rocks and the granite exhibit typical igneous growth zoning. Selected zircon crystals were analysed using the EPMA for Zr, Si, Hf, Ca, Fe, Y, and P, and revealed the zircon grains from the volcanic host rock and granite to be of near stoichiometric composition. Zircon crystals from the ore and syenite contained elevated Fe and P concentrations and have low analytical totals. EPMA elemental X-ray maps reveal Fe rich inclusions, veins and/or zones in zircon crystals from the ore and syenite. Similar features are not found in host rock or granite zircon. FTIR spectroscopy done on selected zircon grains from the ore and syenite revealed that they contained several weight percent of H_2O. This suggests that zircon from the ore and syenite intrusion experienced post-crystallization hydrothermal fluid alteration. A high temperature (~600-700°C) magmatic fluid(s), at the magmatic-to-hydrothermal transition, possibly exsolved from the intrusions, seems the most likely heat and fluid source to have remobilised the iron, possibly locally derived, and concentrated it in the massive iron oxide deposits located at Kiirunavaara.

Abstract ID: 36434

Final Number: MD32A-04

Title: Trace element systematics of footwall and hanging wall alteration associated with volcanogenic massive sulfide deposits of the Bathurst Mining Camp, Canada: developing LA-ICP-MS methodology for phyllosilicates and its application as geochemical vectoring tool in exploration

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Abstract Body: An innovative approach using *in situ* LA-ICP-MS of phyllosilicates in and around massive sulfide deposits of the Bathurst Mining Camp (BMC) is presented, which compliments existing work on sulfides in the same context. LA-ICP-MS is a powerful tool to study the composition, to sub-ppm levels, of phyllosilicates in fine-grained contexts. Moreover, lack of any special sample preparation (only polished thin sections) and cost efficiency for examining a large number of grains (100s of analyses per day) make this methodology practical in both academic and applied projects. The main purpose of this study is establishing trace element variations of the key hydrothermal alteration assemblages associated with VMS deposits of the BMC to introduce its application in exploration.

Chlorite and white mica are the most abundant minerals in different hydrothermal alteration assemblages throughout the BMC. Chlorite is a major silicate constituent, forming with the massive sulfides (disseminated to sub-massive sulfides) and exhalative sedimentary rocks along mineralized horizons. White mica is also ubiquitous in quartzo-feldspathic volcaniclastic rocks, clastic, and exhalative sedimentary rocks. In comparison to chlorite, white mica accommodates higher concentrations of As (from detection limit (4.13 ppm)-1.12 wt. %), Sb (<0.2-4750 ppm), Tl (<0.03-697 ppm), and Hg (0.16-67 ppm), whereas Cd (<0.07-420 ppm), In (0.02-384 ppm), and Bi (0.02-185) are more enriched in chlorite. Phyllosilicate chemical dispersals along the studied drill holes are variable for different elements.

Compositional variations of phyllosilicates demonstrate that some of trace elements, such as As, Sb, and Tl form the most extensive halos related to the mineralization. Chemical distributions in stratigraphic profiles of studied deposits display the highest anomalies proximal to the ore lenses for As, Sb, and Tl values, ranging from 11-39 ppm, 1.29 to 185 ppm, and 3 to 223 ppm, respectively. Somewhat analogous to lithogeochemistry, proximal to distal signatures of trace elements can be observed in several 10s of meters distance from the ore horizons. Therefore, this study introduces mineralogical trace element vectors in mine-scale exploration that can be potentially examine at unexplored areas of the BMC, as well as in other VMS districts.

Abstract ID: 36368

Final Number: MD32A-05

Title: In-situ LA-ICP-MS trace elemental analyses of magnetite: the late Palaeoproterozoic SokomanIron Formation in the Labrador Trough, Canada

Presenter/First Author: Diane Chung, University of Hong Kong, Hong Kong,

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Co-authors: Mei-Fu Zhou, University of Hong Kong, Hong Kong, China; Jian-Feng Gao, , , ; Wei Terry Chen, University of Hong Kong, Hong Kong, China

Published Material: The findings are reported in a scientific paper which has been accepted by Ore Geology Reviews. It is available online on 16 October 2014 and will be published in March 2015. Chung, D., Zhou, M.-F., Gao, J.-F., Chen, W.T., 2015. In-situ LA-ICP-MS trace elemental analyses of magnetite: the Palaeoproterozoic Sokoman Iron Formation in the Labrador Trough, Canada. Ore Geol. Rev., 65, 917-928.

Abstract Body: The Sokoman Iron Formation in the Labrador Trough, Canada, a typical granular iron formation (GIF), is coeval with the ~ 1.88 Ga Nimish volcanic suites in the same region. It is composed of the Lower, Middle and Upper Iron Formations. In addition to primary and altered magnetite in iron formations of the Hayot Lake, Rainy Lake and Wishart Lake areas, magnetite in volcanic breccia associated with the iron formation is identified for the first time in the stratigraphy. Trace elemental compositions of the most primary, altered and volcanic brecciated magnetite of the Sokoman Iron Formation were obtained by LA–ICP-MS. Commonly detected trace elements of magnetite include Ti, Al, Mg, Mn, V, Cr, Co and Zn. These three types of magnetite have different trace elemental compositions. Primary magnetite in the iron formation has a relatively narrow range of compositions with the depletion of Ti, Pb, Mg and Al. Magnetite from volcanic breccia is rich in Ti, Al, V, Mn, Mg, Zn, Cu and Pb, indicative of crystallization from mantle-derived magmas. Altered magnetite in the iron formation shows a relatively wide range of trace elemental compositions. Mineralizing fluids associated with magmas that generated the ~ 1.88 Ga Nimish volcanic suites circulated through the sedimentary piles to further enrich the iron formations and to form magnetite with variable compositions. The comparisons of different types of primary and altered magnetite in the iron formation in the region show distinct provenance discrimination. Our findings also support the origin of iron formations in association with multiple stages of exhalative volcanic and hydrothermal processes.

Abstract ID: 36517

Final Number: MD32A-06

Title: Magnetite chemistry as a provenance indicator in Archean metamorphosed sedimentary rocks: Implications for mineral exploration.

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Co-authors: Sarah Dare, Université du Québec à Chicoutimi, Saguenay, QC, Canada; Pierre A. Cousineau, UQAC, Chicoutimi, QC, Canada; Jean Goutier, Géologie Québec, Rouyn-Noranda, QC, Canada

Abstract Body: We used magnetite compositions to determine the provenance of amphibolite metamorphic grade alluvial sediments from the Magin and Keyano formations, situated in the La Grande area of the Archean Superior Province of Canada. Magnetite is common in a wide range of depositional environments and can be formed throughout a range of temperatures, from low temperature hydrothermal to high temperature magmatic environments. We used a new analytical technique (LA-ICP-MS) to determine a wider range of trace elements at lower concentrations. The detrital magnetite data was plotted on multi-element diagrams. This revealed that the most discriminant elements that were used to differentiate four potential different sources for the Magin formation are the elements most compatible into magnetite. Overlap between the spectra of the Magin and Keyano formations prove the existence of a common source for them both. Our results show that detrital magnetites have low Ti values that could be either magmatic (felsic) or hydrothermal in origin. The spectra of detrital magnetite from the sediments were compared to magnetite spectra from fragments of banded iron formation and tonalite, which are present in the conglomerates and represent the potential sources in the study area. However, only magnetites from tonalite have a signature similar to those from the sediments. A detailed LA-ICP-MS study of magnetite from ten felsic plutons, sampled in close proximity to the sedimentary formations, allowed us to recognize that each pluton has a particular signature with a wide variation in Ni and Cr. Thus two individual plutonic sources were identified for both sedimentary formations using magnetite chemistry. Using our large dataset of magnetite from felsic rocks we have evaluated the current magnetite discrimination diagrams used for mineral exploration. We show the importance of identifying low Ti magnetite from felsic rocks which could be misidentified as magnetite from hydrothermal mineral deposits. We propose to plot magnetite data first on the Ti vs. Ni/Cr diagram which allows the identification of low Ti magnetite of felsic magmatic (low Ni/Cr) from hydrothermal (high Ni/Cr) origin. After this screening process the existing magnetite discrimination diagrams from the literature can be used with more confidence for mineral exploration.

Abstract ID: 33342

Final Number: MD33A-01

Title: Alkali Carbonatite Melt Inclusions in Volcanic Carbonatites from Kerimasi Volcano, Tanzania

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Abstract Body:

The Trig Point Hill debris flow, originating from Kerimasi volcano (Tanzania) contains numerous blocks of extrusive/pyroclastic carbonatites similar to those exposed at the rim of the currently inactive crater. The blocks of calcite carbonatite consist of: (1) large clasts of corroded and altered coarse grained calcite; (2) primary prismatic inclusion-bearing phenocrystal calcite; and (3) a matrix consisting primarily of fine grained prismatic calcite . The large clasts are inclusion free and exhibit a ‘corduroy-like” texture resulting from solution along cleavage planes. The resulting voids are filled, in part, by brown Fe-Mn- hydroxides/oxides. The prismatic or lath shaped phenocrystal calcite is not altered and contains melt inclusions consisting principally of primary Na-Ca-carbonates in which are set earlier-formed crystals of monticellite, periclase, apatite, Mn-Mg magnetite, Mn-Fe-sphalerite and Nb-perovskite. The Na-Ca-carbonates consist of (wt.%): 19-20 Na_2O; 30-31 % CaO; 2-3 % K_2O; 1-2 % SO_3; and 0.4-0.6 %SrO. Although the Na-Ca-carbonate composition is similar to that of shortite, this phase is not considered as a secondary mineral formed after nyerereite. Periclase is Fe-bearing with up to 13 wt.% FeO. The matrix in which the “corduroy” clasts and phenocrystal calcite are set consists of closely-packed small stubby prisms of calcite lacking melt inclusions, with interstitial fine grained apatite, barite, strontianite, and minor fluorite. Pore spaces are filled with secondary Mn-Fe hydroxides/oxides, anhydrite and gypsum Although the compositions of the Na-Ca carbonate inclusions do not correspond to those of nyerereite.The presence of primary K-S-bearing Na-Ca carbonates as melt inclusions suggests that the magma which formed these calcite carbonatites could differentiate to natrocarbonatite-like residua.

Abstract ID: 33755

Final Number: MD33A-02

Title: Mineralogy, Geochemistry REE bearing Alkaline Plutons in and around Ananthapur and Chittor districts, Andhra Pradesh, India

Presenter/First Author: Raju Pvs, National Geophysical Research Institute, Hyderabad,

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Abstract Body: Preliminary assessment of REE (rare earth elements) and rare-metal potential and geochemical characterization, with implications for metallogeny, is currently underway at alkaline syenite complexes in Andhra Pradesh. The alkaline complexes are located to the west and south-west of the Paleoproterozoic Cuddapah basin in the Ananthapur district. Several alkaline plutons ± nephyline syenite earlier reported by GSI, were relooked for REE bearing minerals and their REE contents. (Around Dancherla,Peddavaguru, Danduvaripalle,Reddypallae, Chintalchervu areas) and Pulikonda complex in Chittor districts of Andhra Pradesh. The main Dancherla syenite body is oval-shaped and has a total area at the current level of exposure of around 18 km2. It consists of medium- to fine grained mesocratic syenite, leucocratic, porphyritic and quartz syenite in cross-cut relations with diabase-hornblendite dyke swarms. The SEM and microscopic studies revealed REE bearing minerals like Eudeilyte, Zircon, Sphene (Fig 1), Allanite ((Fig.2), Apatite (Fig 3), REE enriched (Fig 4) with opaques and Fe oxide phases.The total REE in one of alkaline plutons with Nephline bearing syenites is 800 ppm.The Major element distributions show simple trends of decreasing MgO, FeO, P_2O_5 and TiO_2 contents with increasing SiO_2. Bulk-rock chemical analyses gave > 8 wt.% Na_2O, > 5 wt.% K_2O, low CaO and MgO contents (< 5 wt.%) and ~16 wt.% Al_2O_3. In binary Na_2O+K_2O vs. SiO_2 diagrams, the samples plot in the nepheline syenite field. Our preliminary geochemical data suggest enrichment in light REE and flat heavy-REE distribution in chondrite-normalized patterns. In some samples, positive Eu anomalies were detected, suggesting plagioclase enrichment. The maximum La and Ce concentrations recorded thus far are 200 and 350 ppm, respectively. Binary diagrams showing variations in Hf-Zr and Nb-Ta ratios show a positive correlation and indicate an overprint from externally derived fluids.

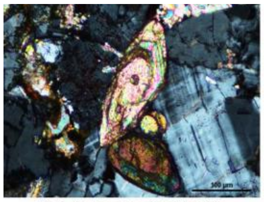

Fig 1. Sphene bearing Syenite

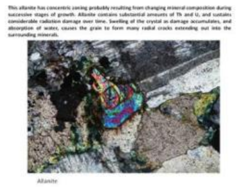

Fig 2. Allanite bearing syenite

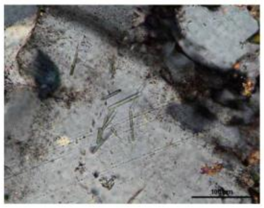

Fig 3 Apatite crystals

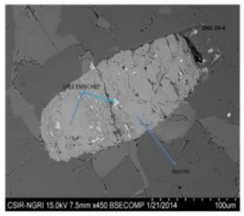

Fig 4 REE enriched

Abstract ID: 35573

Final Number: MD33A-03

Title: The Petrosomatic Evolution of Magmatic Rocks through Distinct Mantle Pulses: Insights from Montviel Alkaline Complex, Canada

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Co-authors: Michel Jebrak, UQAM, Montreal, QC, Canada; Ross Stevenson, Universite du Quebec a Montreal, Montreal, QC, Canada

Published Material: Some of these results were presented at GAC-MAC and Goldschmidt in 2014. This is now a manuscript in preparation.

Abstract Body: Magmatic volatiles are of paramount importance for the petrogenesis of igneous rocks but are so evanescent that some of the processes in which they are involved are not yet fully understood, sometimes not even recognized. Although their role is relatively well understood in some systems, more research is required to improve our understanding of their behavior in mantellic and crustal magmatic-hydrothermal systems. In order to investigate the roles of magmatic volatiles during petrogenesis, the Paleoproterozoic alkaline complex of Montviel was studied. The 1.894 Ga alkaline intrusion consists of clinopyroxenites, melteigites, ijolites, melano- to leucosyenites, riebeckite granite, silicocarbonatites, calciocarbonatites, magnesiocarbonatites, ferrocarbonatites, mixed carbonatites and a polygenic breccia and host the Montviel world-class-level, carbonatite-hosted REE-Nb deposit. Field and drill core relations and geochemical and isotopic analyses on minerals and bulk rocks suggest the alkaline complex was emplaced as three distinct mantle pulses, each of which evolved by fractional crystallization and autometasomatism. The carbonatite melt was not generated directly from partial melting of a metasomatized mantle source and carbonatite magma has separated from silicate magma so immiscibility is not ruled out.

Abstract ID: 34545

Final Number: MD33A-04

Title: Intrusion-related Pb-Zn sulfide veins associated with an Acadian strike-slip regime in the Nicholas-Denys property, Bathurst mining camp, Canada.

Presenter/First Author: Clyde McMillan, University of Quebec at Montreal UQAM, Montreal,

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Co-authors: Alain Tremblay, GEOTOP, Montréal, QC, Canada; Dominique Gagné, , ,

Published Material: GSA meeting, Bretton Woods - March 2013 - Poster presentationGAC-MAC meeting, Fredericton - May 2014 - Oral presentationSEG meeting, Keystone - September 2014 - Poster presentation

Abstract Body: In northern New Brunswick, Pb-Zn-Ag epigenetic mineralization is located on the edge of the Nicholas-Denys intrusion, a lowermost Upper Devonian (ca. 381 Ma) granodioritic pluton occurring along the northern block of the Rocky Brook Millstream Fault (RBMF). The granodiorite intrudes the Nigadoo River Syncline, an east-northeast striking structure belonging to the Chaleur Bay Synclinorium that formed during the Acadian Orogeny. The RBMF strikes east-northeast and has been recognized as a major right-lateral, transpressionnal strike-slip fault.

Polymetallic veins, consistent with right-lateral shearing, are: (1) transverse tension structures in the Dante-Raya showings, and (2) longitudinal tension structures in the Hachey showing. Ore mineralogy consists of sphalerite-galena-pyrrhotite-pyrite-arsenopyrite-chalcopyrite. Euhedral epidote occurs with sulfide mineralization in all showings. Veins in the Dante-Raya showings crosscut Silurian limestone and show a coarse-grained mineralization, whereas veins in the Hachey showing, crosscutting Ordovician mudslate and pelitic schist, show a finer-grained, pyrrhotite-rich mineralization. The zonal distribution of Mo, Cu, Pb, Zn, Ag, Au and Sb as compared to regional structures is suggestive of a magmatic source, and similar polymetallic deposits have been reported along other right-lateral strike-slip faults of the area, such as the Ristigouche-Grand Pabos faults in Gaspé peninsula. Our current interpretation is in contradiction with a previous study in which the ore bodies of the Hachey showing have been interpreted as a syngenetic mineralization that has been deformed by Acadian folds and faults. Rather, we believe that these deposits are related to late-Acadian convection controlled by the activity of a hydrothermal-magmatic system related to the Nicholas-Denys pluton.

Deformed mineralization textures observed on the Hachey showing, suggests that Acadian transpressionnal deformation was still active during mineralization. The rounded shape of the intrusion suggests, however, that right-lateral shearing deformation had considerably diminished during the emplacement of the Nicholas-Denys pluton, which is consistent with its lowermost Upper Devonian age.

Abstract ID: 34838

Final Number: MD33A-05

Title: Contribution to Geologic and metallogenic study of Bakoudou golden ore deposits (Gabon)

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Co-authors: Traoré Kalidou, , , ; Saquaque Ali, , , ; Nzaou Mabika Nazaire, , ,

Published Material: RST- 27 to 31 october 2014- Pau, France

Abstract Body: The objective of This study is to determine the Bakoudou gold deposit type. So to characterize the Bakoudou gold deposit, we characterized microscopically samples of two core drilling (BA06-36: 13 and BH2: 1). ICP-MS and X-ray diffraction (XRD) Analysis were also used to characterize the gold deposit.

The main results of these studies are :

- ICP-MS results indicate that the percentages of Si02 for all samples are upper or equal to 52, implying that the facies are supersaturated with silica (intermediate to acid rock). As lithology, microscopic study has concluded that the facies granites, granodiorite or diorite quartzic.

- These rocks have undergone regional metamorphism marked by the appearanceof quartz crystals recrystallized, foliation in some rocks and start metamorphic ribbon trimming following by hydrothermal alteration process of low intensity marked by the development of chlorite and sericite.

- The spectra of X-ray diffraction have revealed the particular presence of crossite, a sodic amphibole mineral, tracer of regional metamorphism blue schist facies.

- Petrologic and metallogenic study reveals that gold, our main interest, is disseminated in free grains present in quartz, plagioclase, biotite and amphibole of surround rocks and so abundant in quartz facies, which is consistent with a magmatic origin of the gold. That does not exclude the contribution of hydrothermal because it is shown very lowly in some blades that gold is related to chlorite from hydrothermal origin. Sulphides contained in the blades are low quantities. Part of these latters is related to magmatic origin and a greater amount is related to hydrothermal origin.

Keywords: Gold; Bakoudou, Gabon, Petrology, Geochemistry

Abstract ID: 35913

Final Number: MD33A-06

Title: REE, Y, Zr, and Nb Mineralogy of the Neoproterozoic Rift-related Robertson River Igneous Suite, Northern Virginia, USA

Presenter/First Author: Harvey E Belkin, Retired, Reston, VA

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Published Material: Some of the material was discussed, but not published, in a workshop in Warsaw, Poland September 2014

Abstract Body: The Robertson River igneous suite is the largest Neoproterozoic A-type granite body emplaced along the eastern Blue Ridge flank during regional Rodinia crustal extension related to the opening of Iapetus. U-Pb zircon age indicates emplacement in two magmatic pulses, 735–722 and 706–702 Ma. Metaluminous magmas were emplaced during both pulses and form most of the batholith. Peralkaline magmas comprise the final phase of activity. The peralkaline rocks have exceptionally high trace-element contents, Zr ~1000 ppm, Nb ~200 ppm, and Σ Y, Sc, REE > 1000 ppm, and a diversity of accessory phases. Zircon, the only Zr-phase observed, ranges in habit from euhedral, mm long crystals to hydrothermal amoeboid, commonly altered masses. HfO_2 content ranges from 0.49 to 3.14 wt% and the mean ΣREE, Y is 1.3 wt%; the Zr/Hf ratio (w/w) varies from 17 to 82. The major REE-bearing phases are fluorocarbonate, chevkinite group mineral, allanite, gadolinite, and a variety of Nb phases. Bastnäsite-(Ce) is the major fluorocarbonate with minor parisite-(Ce), and synchysite-(Ce). Chevkinite-(Ce) averages 11.50 wt% FeO and 2.60 wt% CaO, and is commonly altered. Allanite-(Ce) occurs in a wide variety of habits from subhedral crystals to amoeboid masses and averages 25 wt% ΣREE. Gadolinte-(Y) occurs as euhedral to subhedral crystals, sometimes zoned, and averages 52 wt% ΣREE, Y. The Nb-bearing phases occur in a wide variety of chemistry, habits, and typically show alteration, multiple generations, and deposition by late-stage fluids. Three major groups, aeschynite-euxenite, fergusonite, and samarskite were identified. The mafic assemblage in the peralkaline rocks is dominated by aegirine, riebeckite, and stilpnomelane; fluorite is ubiquitous. The mineralogy and petrography suggest Na-, Fe-, and F-rich fluids carrying REE, Y, Nb, and Zr were late-stage and moved through the rock during the early cooling process.

Abstract ID: 33272

Final Number: MD34A-0197

Title: Indium in Tin and Sn-sulfide Ores of the Deputatsky Ore District (Yakutia)

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Co-authors: Alexander S. Borisenko, V.S.Sobolev Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia; Andrey A. Borovikov, V.S.Sobolev Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia; Andrey V. Prokopiev, Diamond and Precious Metal Geology Institute SB RAS, Yakutsk, Russia; Alexandr I. Ivanov, , ,

Published Material: New geochronological data have been reported at the scientific conference "Granites and the Earth's evolution", V.S.Sobolev Institute of Geology and Mineralogy SB RAS, Novosibirsk, August 17-20, 2014. Fluid inclusions data were considered in detail at the XVI thermobarogeochemical conference, A.P. Vinogradov Institute of Geochemistry SB RAS, Irkutsk, September 10-14, 2014.

Abstract Body: Deposits with Q-cassiterite (Sn) and cassiterite-sulfide (Sn-sulfide) mineralization associated with or followed the Cretaceous subduction and later post-collisional rifting are known in the Deputatsky ore district (Northern Yakutia). The Sn-sulfide deposits are located to the south (Ege-Khaya, Kester, Honorskoe, Ilintass, Anomalnoe, Vysokogornoe) in the ore districts with only collision impact. During collision, Kolyma-Omolon superterrane worked as a hard indenter that resulted in the intense folding of the Verkhoyansk passive margin terrigenous rocks of the North Asia craton and transverse fault zones formation along which post-collisional granite porphyry stocks and alkaline mafic dikes were intruded. The large Sn-Ag Deputatsky ore cluster comprises: 1) Sn (111-108 Ma), 2) Sn-sulfide and low temperature Sn-Ag (106-100 Ma) mineralization. The Sn deposits (<100 g/t In) are linked with granite magmatism (112 Ma). The In-bearing Sn-sulfide mineralization (400 g/t In) coincides with lamprophyre and rhyolite porphyry intrusions (106 Ma). Fluid inclusion study in quartz from the Sn and Sn-sulfide veins using LA-ICP-MS and Raman-spectroscopy shows that ore-forming fluid of the Sn stage was enriched in Sn, W, and As. Minerals of the Sn-sulfide veins deposited from the chloride-carbonate

hydrothermal fluid (siderite daughter minerals) rich in Fe, Mn, Zn, In (7 ppm), Ag (160 ppm). Indium occurs as impurity in sulfides and does not form own minerals. At the low Cu, Zn and Pb contents, alabandite (MnS) veins hosted by volcanic rocks at the Vysokogornoe deposit contain In-minerals. Mid-Cretaceous and Paleocene Sn, Sn-sulfide, and Sn-Ag ores linked with granites and K-monzonite-syenites were formed in the Russian Far East in a continental margin setting. Granites are usually followed by Q-cassiterite veins, while bimodal magmatism (alkaline basite+granite/rhyolite) in a rifting setting led to the Sn-sulfide mineralization forming. Large Sn-Ag ore clusters were formed due to superposition of Sn-sulfide and Sn mineralization with contribution from crustal and mantle sources.

Abstract ID: 33699

Final Number: MD34A-0198

Title: Mineralogy of the Clay-Howells Magnetite Carbonatite: An A-type Granite-Related 'Carbonatite'

Presenter/First Author: Shannon E Zurevinski, Lakehead University, Thunder Bay, ON

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Co-authors: Roger Howard Mitchell, Lakehead University, Thunder Bay, Canada

Abstract Body: The Clay-Howells complex (NW Ontario) consists predominantly of fayalite augite amphibole syenite. A sinuous c. 1km long, dike-like body of magnetite carbonatite apparently intrudes the syenite at the southeast margin of the intrusion. The carbonatite exhibits pronounced modal layering with respect to magnetite and carbonates, with magnetite ranging from 10-90 vol.%. Both minerals exhibit allotriomorphic granular textures. The magnetite is a Mn-bearing (2-3 wt.% MnO), Ti-poor (< 0.3 wt.% TiO_2) variety intergrown with manganoan fayalite ($Fa_{47}Tp_{30}$ Fo_{24}). It typically contains numerous small (< 50 micron) round inclusions of Pb-bearing thorianite and micro-inclusions (< 5 micron) of manganoan ferrocolumbite, fersmite, hercynite, and gahnite. The carbonate-rich parts of the carbonatite consist predominantly of co-existing calcian rhodocrosite, Mn-poor Sr-bearing calcite, magnetite, apatite, biotite, fluorite, and quartz in diverse modal amounts. Sr and Y-bearing fluorapatite typically exhibits complex resorption and mantling textures reflecting light REE compositional variation. Accessory minerals occurring interstitially between magnetite and carbonates as thin veins include fluor-thoro-britholite, thorite, pyrochlore, niobo-aeschynite, Sn-bearing manganocolumbite, baddelyeite, ferroan sphalerite, kinoshitalite, diverse zeolites and strontianite. Pyrochlore group minerals are Na-, Th, U, and REE-poor calciopyrochlores, and U-Ta-bearing pyrochlores. Pyrochlores and aeschynites are commonly altered by deuteric fluids to complex intergrowths of unidentifiable secondary Nb- and Th-bearing minerals. The minor and accessory mineral paragenesis is similar to that occurring in mineralized A-type granitoids. As undersaturated alkaline rocks of the ijolite and melilitite suites are not present at Clay-Howells we consider that this magnetite carbonatite is a derivative of an A-type granitoid magma and is not formed from a undersaturated mantle-derived magma.

Abstract ID: 34597

Final Number: MD34A-0199

Title: Tracking the Evolution of the Metal and Volatile Budget of the Magma Reservoir Underneath the World-Class Porphyry Cu-Au Mineralization at Bingham Canyon, Utah, USA

Presenter/First Author: Carter Grondahl, University of Toronto, York,

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Co-authors: Zoltán Zajacz, University of Toronto, Toronto, ON, Canada; Jeffrey D. Keith, , Provo, UT

Abstract Body: Introduction of a primitive, Cu, S and CO_2-rich magma to a partly crystallized felsic magma chamber has been suggested as a crucial step in the formation of the world-class Bingham Canyon Cu-Au-Mo deposit. This interpretation is based partly on mafic lava flows identical in age to the mineralization, preserved within the remaining volcanics of the eroded Bingham stratovolcano. Rocks from basanite to rhyolite in composition have been sampled from the volcanic edifice. We have identified mineral decomposition textures in many intermediate and felsic rocks, suggestive of olivine phenocrysts introduced into a melt with which they were at a strong disequilibrium. Specifically, symplectites consisting of vermiculitic magnetite and orthopyroxene are occasionally found throughout the mineralization-aged volcanics. In the well-developed examples, an outer zone of orthopyroxene surrounds the inner symplectite. This outer orthopyroxene occasionally hosts sulfide inclusions, an evidence of magmatic sulfide saturation which have affected the availability of ore metals for exsolving fluids. These symplectites provide direct evidence for magma mixing. Additionally, the volcanics are rich in apatite, which displays significant compositional variability. Scanning electron microscope (SEM) and electron microprobe (EMP) analyses revealed that the apatites (<200 um) are Fe-bearing, either Cl- or F-rich, and exhibit variable S concentrations. Some Cl-apatites display a spotty exsolution trellis of iron sulfides. Abundant silicate melt and fluid inclusions are present in several hosts including pyroxene, amphibole, plagioclase, biotite, and apatite. Further work will include homogenization experiments, and the analysis of metal and volatile concentrations in silicate melt and sulfide inclusions by methods including Laser Ablation ICP-MS, Fourier Transform Infrared Spectroscopy, SEM, and EMP as well as detailed investigation of the chemical zonation of the phenocrysts.

Abstract ID: 34868

Final Number: MD34A-0200

Title: Lode field of Roc Blanc (central Jebilet, Hercynian, Morocco) with Ag-Pb (Zn, Sb, As, Cu, Au) mineralization

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Abstract Body: Lode field of Roc Blanc is located in the Hercynian massive of Jebilet, a few kilometers northwest of Marrakech city. It is steep-sided in a marine sedimentary series of Visean higher-Namurian age, the Sarhlef series is the central group of this massive. Sulphide mineralization of Roc Blanc is a polyphased mineralization, lithologically associated with speckled schists with cordierite in the contact metamorphic aureole of granodiorite pluton. It is a lode mineralization structurally controlled, formed by veins or lenses and has a banded or brecciated structure. The metallic mineral association consists of pyrrhotite, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, gray copper, argentite, pyrargyrite, owyheeite, polybasite and native silver. We can subdivide into: 1) An early metamorphic episode in the black shales facies. This stage characterized by sulfides of Fe and Cu. 2) A hydrothermal episode in the black shale facies (chlorite, muscovite and sericite). It is characterized by silver mineralization as sulfides and sulfosalts and native silver. This episode defines as a holding economical mineralization in the deposit. It is characterized by three mineralized phases: i) A phase with pyrrhotite, pyrite, chalcopyrite, arsenopyrite and sphalerite. ii) A phase with pyrite, sphalerite and galena, copper, gray and owyheeite into beds or flies scattered in the milky quartz. iii) A phase with pyrite or often chalcopyrite, black silver, red or native silver localized in the geodic quartz associated with carbonates. The presence of sulfides, sulfosalts of bases metal and silver indicated that is a hydrothermal fluid circulation warm (chlorite, quartz and muscovite), acid and reducers (sulfides) formed under mesothermal at epithermal conditions.

Keywords: Ag, Pb, Zn, Sb, As, Cu, Au, vein, Roc-Blanc, Mesothermal, Epithermal.

Abstract ID: 36506

Final Number: MD34A-0201

Title: Role of hypabyssal subvolcanic magmas in the genesis of the Albany graphite deposit

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Co-authors: Lindsay C Moore, Zenyatta Ventures Ltd., Thunder Bay, ON, Canada

Abstract Body: The Albany graphite deposit comprises two breccia pipes within the Albany Alkalic Complex; a satellite igneous complex situated along the southern margin of the larger Nagagami River Alkali Rock Complex. The deposit is interpreted as near surface volcanic vent breccias formed by the ascent of carbonaceous fluids separated from alkali magmas. The graphite-hosting "syenite" ranges in composition from quartz syenite to diorite, with quartz monzonite being the most common composition. The "syenite" is considered to have a passive role in graphite formation; however, it is suspected that a recently identified porphyritic, hypabyssal subvolcanic monzodiorite/foid monzodiorite may have played a critical role. A hypabyssal origin is inferred from the occurrence of: i) aphanitic groundmass consisting of albite, paragasite and minor nepheline; ii) embayed and sericitized albite xenocrysts with discontinuous, epitaxial overgrowths of sanidine; and, iii) corona textured magmaclasts (consisting of a core of variably altered groundmass, an intermediate zone of subhedral euhedral phlogopite and rimmed by anhedral to subhedal and radiating paragasite ± phologopite). The hypabyssal facies has only been identified along the margins of the western breccia pipe where it intruded Archean country rocks and brecciated and non-brecciated facies of the Albany "syenite". We postulate that orthomagmatic CO_2-dominant fluid and aqueous fluid originated from the hypabyssal magma. The inferred alteration of an unidentified anhydrous phase to biotite + paragasite by reaction with a hydrous fluid could have generated H_2, with the subsequent reaction of this H_2 with orthomagmatic CO_2 to form CH_4 via Fischer-Tropsch synthesis. Graphite crystallization was induced by rapid depressurization and cooling of a CH4-CO_2 fluid in response to explosive surface venting. This reaction mechanism is supported by estimated temperatures for graphite mineralization of 485 to 555°C and an initial carbon isotope value of -16.9‰ for graphite.

Abstract ID: 34930

Final Number: MD34B-0202

Title: Genesis of the Pd-Cu Mineralization at the Marathon Deposit, Ontario: Preliminary Insights from Oxide Chemistry

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Co-authors: Iain M. Samson, University of Windsor, Windsor, ON, Canada; Joel E Gagnon, University of Windsor, Windsor, ON, Canada; David John Good, University of Western Ontario, London, ON, Canada; Robert Linnen, University of Western Ontario, London, Canada

Abstract Body: The Marathon Cu-Pd deposit is hosted by the Two Duck Lake Intrusion (TDLI), a late phase of the Eastern Gabbro (EG) in the Coldwell Complex. The EG is subdivided into the Fine-Grained Series, Layered Series, and Marathon Series, with the latter hosting all of the Cu-PGE mineralization. Magnetite is ubiquitous in all rock series, which, along with the sensitivity of magnetite chemistry to its environment of crystallization, make it a suitable mineral to help understand the genesis of the EG and the mineralization.

Magnetite is disseminated in most gabbros, but can occur in (semi-)massive layers. Two types of magnetite are present. Interstitial, magmatic magnetite always contains very fine lamellae of Fe-Ti oxides ≤ 1 µm across. Analyses thus represent a mineral mixture rather than homogeneous magnetite, which has implications for the internal standard chosen for LA-ICP-MS. Thick (5-20 µm) lamellae and euhedral to subhedral crystals of ilmenite are also typically present in the magnetite. Late magnetite is less abundant than interstitial magnetite and lacks exsolution. It commonly occurs as a replacement of sulphides, but can occur in patches and veinlets in silicates.

Preliminary LA-ICP-MS analyses of magnetite and ilmenite show that late magnetite has the lowest concentration of trace metals, except for Ge, Pb, and Th, which are present in greater concentrations. Magnetite hosted by Fine-Grained Series has the highest Cr, Ni, and Pt concentrations of the EG. Those hosted by Layered Series have the highest Mo and Pd, but lowest Cr and Ni concentrations. Magnetite hosted by Marathon Series has Cr, Ni, Mo, and Pt concentrations intermediate to the other rock series. Magnetite hosted by mineralized TDLI has distinctly higher Cr, Ni, and Au concentrations, but lower Mo than those hosted by barren TDLI. These results suggest that magnetite chemistry can distinguish between various rock series and between barren and mineralized TDLI.

Abstract ID: 35104

Final Number: MD34B-0203

Title: Mineral Chemistry of Magnetite from Kiruna Magnetite-Apatite Ores and their Host Rocks from the Norrbotten Region, Northern Sweden

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Abstract Body: Magnetite-apatite deposits (MAD), also called Kiruna-type or iron oxide apatite (IOA) deposits, are major producers of iron ore that often primarily consist of the mineral magnetite (Fe_3O_4). It remains unclear whether these deposits are hydrothermal or magmatic in origin and this issue has been debated for several decades. MAD deposits are considered an end member in a continuum of iron oxide deposits; with the opposite end member being iron oxide copper gold (IOCG) deposits. The type locality, from which the name "Kiruna-type" is derived, for this style of mineral deposit are the deposits in the vicinity of the town of Kiruna,

located in the Norrbotten region of northern Sweden. The main deposit in this region is the Kiirunavaara MAD deposit (~ 2 billion tons of iron ore, extracted and in reserve) and magnetite chemistry from this deposit is the focus of this project. Magnetite samples from smaller nearby MAD deposits in the Kiruna region (e.g., the Per Geijer ores) will also be investigated. Magnetite is sensitive to fluctuating physiochemical conditions in which it forms (such as temperature, pressure and fO_2) and may contain distinct minor and trace element concentrations depending on the environment in which it formed, making it a useful geochemical indicator for understanding the genesis of MAD deposits. Several ore samples as well as samples from the adjacent hanging wall and footwall host rocks will be examined. For this study, magnetite will be investigated using an electron probe microanalyzer (EPMA) for major and minor element quantitative chemical analyses, X-ray maps, and back-scattered electron (BSE) images. Additionally, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses will be done to determine the minor and trace element concentration of the same magnetite samples and to determine the inter- and intra- sample variation in the magnetite chemistry.

Abstract ID: 36280

Final Number: MD34B-0204

Title: Trace elements in magnetite as indicators of petrogenesis and provenance

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Published Material: Much of this work has been published as a paper in Mineralium Deposita (2014) after presentation at SGA 2013 (Uppsala). However, it will be updated with new results.

Abstract Body:

Abstract ID: 36609

Final Number: MD34B-0205

Title: Discrimination between different VMS deposit subtypes in the Bathurst Mining Camp using the trace element composition of magnetite

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Abstract Body: Magnetite grains from 4 felsic-siliciclastic VMS subtypes including Austin Brook deposit, Brunswick #12, Brunswick #6, and Halfmile Lake deposit and the respective alteration zone, and from a mafic VMS subtype, Turgeon deposit, have been examined by the EPMA and the LA-ICP-MS for their major and trace element composition. The geochemical censored data were investigated using the robComposition package implemented in the software R. The data analysis was done using Partial Least Square-Discriminant Analysis (PLS-DA) to reveal hidden correlations among elements in magnetite composition causing discrimination between different VMS deposits. Petrographic studies distinguish 2 magnetite types: 1) magmatic magnetite characterized by ulvöspinel exsolution in Halfmile Lake gossan; and 2) hydrothermal magnetite formed by replacement of sulfides and/or silicates in the other VMS deposits, and in the Halfmile Lake respective alteration zone.

PLS-DA of magnetite composition from the selected VMS deposits shows that magnetite from Halfmile Lake gossan, grains from Halfmile Lake magnetite alteration zone, and magnetite from Turgeon deposit form distinct clusters. Magnetite grains from Austin Brook, Brunswick #6 and Brunswick #12 form overlapping clusters. However, the contribution score plots show that each of these clusters can be discriminated by a distinct mean composition (MC). Positive contribution of Al, Zn and Zr mainly characterize the Austin Brook MC, whereas the MC of Brunswick #6 is mainly discriminated by positive contribution of Zr, Mn and Zn. Positive contribution of Zn and negative contribution of Al are main factors in isolation of the MC of Brunswick #12. The contribution score plots suggest that magmatic magnetite from Halfmile Lake gossan is relatively enriched in Ga and depleted in Si, Ca and Mg, whereas hydrothermal magnetite from Halfmile Lake MAZ is relatively depleted in Mn and Zn, and enriched in Si, Al, and Mg. The MC of Turgeon cluster is mainly characterized by positive contribution of Ca and Mg and negative contribution of Ga. The results show that the chemistry of magnetite can be used to discriminate between felsic-siliciclastic and mafic VMS subtypes, and to distinguish different VMS deposits.

Abstract ID: 35845

Final Number: MD34B-0206

Title: Remobilization of PGE and Other Chalcophile Elements During the Metamorphism of the Massive Sulfide of the Delta Deposit (Raglan Area, Northern Quebec)

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Abstract Body: The Cape Smith Belt (ca. 1.9 Ga) in northern Quebec contains numerous Ni-Cu-PGE (platinum-group element) deposits associated with komatiitic basalts. The entire belt has then been affected by the Trans-Hudson orogen and the regional metamorphism in the Cape Smith Belt reached the upper greenschist-lower amphibolite facies (~450°C). The Delta deposit is composed of several lenses two of which are located in a fault zone. We have investigated whether there is remobilization of the PGE and chalcophile elements during the metamorphism and deformation of the massive sulfides.

Petrographical observations revealed that the ore is composed of pyrrhotite, pentlandite and chalcopyrite in magmatic proportions, thus major elements have not been affected. The pyrrhotite and pentlandite have recrystallized and the chalcopyrite contains deformation textures. The mantle-normalized patterns show that some fractionated samples (high Pd/Ir, low Cu) are as Pd, Pt-rich as the Cu-rich samples (residual sulfide liquid). In addition, the enrichment of some chalcophile elements (As, Sb, Cd) in Cu-poor samples compared to Cu-rich sample suggests that some elements have been mobile during the metamorphism. The LA-ICP-MS analyses reveal the presence of micro-inclusions (a few microns in size) of PGM within the recrystallized pyrrhotite or pentlandite. These micro-inclusions are mostly sperrylite ($PtAs_2$) in which signals for the IPGE (Os, Ir or Ru) are detected. This suggests that these PGM could be secondary exsolutions. Compared to other massive sulfide deposits (Aguablanca, Sudbury), the mass-balances reveal a strong control of the Pd by the pentlandite with close to 80% of the Pd being present in the pentlandite in the mss-cumulus samples. This is much more than observed in the other

massive deposits and could suggest the remobilization of the Pd into the pentlandite.

Our results are encouraging and tend to show there is a beginning of remobilization of metals within Ni-Cu-PGE massive sulfide at the upper greenschist facies.

Abstract ID: 36446

Final Number: MD34B-0207

Title: "White mica chemistry by *in-situ* LA-ICP-MS techniques: variation of volatile trace elements and its application in VMS deposit exploration"

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Abstract Body: *White mica is ubiquitous phase throughout the altered rocks enveloping the massive sulphide deposits of the Bathurst Mining Camp, Canada. It occurs largely as a potassic (sericitic) alteration product of quartzo-feldspathic volcaniclastic rocks, and as a pelagic component in clastic and exhalative sedimentary rocks. In this study a new tactic has been developed to quantify the composition of white mica by in situ LA-ICP-MS. The* high sensitivity of the LA-ICP-MS method allows the detection of trace elements at the sub-ppm level. Lack of any especial sample preparation and cost efficiency for examining a large number of grains make this methodology appropriate in academic and industrial applications. *LA-ICP-MS is an efficient method for examining fine grained phases in complex matrices by using <30 µm laser craters*. In this study, calibration was performed using NIST 610 as external standard, and an assumed stoichimetric Si concentration as internal standard.

The composition of white mica is defined as solid solution between muscovite and celadonite (phengitic) in the BMC. White mica shows extensive systematic substitutions (e.g., Tschermak substitution) allowing it to host a wide range of trace elements. Analyzing a large number of white mica by LA-ICP-MS demonstrates lattice-bound occurrence for the volatile trace elements. White mica accommodates high quantities of As (up to 1.12 wt.%), Sb (up to 4750 ppm), Tl (up to 697 ppm), and In (up to563), whereas Cd (from detection limit (0.14)-225 ppm), Hg (<0.16-67 ppm), and Bi (<0.04-49), occur in moderate values. Anomalous values recorded in the Louvicourt and Brunswick No. 12 deposits can be related to their genetic manifestation, for instance the former has signature analogous to high sulphidation VMS deposits. Compositional variations of white mica exhibit vectors for some of trace elements such as arsenic, antimony and thallium related to the mineralization. By proximity to the sulfide horizons, increasing values of As, Sb and Tl form the most extensive halos. Consequently, the results of this study indicate the existing of white mica trace element vectors at the deposit-scale. Application of this approach to the BMC as well as areas outside the camp demonstrates its prospective application in VMS exploration worldwide.

Abstract ID: 35440

Final Number: MD34B-0208

Title: Fingerprinting and Tracing the Signature of Basement Hosted Unconformity-type Uranium Alteration Through Thick Tills: an Example from the Thelon Basin, Nunavut

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Published Material: Preliminary results were presented as a poster at the 2014 GAC-MAC conference in Fredericton, NB.

Abstract Body: The Thelon Basin of Nunavut and the Northwest Territories exhibits great potential to host the next generation of unconformity-type uranium deposits. Exploration in the Thelon Basin is often complicated by nearly continuous cover of Quaternary sediments and lack of subcropping mineralization. Our investigation southeast of Aberdeen Lake is focused on deeper basement-hosted unconformity-type uranium mineralization with a subcropping alteration halo buried by till successions ranging from 12 to 34 m in thickness. The alteration haloes in the area are characterized by intense illitic alteration and present promising geochemical exploration targets. The goals of the study are 1) to fingerprint the alteration signature in the tills, 2) map the dispersion patterns, and 3) establish whether the alteration footprint in the till reaches the ground surface. Drill core samples of till combined with surficial mudboil sampling over the subcropping alteration allows for 3D modelling of glacial dispersal of material from the halo. Geochemical data is complemented by textural, pebble lithological, and clay mineralogical data to define alteration trends in the till. Analysis of the data using multivariate statistics, including principal component analysis, has proven to be useful for discriminating till units and identifying alteration signatures. The strongest observed geochemical signatures of alteration include enrichment in B, Al and K, with depletions in Na, Ba, Mn, and Sr. Tracing the dispersal of the alteration signature is complicated by the presence of multiple till units deposited during different ice flow events. The elusive 'secondary' alteration footprint and the complex nature of glacial dispersal patterns in the study area highlights the need for enhanced integration of data, methods, and knowledge into exploration programs, especially in areas of thick Quaternary sediment cover.

Abstract ID: 34951

Final Number: MD41A-01

Title: The Brucejack Intermediate Sulfidation Epithermal Au-Ag Deposit, Northwestern British Columbia

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Published Material: GAC Fredericton Meeting May 2014- findings are not yet under review and have not been accepted by a scientific journal

Abstract Body: The Brucejack intermediate-sulfidation epithermal Au-Ag deposit is one of many world-class porphyry and epithermal deposits that formed in association with extensive volcanic arc-related magmatism in Late Triassic–Early Jurassic time in the Canadian Cordillera. Mineralization at Brucejack is hosted by Early Jurassic porphyritic latite flows, block and ash flows, and volcanic sandstones, siltstones and conglomerates. Oldest estimates for these variably altered and mineralized porphyritic flows are 196.4 ± 0.7 Ma (U-Pb zircon). Age estimates for mineralization at Brucejack range between 191.7 ± 0.8 Ma and 188.9 ± 0.8 Ma (Re-Os molybdenite).

Brucejack is crosscut by late stage trachybasaltic dykes dated at 182.7 ± 1.0 Ma (U-Pb zircon), which truncate all mineralized veins, and are crosscut by barren (post-mineralization) quartz-dominated veins. Six vein stages have been recognized at Brucejack, with high-grade Au mineralization occurring in stages II, III, and IV. Fluid inclusions within these auriferous high-grade veins have relatively low homogenization temperatures (~160˚C) and broad ranges in salinity (0.5 to 15.5 wt. % NaCl equiv.), suggesting fluid mixing. Evidence for boiling is recognized in all mineralized veins, and is thought to be the principal mechanism for Au mineralization deposition. Temperature-corrected oxygen isotopic compositions of Au-bearing vein quartz and vein calcite indicate $d^{18}O_{fluid}$ values of -1.5 to -8.0 ‰ and 1.4 to -10.2 ‰ respectively, ranging from modified magmatic to meteoric water values, and suggesting mixing between these fluid sources. Carbon (vein calcite: $d^{13}C_{CO2}$ = -8.4 ± 0.2 ‰, *n*= 22) and sulfur (vein pyrite, sphalerite, and galena: $d^{34}S$= -0.8 ± 0.3 ‰, *n*= 10) isotopic compositions also suggest a magmatic source for these elements, possibly with a minor crustal component. Gold is inferred to have been sourced from these magmatic fluids.

Abstract ID: 35629

Final Number: MD41A-02

Title: Stratigraphy and structure of Archean lode gold deposits in the southeastern Rice Lake greenstone belt, southeastern Manitoba, Canada

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Published Material: I reported part of the study as a poster at the Manitoba Minerals and Mining Convention 2014 and as an oral presentation at the Canadian Tectonic Group meeting 2014. Currently they are not under review or accepted by any scientific journal yet.

Abstract Body: The Central Manitoba and Ogama-Rockland gold deposits are located in the southeastern portion of the Archean Rice Lake greenstone belt in the Uchi Subprovince of the western Superior Province. These two deposits were investigated in the aspects of host-rock stratigraphy, deformation structure and vein systems through detailed bedrock mapping. Four generations (G_1–G_4) of deformation structures are recognized in the study area based on overprinting relationships.

The Central Manitoba deposit is hosted by quartz veins in feldspathic wacke, basalt and gabbroic sills within the Bidou assemblage of the Rice Lake belt. Stratigraphic sequence of host rocks is typically south facing. Auriferous massive quartz veins are dominantly hosted by west-trending dextral G_4 shear zones. Free gold is present in contacts with quartz, pyrrhotite and tellurobismuthite. Chlorite-sericite alteration is typically associated with mineralization.

The Ogama-Rockland deposit is hosted by quartz (-carbonate) veins in tonalite of the Ross River pluton (~2724–2728 Ma). Three vein sets (V_1–V_3) were identified based on crosscutting relations. Auriferous massive V_3 veins were likely emplaced late during the G_4 shearing, and are hosted by a conjugate set of north-to-northeast–trending sinistral shear zones and west-to-northwest–trending dextral shear zones. Free gold and minor gold inclusions are present within fractured pyrite, chalcopyrite and quartz. Chlorite-carbonate-sericite alteration is common. Mutual crosscutting relationships, gradational transitions and quartz segregations in the center of aplite dikes suggest a close temporal and possibly genetic relationship between quartz veins and aplite dikes.

In spite of contrasting host rocks, ore style and alteration, the two gold deposits share identical host-rock structure and structural timing of mineralization, indicating that gold mineralization shares a similar structural setting.

Abstract ID: 36585

Final Number: MD41A-03

Title: The structural and geochronological evolution of the auriferous Santoy shear zone, northeastern Glennie domain, Saskatchewan

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Abstract Body: The study area lies within the Pine Lake Greenstone belt of the Glennie domain, 125 km northeast of LaRonge, SK. The Santoy shear zone (SSZ) hosts the Santoy 7, Santoy 8/8 east, and “Santoy Gap” gold deposits. This shear zone was studied using a structural and geochronological (ID-TIMS) approach in order to decipher its complex relationship with plutonism, deformation, alteration and gold mineralization.

Surface and subsurface mapping reveals that the SSZ and deposits therein show a clear structural relationship towards the F_3 Carruthers Lake Synform. The Santoy 7, Santoy “Gap”, and Santoy 8 deposits lie along the western limb of this structure while Santoy 8 east has been reoriented by north trending 45° plunging S folds. The plunges of the ore shoots are parallel to this and coaxial to the plunge of the Carruthers Lake Synform. Appropriately oriented plutonic intrusions acted as structural anisotropies that nucleated shear zones and auriferous fault fill quartz veins along their margins during D_{3A} dextral reverse oblique slip movement. The age of these intrusions (1874.6±2.9 Ma and 1874.6±1.9 Ma) serves as a maximum mineralization age for these deposits. Geomagnetic anomaly data suggest that a quartz syenite pluton in the area acted as a buttress during D_3 and produced a compressional jog in the SSZ and increased fracture density and fluid flow during mineralization. The age of this intrusion (1807±7Ma) serves as a maximum age for the development of this flexure. Gold mineralization is closely associated with a calc-silicate alteration assemblage. This assemblage occurs synchronously with the main stage mineralization event. Titanite and zircon within this assemblage was dated to 1755±8 Ma indicating Syn-D_3 deposit formation and providing the most accurate age date for gold mineralization in the Glennie domain proposed to date. Beriliferous pegmatite dykes display an F_3 axial planar cleavage and crosscut auriferous zones. An age of 1736.1±1.9Ma for the dyke represents a minimum mineralization age for this system and a new minimum age for regional D_3 deformation in the Glennie domain.

Abstract ID: 34977

Final Number: MD41A-04

Title: The Lower Detour Lake Au Discovery, Ontario, Canada: A High-Grade Oxidized Intrusion-Related Au Deposit

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Abstract Body: Newly discovered (2014) high-grade Au mineralization in the Lower Detour Lake region of the Archean Detour Lake mining camp (NW part of the Abitibi Greenstone Belt, Canada) is hosted within high-level felsic porphyries located 7 km south of the spatially associated world-class orogenic-type Detour Lake Au deposit (15.5Moz Au at 1.02 g/t reserves, 4.8Moz at 1.11g/t resources, as of January 2014). The Au mineralization is hosted by a coalesced swarm of felsic dikes that intrude 2.72 Ga mafic volcanic rocks of the Deloro Assemblage, parallel to the main E-W structural fabric of the area. Within these felsic dikes, the Au mineralization is centered on widespread zones of phyllic alteration hosting arrays of vein quartz. The leucocratic dikes are variably feldspar phyric with Plg≥Kspar, have a range of Qtz:Plg ratios, and chemically are enriched in LILE with strongly fractionated REE patterns ($(La/Lu)_N \approx 8$-10)) and lack Eu anomalies ($Eu_N/Eu^* \approx 1$). Thus, the petrology of the dikes reflects melt extraction from an underlying magmatic source that evolved over time. The Au mineralization, which is characterized by a Bi ± W ± Te ± Ag elemental association, is localized to brittle-ductile zones flooded by quartz ± carbonate ± tourmaline ± pyrite veins with alteration halos enriched in sericite ± quartz ± carbonate ± pyrite ± albite ± chlorite ± biotite ± titanite ± epidote which reflect differing fluid:rock ratios and wall-rock bulk composition. The presence of inter-mineralized felsic dikes cross-cutting the mineralization suggests both a spatial and temporal relationship between the Au event and magmatism. Both the intrusive host rocks and mineralization/alteration have textures reflecting an intense ductile overprint. The characteristics of the Au mineralization and setting suggest affinities to the syenite-associated style of mineralization (e.g., Kirkland Lake) versus the orogenic style seen in the Detour Lake deposit, thus the new discovery equates to an oxidized intrusion-type gold deposit.

Abstract ID: 33516

Final Number: MD41A-05

Title: Deformational and Metamorphic Processes in the Formation of the Bellechasse-Timmins Orogenic Gold Deposit, Southern Québec Appalachians, Canada

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Published Material: GAC-MAC 2014 - PosterGSA 2015 Northeastern part - Poster

Abstract Body: The Bellechasse-Timmins (BT) gold deposit is located 110 Km south of Québec City. It is hosted by the Ordovician Magog Group, a synorogenic forearc basin sequence in the Dunnage Zone of the Québec Appalachians, which has been deformed and metamorphosed at greenschist facies during the Acadian orogeny.

The Au mineralization is developed in diorite sills (and dykes) crosscutting the Upper Ordovician (Caradocian) Etchemin Formation, as the result of fracturing and variations in hydrothermal fluid pressure during regional metamorphism and deformation. The BT deposit consists of Au-rich quartz veins and stockwork hosted by faults and anastomosing shear zones formed at or above the brittle-ductile transition. Our structural analysis shows that both the intrusions and hosting sedimentary rocks are crosscut by a steeply-dipping, NE-trending axial-planar schistosity (S_1) and by 50 cm-to 2 metres-wide shear zones subparallel to that S_1schistosity. The shear zones host steeply-plunging slickenlines/lineations and preserved structural evidence for reverse faulting, mainly due to flattening and "locking up" of fold hinges, which have been sheared out by high-angle reverse faults. Subhorizontal lineations/fault striae are also locally found, suggesting late-stage strike-slip motion.

There are 3 main orientations of auriferous veins, almost perpendicular to each other, suggesting that the overall geometry of the ore zones is mainly controlled by and coeval with the regional folding event. It basically represents the product of hydrothermal circulation and fracturing related to regional metamorphism and folding affecting the diorite dykes/sills and the formation of saddle-reef and related structures. Fluids migrated along faults/shear zones and other weakness planes during folding and precipitated in favourable low-pressure dilation zones (e.g. faults, bedding planes, fold axes) created when the hydraulic pressure of trapped fluids exceeded the lithostatic pressure.

Abstract ID: 34593

Final Number: MD41A-06

Title: Gold mineralization of the archean Orfée showing, Baie-James, Québec

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Published Material: I presented a scientific poster with the data I obtained during Québec Mines of last year (2014).

Abstract Body: The Orfée gold deposit (~0.2 Mt at 14.5 g/t Au) is part of the La Grande Subprovince, in the Baie-James region. Discontinuous gold-rich zones are associated with an oxidized/silicate iron formation and with graphitic sediments containing up to 20% disseminated to massive pyrrhotite and pyrite, and are edged by basaltic amphibolites to the north and by wackes to the south. The graphitic sediments enclose <1% visible gold, as well a maximum gold content of 54.6 g/t in a gold-rich mylonitic corridor. The mineralization and its hostrocks, metamorphosed to the amphibolite facies, is 300 m north of the La Grande and Opinaca Subprovinces contact. The basaltic amphibolites are composed of hornblende, plagioclase and, locally, of biotite and garnet, and have an east-west oriented foliation. Plagioclase glomeroporphyritic horizons have been observed in the basaltic amphibolite unit. Tholeiitic and calc-alkaline geochemical signatures divide the basaltic amphibolites into two populations. Weakly plagioclase-phyric dioritic dykes, containing fine-grained mafic enclaves, cut across the amphibolites. These east-west foliated dykes intersect a pervasive garnet, hornblende, chlorite and pyrrhotite alteration affecting the amphibolites. The oxidized/silicate iron formation displays alternation facies characterized by quartz-plagioclase-rich, magnetite-rich and grunerite-hedenbergite-hornblende-garnet-sulphide-rich bands. The sub-vertical regional fabric was affected by a late dextral strike-slip movement, which explains the local thickening and boudinage of the iron formation. The wackes are composed of quartz, plagioclase and biotite and are affected by a S1 schistosity and a S2 foliation. Most of the wackes have geochemical signatures suggesting sources-derived intermediate component, while a small percentage have relatively high Mg, Cr, Ni content suggesting some sources-derived ultramafic component. The amphibolites, iron formation and wackes have been injected by a wide variety of deformed sterile quartz veins. Sheared and boudinaged pegmatite cuts across the wacke and amphibolite units. The metallogenic study of the Orfée showing will enable us to develop a model for the gold mineralization paragenesis, in relation with the geodynamic history of the La Grande – Opinaca contact.

Abstract ID: 34974

Final Number: MD41A-07

Title: Geology of the metamorphosed Roberto gold deposit and tonalite-hosted Cheechoo discovery, Superior Province, James Bay Region, Québec, Canada

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Abstract Body: The world-class Roberto gold deposit, with resources of 4.03 Moz at 6.49 g/t Au and reserves of 4.10 Moz at 9.63 g/t Au, is a major discovery in the James Bay Region, located a few km south of the boundary between the La Grande and the Opinaca sub-provinces. Hosted by <2675 Ma sedimentary rocks, a structurally complex ≤ 70-80 m wide N-S trending mineralized envelope hosts various styles of mineralization. A large hydrothermal system is defined by distal calcium-rich metasomatism, proximal potassic alteration and Au-As-Sb-B signature. The main ore zones are characterized by quartz-dravite-microcline-phlogopite-arsenopyrite stockwork and replacement zones and by quartz-diopside-schorl-arsenopyrite veins while the high-grade zone is locally hosted by paragneiss. The bulk of the gold mineralization is confined within a steeply plunging ore shoot coaxial with an F_2 fold hinge.

Diversity of ore styles, mineralogy and geometry is in part related to i) lithological heterogeneity, ii) proximity to a granulitic metamorphic front, and iii) syn- to late magmatism. Paragneiss (<2685 Ma), which recorded a complex D_2 deformation, is exposed 1km east of the main ore zone illustrating the steep metamorphic gradient towards the Opinaca sub-province. Magmatism in the vicinity of the deposit includes granitic pegmatites (2620-2603 Ma), most of which have recorded the main phase of deformation (D_2) and postdate the bulk of the ore; however, some are undeformed, cut the main Roberto ore zone and contain clasts of foliated ore. Locally pegmatites host significant gold mineralization. The newly discovered CHEECHOO showing (up to 7.24 g/t Au over 7.9 m) is located about 10 km southeast of the Roberto deposit. The host tonalite yielded a preliminary U-Pb ID-TIMS zircon crystallization age of 2612 Ma. This age is similar to the pegmatites at Roberto, illustrating the complexity of the tectono-metamorphic setting and late-magmatic activity in the area, as well as the complex protracted or multi-stage nature of auriferous events.

Although clearly deformed and metamorphosed, the bulk of the gold mineralization is hosted by Timiskaming-age sediments, near the boundary between sub-provinces marked by a strong strain and metamorphic gradient, magmatism, local conglomerate, and therefore shares analogies with most Archean gold deposits

Abstract ID: 35013

Final Number: MD41A-08

Title: Gold Metallogeny of the Southern Swayze Greenstone Belt: Poor or Rich Cousin to the Abitibi?

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Abstract Body: The southern Swayze greenstone belt (SGB) is located approximately 40 km west of Shining Tree in northern Ontario and represents the southwestern extension of the Abitibi greenstone belt (AGB). The general consensus, based on years of mineral exploration and prospecting, is that the SGB is not as richly endowed as the AGB. The SGB and AGB share similar lithologies, stratigraphy, and deformation history. Two gold-rich fault systems, named the 'Rundle high strain zone' and the 'Ridout high strain zone', extend across the central and southern portions of the SGB, respectively, and represent the possible westward extensions of the Cadillac-Larder Lake deformation zone. Both of these high strain zones show spatial and temporal relationships to Timiskaming-like rocks and gold mineralization. Thus, these latter relationships together with the presence of the recently discovered world-class 2740 Ma intrusion-related Côté Gold deposit (indicated resource of 7.6 M oz. as of February, 2012) collectively suggest that the SGB may be as prospective as the AGB and offers an opportunity for new insights into Archean gold in a belt that is presently underexplored. To further our understanding of the Au metallogeny of the SGB, two deposits, the Jerome and 4K deposits, that constitute part of a regional Au metallogenic study of the SGB are discussed. The Jerome deposit is located within the Ridout high strain zone ≈ 20 km along strike ENE from the Côté Gold deposit. Given that this deposit is hosted in Timiskaming-like rocks that are cut by felsic porphyries, and is spatially related to a major deformation zone, it has obvious analogies to gold mineralization in the AGB, in particular Kirkland Lake area. The 4K deposit, located in a southern lobe of the SGB, represents epigenetic-type Au mineralization. In this case, Au occurs proximal to gr-grt-amph layers within banded iron formation, which is an important Archean-age Au deposit type globally (e.g., Musselwhite, Beardmore-Geraldton, Homestake). Despite the similarities between the SGB and the AGB, their gold endowments vary considerably and it is the goal of this project to determine reasons for this.

Abstract ID: 35129

Final Number: MD42A-01

Title: Genesis of silver mineralization associated with the Anvil Batholith, Mt Mye Trend, Yukon, Canada

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Abstract Body: The Keg Property is located 20km north of the mining town of Faro in south-central Yukon. It lies along the Mount Mye trend, a structural trend predominantly contained within the Cretaceous Anvil Batholith. The Hammer Zone, an epithermal style Ag±Zn-Pb system, is one of the most interesting prospects within the Mount Mye trend; assays of the Hammer Zone have produced silver grades in the thousands of grams per ton. In this study, the mineralization and alteration at the Hammer Zone are evaluated to determine the relationship between deposit and batholith, and to develop a deposit model.

The Hammer Zone prospect comprises three discrete ten to fifteen centimeter, sulfide bearing quartz-carbonate veins emplaced in a granodiorite host rock. The veins run almost N-S and are associated with sericitic, propylitic and argillic alteration. They were emplaced late in the development of the batholith and crosscut many late features such as pegmatites.

Transmitted and reflected light microscopy work, supported by analysis of mineral chemistry using the electron probe micro-analyzer, has yielded a paragenesis. There are two main sulfide events in the Hammer zone veins; (1) a carbonate hosted pyrrhotite stage associated with silver deposition, and (2) a quartz hosted pyrite stage. These are preceded by barren brecciation phases and post-dated by a chlorite- and hematite-forming event. Silver is present in stage 1 principally in sulfide form, although some oxidized forms exist. The silver-bearing mineral is freibergite, although there are also small amounts of Ag-bearing galena and other silver-bearing phases. Stable isotope work has been completed on the carbonate phases, and yielded $\delta^{13}C_{PDB}$ values of -9.0‰ to 2.8‰, and $\delta^{18}O_{SMOW}$ values of -2‰ to 9‰. Stable isotope work is currently ongoing for the vein quartz. Fluid inclusion analysis will constrain the temperature and salinity of the stage (1) carbonate and stage (2) quartz. These temperatures can be used to further understand the $\delta^{18}O_{SMOW}$ values of the mineralizing fluids and to assess the importance of boiling versus mixing in silver precipitation.

Abstract ID: 34754

Final Number: MD42A-02

Title: A Nanoparticulate Origin for Orogenic Gold

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Abstract Body: Gold concentrations in gold deposits are several orders of magnitude higher than in most ore forming fluids and up to five orders of magnitude more concentrated than in typical crustal rocks. At such low concentrations, vast quantities of fluids must pass through small rock volumes to deposit the metal found in even a modest deposit. Nanoparticulate suspensions or colloids present an alternative transport medium to the aqueous ionic gold complexes that are typically considered to have formed gold deposits. By combining micro-and nano-scale characterisation of the crystallographic and chemical variation in gold grains from the Plutonic Gold Mine, Western Australia, we present the first direct evidence that large, high economic grade, orogenic gold deposits may form from gold nanoparticles.

Electron backscatter diffraction (EBSD) shows that there micron-scale domains of orientation variation within the grain. At the sub-micron-scale these domains contain grains on the order of 50 – 100 nm that have a strong crystallographic texture. In between the gold nanoparticles are nanoparticles of platinum and platinum-iron alloy that have crystallised with the gold. 10 micron-scale inclusions of Fe-Ca aluminosilicate are also present within the gold grains. The inclusions contain nanoparticulate mixtures of gold, Fe-Ca-Al oxide and SiO_2, derived from the same transport medium as the gold. This hypothesis is supported by the strong spatial correlation between calcium-aluminium silicate alteration and gold throughout the deposit. The mixture of oxide and metal/alloy nanoparticles shows that large quantities of gold can be transported as mixed colloids with gold nanoparticles being prevented from coagulating by the oxides at temperatures in excess of 350°C. Post-depositional annealing of the nanoparticulate microstructure has not gone to completion meaning that we have the first evidence that colloids play an important role in orogenic gold deposits.

Abstract ID: 33450

Final Number: MD42A-03

Title: Gold Mineralization and Genetic Evaluation in the North Khentei Gold Belt, Central Northern Mongolia

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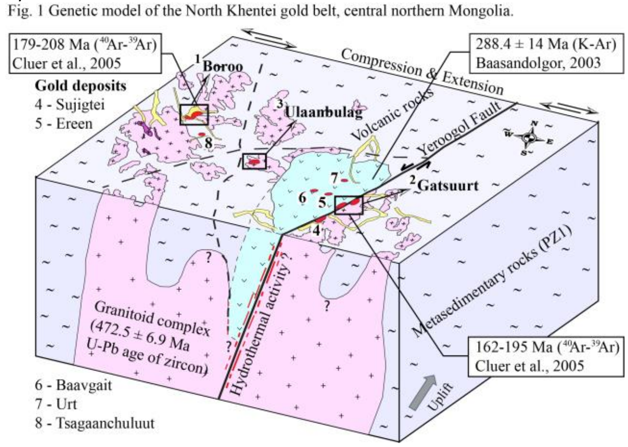
Published Material: Khishgee, C., Akasaka, M., Ohira, H. and Sereenen, J. (2014) Gold mineralization of the Gatsuurt deposit in the North Khentei gold belt, central northern Mongolia. Resource Geology, 64, 1-16.

Abstract Body: Gold mineralization and crystallization sequences of ore-forming minerals in representative deposits of the North Khentei gold belt of Mongolia were investigated to characterize the ore genesis. The Au mineralization occurs as two ore types: I) disseminated and stockwork ores; and II) auriferous quartz-veins. Type-I mineralization in the ^{1}Boroo, ^{2}Gatsuurt and ^{3}Ulaanbulag deposits is composed of four distinct stages: (i) ^{1,2,3}pyrite-I + ^{1,2,3}arsenopyrite-I, (ii) ^{1,2,3}pyrite-II + ^{1,2,3}arsenopyrite-II, (iii) ^{1,2,3}sphalerite + ^{1,2,3}galena + ^{1,2,3}chalcopyrite + ^{1,2}tetrahedrite + ^{1,2}bournonite + ^{1,2}boulangerite + ^{2}jamesonite + ^{2}scheelite + ^{1}alloclasite + ^{1}native gold and (iv) ^{1,2,3}native gold. In Type-II mineralization, five, four and four crystallization stages are also recognized in these deposits, respectively: (i) ^{1,2,3}pyrite-I + ^{1,3}arsenopyrite, (ii) ^{1,2,3}pyrite-II + ^{1,2,3}arsenopyrite + ^{2}galena + ^{2}tetrahedrite-tennantite, + ^{2}sphalerite + ^{2}chalcopyrite + ^{2,3}bournonite, (iii) ^{1,3}sphalerite + ^{1,3}galena + ^{1,3}chalcopyrite + ^{2}geocronite + ^{2}geerite + ^{2}native gold, (iv) ^{1}tetrahedrite-tennantite + ^{1}bournonite + ^{1}geerite + ^{1,2,3}native gold, and (v) ^{1}electrum. Both ore types are associated with sericitic and siliceous alteration. At Boroo and Gatsuurt both ore types contain coexisting CO_2-rich and aqueous fluid inclusions. The inclusions in the Type-I ores homogenized between 254–362ºC, whereas Boroo Type-II ore inclusions homogenized between 237–305ºC. Fluid salinities in both ore types range from 3–6 wt% (NaCl equiv.). The U-Pb age of zircons from Boroo host granites of 472.5 ± 6.9 Ma is much older than previously defined alteration minerals ages (Fig.1). The results indicate that these gold deposits can be classified as contiguous orogenic-type gold mineralization that developed in two stages. Type-I ores are early stage, formed by hydrothermal metasomatic alteration, and Type-II ores are later stage, deposited due to rapidly cooling temperature of the hydrothermal fluids.

Fig. 1 Genetic model of the North Khentei gold belt, central northern Mongolia.



Abstract ID: 34513

Final Number: MD42A-04

Title: Gold and Trace-element Content of Copper Sulphides of the Far Southeast Porphyry Cu-Au Deposit, Philippines

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Abstract Body: The Far-Southeast porphyry Cu-Au deposit, northern Luzon, Philippines, is hosted within the Imbanguila diorite – dacite intrusion complex and formed at 1.3-1.4 Ma, making this one of the youngest porphyry deposits in the world. Far Southeast Gold Resources Inc, a joint venture of Lepanto Consolidated Mining Company and Gold Fields Ltd, recently completed 102 km of underground drilling and confirmed a resource of 892 Mt at 0.7 g/t Au and 0.5 wt% Cu. Previous studies identified native gold as blebs in sulphides, and also proposed the presence of gold micro-inclusions in sulfides. The present study focused on gold deportment using microscopy, SEM with EDS, and LA-ICP-MS. Bornite, chalcopyrite, pyrite, covellite and chalcocite (the latter two replacing bornite) were analyzed in samples that ranged in depth from ~1100 to 1550 m below surface. Gold occurs in or on the margins of sulphides as blebs (<10 um) of native gold (with ~8-15 wt% Ag), krennerite (Au_3AgTe_8) and petzite (Ag_3AuTe_2). LA-ICP-MS analyses of 28 points on sulphide grains that are free of mineral inclusions under SEM indicate that bornite has the highest Au content (≤8 ppm) in its crystal structure; Au in other sulphide minerals is <1 ppm. Locally high Au spikes in bornite are due to micro-inclusions (<1 um), mainly Au tellurides; Te is <1-58 ppm in the crystal structure (i.e., without a discernable phase) and correlates with Au content. High values of Bi (≤ 2160 ppm), Se (≤ 680 ppm) and Pb (≤ 1270 ppm) in bornite tend to correlate; high values of Bi (≤ 482 ppm) and Se (≤685 ppm) in covellite are associated with Pb (≤4 ppm). High Se (133-560 ppm) and Bi (147-5680 ppm) in bornite correlates with high Ag (70-180 ppm). Values of >550 ppm Se and Pb each in sulphides are due to micrometre-size inclusions of clausthalite (PbSe). Sn in bornite is <1 to 22 ppm and in covellite is ≤90 ppm; all sulphides contain <2 ppm Mo and As. We conclude that blebs of native gold and Au tellurides (most ≤10 um to inclusions <1 um in size) are responsible for much of the Au in the deposit.

Abstract ID: 35649

Final Number: MD42A-06

Title: Origin of copper showings in the Cornwallis District and Borden Basin, Arctic islands, Nunavut

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Abstract Body: Two unusual copper showings that are spatially associated with Zn-Pb districts (Borden Basin [Nanisivik; Mesoproterozoic host]; Cornwallis [Polaris; Paleozoic host]), were studied using in-situ micro-analytical techniques to determine their origin.

Abstract ID: 33088

Final Number: MD42A-07

Title: The Eocene Morrison porphyry Cu-Au-Mo deposit, Babine Lake area, British Columbia

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Abstract Body: Morrison is a calc-alkaline porphyry Cu-Au-Mo deposit in the northern Babine Lake area of British Columbia. Mineralization is genetically and spatially related to Eocene plagioclase-hornblende-biotite porphyry intrusions, which intruded into the Upper Jurassic Ashman Formation of the Bowser Group sedimentary rocks. The plagioclase-hornblende-biotite porphyry intrusions yielded a U-Pb age of 52.21 ± 0.37 Ma. The mineralization can be divided into 3 stages: (1) vein-type and disseminated chalcopyrite and minor bornite (associated with potassic alteration); (2) vein-type molybdenite (associated with weak potassic alteration); (3) polymetallic sulfide-carbonate veins (dolomite ± quartz-sphalerite-galena-arsenopyrite-chalcopyrite; related to sericite-carbonate alteration). Re-Os dating of molybdenite from stage 2 yielded ages of 53.55 ± 0.22 and 52.69 ± 0.22 Ma. One of the ages (52.69 ± 0.22 Ma) overlaps within error the age of the plagioclase-hornblende-biotite porphyry and suggests a genetic relationship. Gold is associated with copper mineralization, whereas molybdenite mainly occurs at the edge of copper mineralization zone. Stage 1 vein fluids are higher temperature (Th = 400° to 524°C) and saline. (39.8 to 47.8 wt.% NaCl equiv.). Stage 1 disseminated chalcopyrite-pyrite mixtures have $\delta^{34}S_{CDT}$ compositions of -0.2 and 0.8‰, and calculated $\delta^{18}O_{fluid}$ values from vein quartz range from 5.1 to 7.9‰. These data suggest that the early Cu-Au mineralizing fluids were likely of magmatic origin. Stage 2 is associated with cooler and slightly less saline fluids (Th = 320° to 408°C; salinities = 37.0 to 43.1 wt.% NaCl equiv.). Molybdenite and pyrite from stage 2 veins have $\delta^{34}S_{CDT}$ values of -2.1 to -1.2‰ respectively, and calculated quartz $\delta^{18}O_{fluid}$ values range from 0.9 to 4.6‰, possibly indicating increased groundwater involvement. Fluid inclusions in stage 3 veins have homogenization temperatures of 163° to 218°C and salinities of 3.1 to 3.9 wt.% NaCl equiv. $\delta^{34}S_{CDT}$ compositions of sphalerite and pyrite from these veins range from -7.1 to -5.6‰, and the calculated maximum $\delta^{18}O_{fluid}$ values derived vein quartz range from -16.8 to -6.0‰. These data suggest that stage 3 is associated with a cool and dilute fluid, likely dominantly of meteoric water origin.

Abstract ID: 34028

Final Number: MD42A-08

Title: Using Remote Sensing and GIS to Better Understand a Copper Porphyry Deposit (Peru)

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Abstract Body: This study concerns a copper porphyry which was recently discovered in Central Peru. The overall copper reserves are unknown and cannot be estimated from field inspection alone. The primary objective is to develop new Remote Sensing (RS) and GIS techniques. The second objective is to use these new techniques, along with existing methods, to map and interpret mineral, lithological and structural features.

The two primary RS data types used are medium-resolution ASTER data and high resolution Worldview-2 (WV-2) data. ASTER is a multispectral sensor, which has a broadband coverage (14 bands). ASTER's 14 bands are divided into three wavelength subsystems, with three bands in Visible and Near Infrared (VNIR), six in Short-Wave Infrared (SWIR) and five in the

Thermal Infrared (TIR) portion of the Electro-magnetic spectrum. ASTER's SWIR has sufficient spectral resolution to be used for lithological mapping and hydrothermal alteration mineral exploration associated with porphyry copper. WV-2 is a multispectral satellite with a high spatial resolution of 1.84m.

The study area is about 2x2km situated in a Cu-Mo porphyry belt in central Peru with a semi-arid climate and has considerable relief. The porphyry is approximately 50 million years old and the Pre-Andes orogeny, in which it is found, originated approximately 30 million years ago. The mineralized Cu-Mo porphyry system is dacitic in composition and intruded into the Cretaceous volcanics and the granodiorites of the Coastal Batholith. Most of the porphyry is phyllic altered and strongly leached with hematite/ferric capping and Cu-oxide occurrences.

Various RS-GIS techniques are used to aid in understanding the movement of copper in this deposit. These techniques include False Color Composites (FCC), band ratios, PCA for alteration minerals, and digital image classifiers for lithology. A Sobel edge fetection filter was implemented in MATlab for lineament mapping. A weighted omnidirectional shaded relief filter model was implemented in ArcGIS for structural mapping. ASTER and WV-2 are utilized in conjunction with SRTM DEM data. Results indicate ASTER is applicable to alteration minerals and lithology mapping, while WV-2 is effective in structural mapping.

Keywords: Copper Porphyry, Exploration Geology, Remote Sensing, GIS, ASTER, WorldView-2, Peru

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Abstract ID: 34590

Final Number: MD43A-01

Title: The Key Controls on Making Rare Earth-Rich Carbonatites

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Published Material: Gathers together and analyses results from PhD and MSc theses, which are being prepared for various separate publications and have been presented as conference papers

Abstract Body: Deposits related to carbonatites are still the most important resource for rare earth elements (REE). Levels of light rare earths (La, Ce, Pr, Nd, Sm) can reach >10 wt% in some carbonatites, e.g. in the carbonatite mines at Mountain Pass, USA and Mount Weld, Australia, and although enrichment in the higher atomic number 'heavy' REE is rare, it does occur, and the deposit under exploration at Lofdal, Namibia is an example.

Results from our studies at Songwe, Chilwa Island and Kangankunde, Malawi, at Lofdal, Namibia; Mountain Pass and Mount Weld help towards a better understanding of the key controls needed to produce high enough levels of REE, in large enough quantities, to be of economic interest.

Carbonatites originate from small degree partial melts in the mantle. The most important control on production of large REE-rich carbonatites may be geodynamic environment or a changing mantle through geological time. Whatever the source, it is hard to envisage creating a REE-rich carbonatite without fractionation of magma during the journey into the upper crust. Apatite is the most important single mineral control on fractionation of REE in carbonatite magmas.

Many REE-rich carbonatites form in transition environments and show pegmatoid textures. All have evidence of substantial fluid activity, including fluid metasomatic aureoles around the carbonatite, explosion breccias and subsolidus fluid activity within the carbonatite intrusions. REE-bearing mineralizing fluids follow earlier fenite fluids out into the metasomatic aureole. Mantle source is the ultimate control on the heavy REE-enriched carbonatite at Lofdal but hydrothermal processes are key to precipitation of the ore minerals.

Subsequent alteration can provide further upgrading, for example the concentration of insoluble components during weathering at Mount Weld and the wholesale reworking of probable earlier carbonatite dykes during metamorphic and metasomatic alteration at Bayan Obo, China.

Abstract ID: 36814

Final Number: MD43A-02

Title: Rare earth deposits associated with carbonatites: little-known stats and facts every explorationist should know

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Abstract Body: There are three principal types of rare-earth deposits associated with carbonatites, listed in order of decreasing historical importance: (1) primary magmatic, (2) supergene, and (3) hydrothermal-metasomatic. Primary magmatic deposits have been of historic significance, but are gradually giving way to supergene sources containing higher grades and a relatively larger proportion of heavy REE. Primary REE deposits are scarce for reasons that we are just beginning to understand and place in a global geodynamic context. Phosphorus cycling through mantle sources of carbonatitic melts and early apatite fractionation from these melts appear to figure prominently in REE metallogeny. For purely subjective reasons, igneous provinces that should have been at the forefront of REE exploration activities, have been largely neglected. Hydrothermal reworking of carbonatites has a significant effect on their REE budget, and is generally conducive to the development of high-grade, but localized mineralization. Development of hydrothermal-metasomatic deposits is hampered by their typically small size and mineralogical factors, such as elevated contents of REE-Ca(± Sr, Ba) carbonates. Supergene deposits in (reduced) laterites have very favorable economic parameters, but pose greater metallurgical challenges. Contrary to the popular opinion, carbonatite-hosted projects can compete with other bedrock deposit types in the critical REE market.

Abstract ID: 34346

Final Number: MD43A-03

Title: Hydrothermal transport, deposition, and fractionation of REE: Experimental data and thermodynamic calculations

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Abstract Body: Evidence collected from natural systems suggests that hydrothermal transport and deposition often play a key role in concentrating the REE to economically exploitable levels. Understanding the chemical mechanisms responsible for the aqueous mobilization/deposition of the REE at elevated temperature is, thus, crucial for developing predictive models of REE ore formation. The stability of the aqueous complexes which the REE form with various ligands at elevated temperature is the key factor controlling the concentration and mobilization of REE in hydrothermal systems. An additional control is imposed by the solubility of the minerals which bind and cause precipitation of the metals of interest.

Over the past two decades, a substantial body of experimental data has been collected on the stability of REE species in aqueous fluids at high temperature. These data suggest that the speciation of the REE in hydrothermal solutions up to 300ºC is significantly different from that predicted by the theoretical models, which are still widely employed to evaluate REE mobility in nature. Moreover, in contrast to an earlier belief, these data demonstrate a pronounced dependence of the stability of some species on the atomic number of the REE, an effect that can cause REE fractionation in some hydrothermal processes.

In this contribution, we report the results of thermodynamic calculations re-evaluating the mechanisms responsible for the hydrothermal transport and deposition of the REE, based on the latest experimental data. We also evaluate the fractionation effects that can be observed during leaching/deposition in various natural environments.

Abstract ID: 35071

Final Number: MD43A-04

Title: The Sullivan Island Carbonatite Complex and Its Relationship to Late Alkalic Magmatism in the Central Metasedimentary Belt boundary tectonic zone, Grenville Orogen, Southeastern Ontario

Presenter/First Author: Robert Michael Easton, Ontario Geological Survey, Sudbury, ON

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Abstract Body: The little studied Sullivan Island carbonatite complex is exposed in and along the Ottawa River 90 km northwest of Ottawa, and is hosted in deformed upper amphibolite facies gneisses of the boundary zone (CMBbtz) that separates the Central Metasedimentary and Central Gneiss belts of the Grenville Orogen. The complex consists of fenitized country rock and a breccia composed of a matrix of calcitic silicocarbonatite (~20% SiO_2) rich in strontium (5955 ppm) and a variety of variably fenitized country-rock fragments. REE-bearing phases in the complex are predominantly fluorapatite and allanite, with the latter forming large crystals. Small grains (<20µ) of synchsite, bastnasite and barian-strontianite are also present. Abundant scapolite within the silicocarbonatite may indicate the presence of Cl- and F-rich fluids. Radioactive mineralization in the complex is limited, but, 2 U-Th airborne gamma-ray spectrometric highs, 1 assayed at 927 ppm U and 2717 ppm Th by scintillometer, occur immediately south of the complex along the north-trending Ross fault, which may have controlled emplacement of the complex.

An unpublished U-Pb zircon age of circa 1050 Ma, obtained in the early 1980s from the siliciocarbonate, is likely an emplacement age, as it is consistent with the presence of zircon grains in the silicocarbonatite matrix, and with a minimum age for the complex based on a cross-cutting mafic dike of the 590 Ma Grenville dike swarm. Furthermore, volumetrically significant alkaline magmatism occurred along the length of the CMBbtz in Ontario between 1055 and 1030 Ma, resulting in the emplacement of nepheline syenite and syenite intrusions and calcite-diopside±scapolite±apatite vein dikes (pseudocarbonatites of Mitchell 2005), and the development of REE-bearing metasomatized marbles characterized by pink-orange calcite. Thus, the Sullivan Island carbonatite complex is likely related to this Grenvillian alkaline magmatic event, and its location in the younger Ottawa-Bonnechere graben may be simply fortuitous.

Abstract ID: 35392

Final Number: MD43A-05

Title: The Solubility and Speciation of Tantalum in Fluoride-Bearing Aqueous Solutions

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Abstract Body: Recent investigations (in press) have demonstrated that niobium is mobile in aqueous fluids at elevated temperature, and that this mobility increases with higher fluoride activity. There are, however, no data on the solubility and speciation in aqueous solutions of its geochemical “twin”, tantalum. Such data would permit assessment of the relative mobility of niobium and tantalum in hydrothermal fluids and their fractionation in various geologic environments. As with niobium, hard acid-soft base (HSAB) considerations suggest that fluoride is the ligand most likely to form stable complexes which will facilitate the development of significant concentrations of tantalum in hydrothermal fluids. Results of previous experiments by Zaraisky et al. (2008) conducted with columbite-(Mn) in fluoride-bearing solutions at elevated temperature and pressure suggest that tantalum is an order of magnitude less soluble than niobium, but no thermodynamic data or equilibrium constants were derived from these experiments.

In this study, we determined the solubility of tantalum oxide in aqueous solutions at elevated temperature (100-250 °C), variable fluoride activity (~10^{-5}-10^{0} mF), and variable pH (2.0 and 2.8). Our experiments involved determining the solubility of tantalum oxide in F-bearing aqueous solutions at temperatures up to 250 °C and vapour-saturated water pressure. The experiments were performed using the autoclave solubility method and employed a technique involving teflon tubes, which was developed previously for determining the solubility of REE fluorides in F-bearing solutions.

Preliminary results indicate that the speciation and solubility of tantalum are dependent on the activity of fluoride in the aqueous solution. At low fluoride activity (~ $<10^{-2.5}$ mF), niobium solubility is low, whereas at higher fluoride activity (~ $>10^{-2.5}$ mF), the solubility of tantalum increases by multiple orders of magnitude. However, at an equivalent fluoride activity the solubility of tantalum is more than an order of magnitude less than that of its twin, niobium. The rapid increase in tantalum solubility at higher fluoride activity is similar to that observed for Nb, and suggests that tantalum may dissolve as a hydroxide or hydroxyl-fluoride species in our experiments.

Abstract ID: 33610

Final Number: MD43A-06

Title: Y and HREE Mineralization in the MAW Zone, Athabasca Basin: Petrography and Fluid Inclusion Studies

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Abstract Body: The MAW Zone REE deposit represents one of the largest heavy REE and Y concentrations inside the Athabasca Basin in northern Saskatchewan. The deposit is located in the southern part of the basin between the Key Lake and McArthur River unconformity-related uranium deposits. The spatial association of this deposit with unconformity-related uranium deposits and faults that parallel a basement high (“quartzite ridge”) led geologists to consider a genetic relationship between each.

Petrographic examination of the host sandstone shows that it has been subjected to silicic, argillic, and dravitic alteration, and is cut by abundant fractures filled with dravite and drusy quartz. Also present in the altered sandstones are minor amounts of zircon, clays, iron oxides, and galena. Xenotime as the ore mineral is generally scarce in the samples examined, but is locally abundant in brown patches in the sandstones. Petrographic studies suggest that mineralization took place after significant compaction of the sandstones. The drusy quartz contains liquid-rich biphase inclusions, vapour-dominated inclusions with various vapour percentages, and daughter-mineral–bearing inclusions. The coexistence of these fluid inclusions suggests a boiling hydrothermal fluid system and heterogeneous trapping of fluid inclusions. Homogenization temperatures of the liquid-dominated biphase inclusions range from 71° to 138^{o}C, and the ice-melting temperatures range from -10.4° to -27.1^{o}C, corresponding to salinities from 14.4 to 24.9 wt.% NaCl equivalent. The ice-melting temperature and salinity data are comparable to those reported for unconformity-type uranium deposits present in the same general area, but the homogenization temperatures are relatively low. The potential genetic relationship between the REE mineralization and the unconformity-type uranium deposits needs to be further constrained from geochronological and stable isotopic studies.

Abstract ID: 34342

Final Number: MD43A-07

Title: In situ U-Pb geochronology, Hf and Sm-Nd isotopic characteristics of zircon, titanite, apatite and monazite from the Hoidas Lake REE mineralization, northern Saskatchewan, Canada

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Abstract Body: The diopside-allanite veins and apatite breccia veins of the Hoidas Lake rare earth element (REE) deposit were emplaced along the Hoidas-Nisikkatch Fault, an inferred subsidiary of the regional Black Bay Fault, and cross-cut the strongly deformed Archaean and Paleoproterozoic granitoid gneisses of the Rae Province. We report on the results of laser-ablation ICP-MS U-Pb geochronology of zircon and titanite from the diopside-allanite veins and green apatite and monazite from the apatite breccia veins, Hf isotopic data of zircon and Sm-Nd isotopic compositions of titanite, apatite and monazite, in an attempt to constrain the age of the REE mineralization, and to provide implications on its magmatic source.

Geological relationships and in situ U-Pb data indicates that the REE veins formed during and after peak metamorphism, which occurred at ca. 1.9 Ga. However, there are zircon crystals in the diopside-allanite veins with concordant U-Pb ages of ~2350 Ma which are interpreted to be inherited from granitoids that formed during the Arrowsmith Orogeny. Zircon rims with concordant U-Pb ages around 1906 Ma are inferred to represent zircon growth during the emplacement of the REE veins, based on textural features and the difference in Hf isotopic composition of rims vs. cores (εHf(t) of approximately -5 vs. 30, respectively). Titanite and monazite yielded concordant U-Pb ages ranging from ca. 1931 to 1825 Ma, whereas green apatite defined a discordant array with an upper intercept of ~1814 Ma. The calculated εNd(t) values of titanite, green apatite and monazite (-15.3 to -10.9) are comparable to εNd(t) values reported for the Martin Group alkali basalts in the Beaverlodge Domain and the Christopher Island Formation in the Baker Lake Basin, both of which also yielded similar U-Pb ages, suggesting that these alkali units originated from a similar source, most probably an ancient and compositionally complex lithospheric mantle reservoir.

Abstract ID: 35812

Final Number: MD43A-08

Title: Airborne Geophysics for Rare Earth Element Exploration

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Abstract Body: Abstract:

The Lake Leroux REE project is localized in the upper Gatineau region, Quebec Canada, 265 km NW of Montreal and 100 km N of Mont-Laurier.

Geological setting: The calc-silicate rocks of the Grenville Group are in contact with

Pre-Grenville granitic gneisses. The contact zone is cut by dikes of REE rich pegmatites.

Mineralogy synthesis: Magmatic rock, layered and probably metamorphosed , not magnetic, radioactive. Name: Syenite charnockitique, the mineralization is associated with hydrothermal alteration of pyroxene. The pyroxene are altered in a matrix of quartz and potassium feldspar.

On the outskirts, pyroxene contains thorium. At heart, it is altered in allanite (REE). The altered pyroxene in allanite is then cut by britholite veinlets. Hydrothermal mineralization in britholite and allanite (traces). Traces of hydrothermal zircon. Potassium Feldspar 70%, Quartz 15%, Pyroxene (thorium) (15%)

Geophysical Surveys: An Airborne Geophysical Survey covering 500 Line Kilometers of Aeromagnetic Gradiometer and Spectrometric was flown.

The Survey results indicate an N-S trending magnetic anomaly with a distinct break in the trench south of the central point. Samples taken from the edge of the discontinuity show elevated amounts of mineralization. To date ground fellow-up has uncovered more than 188 ground spectrometric anomalies. Richest samples were collected around the Hi/Low Magnetic Contrast, and high spectrometric counts area (Total Counts 500 cps and over).

Geochemistry: Samples shows up to 1, 6% TREO and up to 18% H+M+Y/TREO. More than 45 samples were analyzed by (ICP, ME-MS81) and 60 by XRF.

Ore Characterization : Bulk Samples (100 kg each) from 3 sites, will be analyzed by: " electron microprobe " to get a rough estimate of minerals present, " size- by- size" to get the basic levels for each size fraction based on ICP-MS and ICP-MP analyses , and possibly" QEMSCAN " to get an accurate estimate of minerals.

Abstract ID: 34126

Final Number: MD44A-0209

Title: Gold Mineralization at the Renabie Mine: The Importance of an Early Hydrothermal Vein Anisotropy on Shear Zone Localization

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Abstract Body: Gold mineralization in metamorphic terranes records the structural focussing of hydrothermal fluids of either magmatic or metamorphic affinity. The term “orogenic” emphasizes quartz-carbonate veins that are syn- to post-peak regional metamorphism in timing. Detailed outcrop-scale mapping and sampling at the former Renabie mine (~1.1 Moz Au) within the Wawa subprovince of Ontario suggests that the shear zone-hosted, sericite-banded quartz veins predate deformation. These gold bearing-banded veins are enriched in Ag, Bi, Mo, Pb and Te, and are hosted by ca. 2741 granitoids of the Wawa terrane directly marginal to volcanic units of the Michipicoten greenstone belt. Three deformation events (D_1-D_3) account for the observed vein geometries along the main east-striking mineralized structure. The early sericite-banded quartz veins occupy the centers of east-east southeast trending, reverse-sinistral D_2 shear zones. Although there is a spatial association between the banded veins and D_2 shear zones, the veins are overprinted by F_1 and F_2 folds, suggesting that they were emplaced early with respect to both deformation events. Gold-bearing pyrite veins were generated late relative to the D_2 event possibly during D_3 reactivation of the shear zones as dextral transcurrent fault zones. The intimate spatial association between the sericite-banded veins and D_2 shear zones suggests that the veins acted as a pre-existing anisotropy, which facilitated the initiation and propagation of the shear zones that then acted as conduits for the migration of hydrothermal fluids. The results of this study have implications for genetic models regarding gold deposits in metamorphic terranes by illustrating that the presence of early veins and altered domains, mineralized or barren, can subsequently focus strain and localize later vein generation. Thus, the Renabie mine exemplifies how composite veins can form during multiple events in a shear-zone hosted gold deposit.

Abstract ID: 34924

Final Number: MD44A-0210

Title: Unravelling the Archean to Proterozoic History at the Meliadine Gold District, Nunavut, Canada

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Published Material: Part of these findings (Re-Os ages and U-Pb monazite ages) were presented at 'Geology Matters' (November 2014, Halifax) and the Yellowknife Geoscience Forum (November 2014, Yellowknife). Some of these findings (Re-Os ages and U-Pb monazite ages) comprise part of a manuscript submitted to Economic Geology. However, new U-Pb dettrital zircons have not previously been reported.

Abstract Body: The Meliadine gold district comprises a combination of orogenic greenstone- and BIF-hosted gold mineralization. The largest gold deposits (e.g., Tiriganiaq) occur north of the NW-trending Pyke Fault and/or along its E-trending splays. New U-Pb detrital zircon ages suggest that greenschist to amphibolite facies turbiditic and mafic volcanic host rocks were deposited ≤2.66 Ga, in agreement with the inferred age of the Rankin Inlet greenstone belt at ca. 2.66 Ga. However, a polymictic conglomerate south of the Pyke Fault was deposited ≤2.50 Ga and confirms that the Rankin Inlet greenstone belt comprises intercalated Archean to Paleoproterozoic supracrustal successions.

Gold in the district is paragenetically late and occurs at arsenopyrite grain boundaries, fracture fills, and/or as clusters of gold inclusions associated with variably recrystallized arsenopyrite domains and hosted within hydrothermally altered and veined BIF. These micro-textures suggest that sulphide recrystallization liberated gold that was remobilized, at least locally, into low-strain microtextural sites along with other precious- and base-metals during a late fluid-assisted event(s). We propose that remobilization was concomitant with the growth of hydrothermal xenotime and monazite (1.86–1.85 Ga), which post-date arsenopyrite and occur together with gold. New Re-Os arsenopyrite model ages range from 2.3–1.8 Ga, whereas replicate analyses of the two most Re-rich and homogeneous arsenopyrite samples yield Re-Os model ages at ca. 2.27 and 1.90 Ga. We speculate that gold at the Meliadine gold district was initially introduced at 2.27 Ga and/or 1.90 Ga along with arsenopyrite and was subsequently remobilized, coupled with arsenopyrite recrystallization, during the Trans-Hudson orogeny at 1.86–1.85 Ga.

Abstract ID: 34249

Final Number: MD44A-0211

Title: *Key parameters controlling the genesis of the BIF-hosted Meadowbank gold deposit, Churchill Province, Nunavut*

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Abstract Body: *The Meadowbank gold deposit is hosted in banded iron formations (BIF) of the ca. 2711-2710 Ma Pipedream-Third Portage volcanic sequence of the Woodburn Lake Group. This sequence comprises* several similar BIFs of which only one contains economical gold mineralization (Central BIF). Host rocks consist of greenschist to amphibolite grade intermediate to felsic volcaniclastic rocks, mafic and ultramafic rocks, quartzite and BIFs. Notwithstanding cryptic and strongly overprinted Archean tectonism, four phases of Proterozoic deformation have been regionally documented. In the Meadowbank deposit area, several generations of structures are recognized: 1) isoclinal F_1 folds and D_1 faults overprinted by 2) south-trending isoclinal F_{2a} folds and associated D_2 fault zones that cut ore zones. Late D_2 deformation consists of north-trending gentle F_{2b} folds, 3) open to closed SW-plunging F_3 folds, and 4) south-verging shallowly-inclined, open to tight, chevron-style F_4 folds. The bulk of the gold, *associated with pyrrhotite ± pyrite, is hosted in BIF. Gold-rich quartz-pyrrhotite-pyrite veins are present in volcaniclastic rocks intercalated with the BIF.* Grunerite and chlorite are common in mineralized BIFs, whereas muscovite, chlorite and pyrite dominate in volcaniclastic rocks. Biotite, Fe-Mg amphibole and garnet occur in higher metamorphic grade rocks to the south. Crosscutting relationships suggest that the gold was introduced along D_1 faults and was likely remobilized during D_2, especially along sheared contacts and F_{2a} fold limbs. Deposit- and regional-scale field work coupled with new U-Pb ID-TIMS zircon crystallization ages and lithogeochemistry indicate that the Meadowbank deposit is located at or near the boundary between two distinct lithological assemblages (2710 Ma and 2717 Ma) separated by plausibly long-lived fault zones that potentially have controlled gold deposition and distribution, a specific structural setting that is unique to the mineralized Central BIF.

Abstract ID: 34902

Final Number: MD44A-0212

Title: Key geological parameters of the BIF-hosted Musselwhite gold deposit, Superior Province, northwestern Ontario and implications for exploration.

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Published Material: GAC-MAC talk in May 2013 in Fredericton; SOFW during fall 2014; GSC Current Research submitted and currently undergoing edition.

Abstract Body: Musselwhite is a world-class syn-deformation Au deposit hosted by amphibolite facies Algoma-type banded iron formation (BIF) comprised in the Mesoarchean North Caribou greenstone belt, Superior Province. The deposit is located just 2 km west of a major tectonic boundary with the ca. 2857 Ma Schade Lake gneissic complex. Detailed underground and surface mapping provides critical insights on the deposit- and regional-scale geological and structural settings of Au mineralization. The bulk of the Musselwhite ore is hosted in silicate-rich BIF and occurs as stratabound pyrrhotite replacements and associated silica flooding with local discordant qz±po veins. The ore zones are associated with D_2 high strain zones concentrated along hinges and strongly attenuated fold limbs of tight F_2 folds. The layered anisotropy induced by competent BIF and surrounding mafic and ultramafic volcanic rocks has clearly influenced the rheological response to D_2 deformation at all scales, and hence played an important role in Au-bearing fluids flow and ore formation and distribution. A polygenic conglomerate was discovered in the upper part of the stratigraphy. New U-Pb ages of ca. 2665 Ma on late-M_2 monazite provide a minimum timing constraint for the regional D_2 metamorphic/deformation event to which most of Au mineralisation is associated at Musselwhite.

Reappraisal of stratigraphic relationships supported by U-Pb geochronology indicates that the mine stratigraphy is inverted, part of the overturned limb of a kilometre-scale F_1 syncline, in agreement with multiple occurrences of mesoscopic refolded F_1 folds. Previously unrecognized regional F_1 folding, which is strongly overprinted by the dominant D_2 deformation, has undoubtedly influenced the distribution and geometry of the BIF units hosting the bulk of Au mineralisation and provides new vectors for exploration at regional scale. The importance of a major fault and the presence of conglomerate in the upper stratigraphic sequence provide guidelines for exploration throughout the greenstone belt, especially when combined with tightly folded silicate-rich BIF horizons in altered anisotropic succession.

Abstract ID: 35292

Final Number: MD44A-0213

Title: Hydrothermal Chromium Mobility in the MacLellan Au-Ag Deposit: Implications for Petrogenetic Interpretation

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Abstract Body: The MacLellan Au-Ag deposit is located approximately 7 km NE of Lynn Lake, Manitoba and is hosted by a sequence of mafic metavolcanic rocks that comprise part of the northern section of the Lynn Lake greenstone belt. Outcrop mapping, core logging, and petrographic analysis in combination with mineral and whole rock chemical analysis indicate that the host rock sequence was dominated by porphyritic metabasalt (now amphibole-plagioclase schist) with a tholeiitic composition prior to Au-Ag mineralization-related deformation and alteration. The amphibole-plagioclase schist has been subsequently affected by: 1) biotite ± quartz alteration during a syn-D_2 hydrothermal

event, and 2) chlorite + carbonate ± amphibole ± quartz alteration (with and without biotitic bands) during a syn-D_4 hydrothermal event. This second alteration style, which affects rocks for strike lengths of 100s of metres, is accompanied by significant increases in the abundances of Mg, Ni, and Cr relative to unaltered amphibole-plagioclase schist. Although mineralogical evidence of alteration was identified previously, its association with hydrothermal enrichment of Mg, Ni and Cr was not. Rocks identified in this study as deformed and altered amphibole-plagioclase schist (i.e., tholeiitic metabasalt) have been previously classified as 'high Mg-Ni-Cr basalts' or 'picrites', however, their association with hydrothermal alteration makes these magmatic classifications inappropriate. Evidence of mobility of elements routinely considered to be immobile in hydrothermal systems (i.e., Ni and Cr) and the resulting impact on identification of igneous protoliths has implications for greenstone belts in general where mafic to ultramafic metavolcanic rocks have been identified based on classification schemes that use Mg, Ni and Cr. This is particularly relevant to rocks that exhibit relatively high loss on ignition, evidence of shearing, and lack of equivalent, relatively unaltered rocks.

Abstract ID: 35350

Final Number: MD44A-0214

Title: Gold mineralization in the Belleterre mineral district, Pontiac Subprovince, Québec — relationships to deformation events and lamprophyre intrusions

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Abstract Body: Lode gold in Belleterre Group volcano-sedimentary rocks 150 km S of Rouyn-Noranda in the Pontiac Subprovince of the Superior craton is known since the 1930s; the former Belleterre mine produced > 960,000 oz of gold at an average grade of 13.7 g/t. The area still harbours a promising gold potential. Numerous calcalkaline lamprophyre dikes, granodiorite and QFP intrusions cut through volcanic rocks and are present in most gold showings. Lamprophyre dikes are separated into (1) chlorite (after biotite), (2) hornblende-biotite and (3) biotite generations. Most lamprophyres predate lode-gold, although some host gold.

The first deformation phase (D1) produced regional structures and a penetrative cleavage (S1) oriented E-W in the southern part of the belt, progressively becoming N-S northward. The second deformation phase (D2) is characterized by a crenulation cleavage coplanar with the Belleterre anticline axial plane and shear zones. Some tonalite, granodiorite, monzonite and monzodiorite bodies intruded in D2. Conjugate faults formed in a third (D3) event. Mineralization comprises: (1) early lode gold that predates D1; (2) late-D1 veins up to 700 m long, varying from 10cm to 3m thick infilling faults and tensile fractures; (3) contemporary syn-D2 lode gold in very narrow shear veins, and veins in felsic intrusions. Fault-fill veins, controlled by syn-volcanic faults along basalt-gabbro contacts which focused hydrothermal fluids, display a multiphase paragenesis enriched in Py, Po, Sp, Ga, Cp ± quartz, ankerite, calcite, electrum and gold (associated with sulfides). Pyrite is the main sulfide mineral in some veins while pyrrhotite dominates in others, despite the greenschist facies metamorphism. The first episode of mineralization is characterized by disseminated pyrite containing sub-microscopic gold. The second episode consists of gold remobilized during peak metamorphism (continuing during retrograde metamorphism) and free gold with pyrrhotite, galena, and bismuth.

Abstract ID: 35420

Final Number: MD44A-0215

Title: Syn-Orogenic, Intrusion-Related Gold Mineralisation Associated with an Archean Compressional Fault in the Bachelor Mine, Desmaraisville, Abitibi, Canada.

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Co-authors: Alain Tremblay, GEOTOP, Montréal, QC, Canada; Jérémie Lemarchand, , ,

Abstract Body: Located in the northeastern part of the Archean Abitibi greenstone belt (AGB), the orogenic gold mineralisation of the Bachelor mine is hosted by the 2730-2720 Ma Obatogamau Formation. The source of gold mineralisation is presumably related to the 2650-2680 Ma syenite of the O'Brien pluton, a late syn-orogenic intrusion of the AGB. This contribution presents our preliminary field observation and structural interpretation based on underground and surface geological mapping of the Bachelor mine.

The Desmaraisville area is located within the Lamark-Wedding structural corridor, a major NE-SW trending structure of the AGB. Two main structures host the mineralization in the Bachelor mine: (1) the "Main Structure", and (2) the "Wac (i.e. Waconichi) Structures". The "Main Structure" is approximately East-West trending (N105) and is sub-vertical or dips steeply to the south. It is host to a massive core of K feldspar-hematite-silica-pyrite (K-Hm-Si-Py) bounded by a dense stockwork of veins locally showing late-stage brecciation that is marked by abundant quartz-rich matrix. The "Wac structures" are frequently underlined by mylonitic shear zones, sometime brecciated, that are characterized by alternating bands of sericite-pyrite-silica (Ser-Py-Si) and K-Hm-Si-Py tectonic layers. Sericite seems to be a late phase of the mineral assemblage, sometimes overprinting the Hm-K rich layers. The "Wac Structures" trend N075 and dip approximately 60º to the southeast. Fault lineations and shear-sense indicators suggest a right-lateral reverse movement. Our preliminary observations suggest that the "Main" and "Wac" structures formed an anastomosed network of fractures relate to the auriferous hydrothermal fluids circulation. The junction of the "Main" and "Wac" structures corresponds furthermore to important mineralised pockets and constitutes high potential ore shoots. Note that the "Wac Structures" are strongly refracted within the "Main Structure" which significantly affects the ore zone geometry. These structures probably also represented preferential weakness planes that have been used for the upward migration of the O'Brien syenite into the Archean crust.

Abstract ID: 35731

Final Number: MD44A-0216

Title: A Mineralogical, Geochemical and Geochronological Study of Marathon Gold Corporation's Valentine Lake Gold Camp; Central Dunnage Zone, Newfoundland

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Published Material: Some minor aspects (deposit location, QTP vein styles and host lithologies) outlined in the abstract have previously been presented (posters) by the author's during the Student Mineral Colloquium at PDAC 2014, and during the 2014 GAC Conference in New Brunswick. These same aspects have also been reported in publications and technical reports released by Marathon Gold Corp, at least annually, since 2011.

Abstract Body: Marathon Gold Corporation's Valentine Lake Gold Camp is located in the Exploits Subzone of the Dunnage Terrane of the Newfoundland Appalachians, approximately 20 km east of the main Iapetan suture - the Red Indian Line (RIL). The property contains numerous auriferous zones within a northeast-southwest trending mineralized corridor, largely hosted within Neoproterozoic (563 Ma) trondhjemite and associated phases of the Valentine Lake Intrusive Suite (VLIS). Gold mineralization occurs primarily within quartz-tourmaline-pyrite (QTP) veins, vein stockworks and adjacent selvedges. Minor gold also occurs within QTP networks containing varying amounts of carbonate, muscovite, chlorite, apatite and rutile - as well as in late base metal-rich quartz veins, and in en echelon quartz-carbonate-chlorite predominated veins and tension gashes. All vein networks reside in close proximity to a 30 km regionally extensive, brittle-ductile shear zone, which defines the eastern contact of the VLIS with a Silurian fault-scarp sequence, the Rogerson Lake Conglomerate (RLC). A suite of heterogeneously deformed basaltic and gabbroic dykes, variably transposed toward the penetrative regional foliation, also traverse the property. Detailed ore petrography has identified pre-native gold precious metal-telluride and post-native gold base metal-telluride assemblages in all QTP vein networks. Locally, an additional late base metal assemblage, associated with silicification and pyrite recrystallization, may pre-date a second generation of gold mineralization. Ore petrography, U-Pb geochronology, trace element analysis of native gold, and sulphur isotopic analysis of pyrite are being combined to constrain the timing and nature of gold mineralization at Valentine Lake and to recognize any correlation between mineralization and distinct events during the Salinic and/or Acadian orogenies.

Abstract ID: 35939

Final Number: MD44A-0217

Title: *Mineralogical and Geochemical Vectors for Ore Targeting: the Footprint of the Canadian Malartic Gold Deposit, Québec*

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Published Material: Preliminary results regarding mineral chemistry were presented at the Keystone SEG conference. Last results greatly improve the understanding of the Canadian Malartic footprint by providing new mineral tools (white mica chemistry) for ore targeting. We also investigated the substitution mechanisms involved in the compositional variations of micas. Last, we provide new whole-rock geochemical data which give us insights on the signature of the Canadian Malartic Gold deposit (investigation of mass changes relative to distance to the ore zones), as well as new parameters to investigate the physico-chemical changes going away from the deposit.

Abstract Body: Canadian Malartic represents an important example of a large-tonnage, low-grade gold deposit in the southern Superior Province. It is located in the Pontiac Subprovince, in contact with, and immediately south of the east-west trending Cadillac-Larder Lake fault zone, marking the contact with the Abitibi Subprovince. Most gold deposits in the Abitibi Greenstone Belt are of orogenic type and are typically associated with quartz-carbonate veins and albite-carbonate alteration. Canadian Malartic contrasts with these deposits in that the gold is disseminated in potassically altered (pyrite-K-feldspar-biotite-calcite) quartz monzodiorite porphyries and adjacent clastic metasedimentary rocks. Mineralization is associated with quartz-biotite-carbonate-microcline±pyrite veinlets with potassic (biotite, K-feldspar) and pyritic alteration haloes, and is distributed as elongated, lens-shaped orebodies, strongly controlled by faults and lithological contacts. Hydrothermal alteration in clastic metasediments was accompanied by mass gains in S, LOI and K, consistent with the mineralogical characteristics of the alteration assemblage. Gold mineralization in metagreywacke is associated with substantial mass gains in Ag-Te-Bi-Mo-Pb-W. These observations can be used to trace the extent of the ore deposit footprint and provide vectors towards mineralization. Core-logging, whole-rock geochemistry as well as variation in gold concentrations show that the intensity of hydrothermal alteration decreases sharply away from the deposit. Biotite compositions are a potentially valuable footprinting tool to identify directional vectors toward mineralization, as they show significant increases in fluorine and magnesium concentrations from distal unaltered rocks toward the ore shell. Preliminary results indicate that the visible alteration halo (*e.g.*, pyritisation, carbonation or potassic alteration) does not extend more than 500 meters from the southern limit of the pit.

Abstract ID: 36482

Final Number: MD44A-0219

Title: Role of colloidal transport in the formation of high-grade gold veins at Brucejack, British Columbia

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Published Material: Some of the field observations will have been presented on a poster at the 2014 Canadian Tectonics Group meeting in Sudbury and in an Oral presentation at the 2015 GEOTOP conference.

Abstract Body: Extraordinary concentrations of gold (up to 40 kg/tonne) occur in quartz-carbonate veins at the Brucejack gold deposit in British Columbia. These veins are part of an extensive mineralized vein stockwork and quartz-sericite-pyrite alteration zone. Unlike nearby lower-grade giant porphyry-style copper-gold deposits, the distribution of grades at Brucejack is highly variable, creating challenges for resource estimation. We propose that a model of structurally controlled, episodic and concentrated gold precipitation might best explain the gold distribution at Brucejack. During rapid fracturing, fluid pressure drops contribute to precipitation of colloidal nanogold (or electrum) and colloidal silica. These colloids may self organize and accumulate locally in structural dilation sites over many cycles of fracturing, eventually reaching extremely high grades. Recrystallization of amorphous silica to quartz destroys any colloidal microstructure and pushes any impurities to grain boundaries. The Brucejack deposit has been deformed post mineralization thus a reference site to compare observations is required. Fresh silica sinter formed in a hydrothermal system associated with active slip on the Fairview Fault, Nevada, contains an amorphous silica phase with 2-3% dispersed gold. Field observations at Brucejack of the structure of veins and faults within the deposit-hosting stock work, as well as microprobe and optical microscopy observations of selected quartz textures, will be presented and compared to preliminary observations from our recent fieldwork at the Fairview Fault. By comparing these two deposits, we hope to determine whether colloidal transport played a role in gold deposition at Brucejack.

Abstract ID: 33320

Final Number: MD44A-0220

Title: GOLD EXPLORATION AT SOUTH EASTERN DESERT, EGYPT USING REMOTE SENSING TECHNIQUES

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Abstract Body:

GOLD EXPLORATION AT SOUTH EASTERN DESERT, EGYPT USING REMOTE SENSING TECHNIQUES

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ABSTRACT

The processing of ASTER images band ratios 7/6*4/6 and (7+9/8) supported by field geology, mineralogical and geochemical analyses enabled detection of two alteration zones as targets for gold exploration at Al Faw- Eqat belt (a case study in the south eastern desert). Representative samples were collected from the detected areas, north of Gabal Eqat (area1) and north of Gabal Al Faw (area 2) for geochemical analyses to assess the gold and associated metals. The result of Atomic absorption and ICP analyses recorded Au content up to 9.8 g/t in the quartz veins and 7.8 g/t in the altered volcanics in area1 and 14.0 g/t in the quartz veins and 6.8 g/t in the altered volcanics in area2.

Al Faw- Eqat belt is made up of metamorphic and magmatic late Proterozoic rock assemblages. The metamorphic suite consists of ophiolitic ultramafics thrusted over the metavolcanosedimentary (mvs) schist of intermediate to basic composition. It is highly tectonized sheared metavolcanics and ultramafic rocks extended in the NW/SE trend. The magmatic suite comprises syn- to late-tectonic calc-alkaline granites of less deformed tonalite and monzogranites which were intruded by post-tectonic potassic calc-alkaline granite form Gabal Eqat body sending sheets, plugs, apophasis and quartz veins in the surrounded mvs leaving marked of alterations promised localities for mineralization.

Keywords: Remote Sensing, Proterozoic, Alteration zones, Gold

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Abstract ID: 35975

Final Number: MD44A-0221

Title: Structural geology and timing of deformation at the Gibraltar copper-molybdenum porphyry deposit, Cariboo Region, British Columbia

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Published Material: presented at the GSA in Vancouver 2014

Abstract Body: The Gibraltar copper-molybdenum mine, located northwest of Williams Lake, is hosted in the Late Triassic Granite Mountain batholith. The main ore zone, hosted within the Mine Series phase tonalite has been structurally dismembered and questions still exist regarding the relationship between pluton emplacement, mineralization (215 ± 1.0 – 210 ± 0.9 Ma; Harding, 2012) and deformation.

The oldest structures on the property include a gently southwest dipping foliation (S_1), that is locally subparallel to mineralized sheeted veins, and large mylonitic high strain zones with a top to the north or northeast sense of displacement. Discrete, imbricate south-southwest dipping thrust faults are interpreted as kinematically linked to the large high strain zones. North-striking dextral-normal faults, with well-developed cataclasites, cross-cut S_1 fabrics and thrust faults and likely formed at shallower crustal levels. Shallowly southeast-plunging lineations, including intersections, fold axes, and boudin necks, affect all fabrics and represent the last stage of deformation: cause of this late-stage flattening resulting in boudinage and crenulations is not yet resolved.

We present structural cross sections through the Granite Lake operational pit to illustrate the effect of deformation on ore distribution. There is generally a positive correlation between areas of intense alteration and mineralization and deformation and this is highlighted on the cross sections.

U-Pb (zircon; TIMS) taken from the Granite Lake pit provides an age of crystallization of the Mine phase tonalite. $^{40}Ar/^{39}Ar$ cooling ages obtained from muscovite that defines deformation fabrics (e.g. S_1, thrust faults, SE-plunging lineations) show a range of Eocene ages for deformation (~54-34 Ma). We interpret that some of the Ar-Ar cooling ages represent resetting during Eocene deformation.

Abstract ID: 36203

Final Number: MD44A-0222

Title: Oxidation state and Cu content of arc magmas: implications for metallogeny

Presenter/First Author: Jeremy P. Richards, University of Alberta, Edmonton, AB

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Published Material: Richards, J.P., The oxidation state, and sulfur and Cu contents of arc magmas: Implications for metallogeny: Lithos, *in press*.

Abstract Body: Published Fe_2O_3/FeO ratios and Cu contents of fresh volcanic and intrusive rocks from Phanerozoic arcs indicate that, on average, they are slightly more oxidized ($\Delta FMQ \approx +1 \pm 1$) than other magmas derived from depleted upper mantle (e.g., MORB; $\Delta FMQ = -1$ to 0), but contain similar Cu contents (median values of ~50–100 ppm) across their compositional ranges from mafic to intermediate rocks. Magmatic Cu content does not correlate with oxidation state, and median values decrease gently with fractionation, suggesting mildly compatible behaviour during partial melting and fractionation in the presence of minor amounts of condensed sulfide phases. It has previously been shown that normal andesitic arc magmas containing ~50 ppm Cu can readily form large porphyry deposits (by late-stage partitioning of Cu into an exsolved hydrothermal fluid phase upon emplacement at shallow crustal levels). There is therefore no evidence for, and no need to invoke, the existence of

unusually Cu-rich magmas to form typical arc-related porphyry Cu deposits.

There is also no evidence or need for the precipitation of large volumes of sulfides in lower crustal cumulate zones during arc magma fractionation (except where lower crustal rocks are unusually reduced, as perhaps in Japan). If such sulfides did exsolve from arc magmas in volume, they would be expected to strongly deplete the magma in Cu and other chalcophile and siderophile metals, and would thus significantly reduce the potential to form later porphyry-type deposits. On the other hand, precipitation of small amounts of sulfide phases is likely, and their incorporation into lower crustal amphibole-rich arc cumulate sequences may provide a fertile source rock for later re-melting events under lower total sulfur fugacity conditions (i.e., after the flux of S from the subduction zone has ceased). Such trace residual sulfides can be expected to be enriched in Cu, Au, and PGE, and may explain the Au-rich (and rarely PGE-enriched) character of some post-subduction porphyry and related epithermal deposits.

Abstract ID: 35883

Final Number: MD44A-0223

Title: Three-Dimensional Electrical Conductivity Models of the Morrison Porphyry-Cu Deposit, British Columbia

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Published Material: These findings add to abstracts submitted to:AGU Meeting, San Francisco 2013GAC-MAC Joint Meeting, Fredericton 2014

Abstract Body: Electromagnetic (EM) methods can detect metallic sulfide-bearing ore bodies, including porphyry deposits with disseminated mineralization, based on their electrical conductivity contrasts relative to the surrounding host rock. The airborne ZTEM (Z-Axis Tipper Electromagnetic) method uses natural low frequency EM signals in the range 30-720 Hz to determine conductivity from the surface to a depth of 2 km. ZTEM measures vertical and horizontal magnetic fields and is effective at determining relative lateral changes in conductivity. However, electric field measurements are required to obtain an absolute value of the subsurface conductivity. The magnetotelluric (MT) method measures both electric and magnetic field data in the range 0.001-1000 Hz to determine conductivity at even greater depths than the ZTEM technique. However, MT surveys require ground contact to measure electric fields and as a consequence are slower and more expensive to deploy. The spatially dense and higher frequency ZTEM data and the lower frequency MT data complement each other to reduce the non-uniqueness of the three-dimensional inversion. Since both methods derive the tipper from measurements of the vertical and horizontal magnetic fields, both datasets can be inverted simultaneously to create electrical conductivity models.

We present a case study from the Morrison deposit, a Cu-Au porphyry system located in the Babine Lake region of British Columbia. The deposit is related to Eocene biotite feldspar porphyry (BFP) stock that intruded into Middle-Late Jurassic sedimentary rocks. Alteration and mineralization zoning at Morrison are clearly observed, and centered on a central BFP stock. The proximal potassic zone is associated with disseminated chalcopyrite and minor bornite, and is an electrically resistive feature in the 3-D model. A surrounding conductive region is consistent with the observed distal chlorite-carbonate alteration, and associated with pyrite enrichment outside the potassic core. This complicated structure requires densely sampled ZTEM data and lower frequency MT data in order to constrain the inversion model. We show that inverting a combination of ZTEM and MT data utilizes the advantages of each technique to create a more comprehensive three-dimensional conductivity model of the porphyry Cu-Au ore body.

Abstract ID: 36860

Final Number: MD44A-0224

Title: A study of the Cu-Ni-Fe-S mineralogy of footwall veins at the McCreedy East mine, Sudbury, ON: The formation of millerite and origin of splays from trunk veins

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Abstract Body: Footwall Cu-Ni-Fe-S ores in the Sudbury basin are considered to have been derived from Fe-Ni-S contact ores which underwent fractionation or post-formational remobilization, exploiting existing structures within the footwall. A study of these ores, which are composed of chalcopyrite (Ccp), bornite (Bn), millerite (Mlr), pentlandite (Pn), was conducted using samples from the McCreedy East mine. The ores are located in trunk veins, which are up to 5 m wide, dominated by Ccp and Pn, and splay veins, which are smaller (<1 m wide) offshoots from the main trunk veins. The research was conducted to better understand how mineralogy varies with depth, the relationship between the main trunk veins and the splays and to develop a model explaining the origin and evolution of the splays. SEM-EDS studies indicate that pn in splays is more Ni-rich, with Ni:Fe ratio of ~2. Mlr exhibits up to 1 wt. % (Fe+Co), which is homogeneously distributed. It commonly exhibits twin lamellae, possibly associated with a local increase in *P*. As NiS undergoes a α – β transition below 379 °C, with a concomitant increase in *V*, this could explain the observed twinning. Chemical analyses (SEM-EDS) indicate near ideal stoichiometry for both Ccp and Bn, with Bn showing up to 1.5 wt. % Ag. The Bn also has inclusions of Ag and AgTe. Ccp and Bn appear to have crystallized nearly simultaneously and no other Fe-S mineral (Py, Po) is found. Secondary covellite develops along fractures and grain boundaries in bn. Platinum-group-minerals (merenskyite, michenerite, moncheite) are found as inclusions in Pn and Mlr. We interpret the splays to be Cu+Ni+PGE-enriched products, possibly resulting fractionation products of the earlier-formed trunk veins. The presence of extensive twinning in the Mlr suggests emplacement at T>379°C. The mineralogical assemblage of the splays suggests formation at fS_2 ~-8 to -4 log units and fO_2 -32 to -28. Strong similarities exist between it and the bornite zone at the Kidd Creek mine.

Abstract ID: 34327

Final Number: MD44A-0225

Title: Resource Potential for Industrial Limestone on Southampton Island, Nunavut

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Abstract Body: Quicklime (CaO) is a product of thermal decomposition of limestone, which has many uses in the mining industry. With the projected growth of the mining industry in the Kivalliq Region of Nunavut alone,

4 000 000, 4 700 000 and 4 000 000–10 000 000 kg of quicklime would be required annually at the Meadowbank gold mine and the proposed Kiggavik uranium and Meliadine gold mines, respectively.

Southampton Island is strategically located within barging distance of the mining projects in the Kivalliq Region, and about 2/3 of the island is covered by Upper Ordovician and Lower Silurian limestone. In view of 1) recent and projected growth of the mining industry in the region, 2) demands for quicklime, 3) reducing transportation costs, and 4) providing significant opportunities for economic development and local employment in Nunavut, Canada-Nunavut Geoscience Office has conducted a research project to test the purity of limestone on Southampton Island.

In 2009, the project stratigraphically focused on the Upper Ordovician Bad Cache Rapids and Churchill River groups, and geographically on the area close to the community of Coral Harbor. Overall, these limestones predominantly demonstrate chemical-industrial purity values in the "low purity" range (52.4–47.6% CaO).

In 2013 and 2014, the project stratigraphically moved up section to the Lower Silurian Ekwan River Formation, and geographically to the southwestern portion of Southampton Island. The area between Manico Point and Nalugalaavik Point, about 320 km^2, has been explored, and detailed sampling for whole rock analysis (X-ray fluorescence) was carried on along several creeks in the area. The majority of the geochemical data suggest that high-calcium limestone (>54.3% CaO) occurs in the Ekwan River Formation on the southwestern part of the island. The newly discovered "high-purity" limestone on Southampton Island should provide a valuable resource for Nunavut, and especially for its Kivalliq Region.

Abstract ID: 36540

Final Number: MD44A-0226

Title: Nunavut Carving Stone: Further Studies Needed on Arctic Canada's Community Commodity

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Co-authors: Jerry Ell, Carver, Iqaluit, NU, Canada; Holly Miranda Steenkamp, Canada-Nunavut Geoscience Office, Iqaluit, NU, Canada; Avery Henderson, , ,

Published Material: Nunavut Carving Stone Deposit Evaluation Program (2010-2010): third year results; in Summary of Activities 2012, Canada-Nunavut Geoscience Office (GSC review format and CNGO's first AR)_ Geology, history and site-management of the Kangiqsukutaaq carving stone quarry, southern Baffin Island, Nunavut; in Summary of Activities 2013, Canada-Nunavut Geoscience Office (H.M. Steenkamp, lead author)_ Nunavut Carving Stone Deposit Evaluation Program: 2013 and 2014 work in the Kitikmeot Region, Belcher Islands, Hall Peninsula and Repuse Bay, Nunavut, Canada; in Summary of Activiites 2014, Canada-Nunavut Geoscience Office (under review)_ Conference and workshop on-stage presentations of ongoing community consultations, fieldwork and results: Kivalliq Trade Show (2011, 2012), Kitikmeot Trade Show (2012, 2013), Nunavut Mining Symposium (2011, 2012, 2013, 2014), Northern Lights Ottawa (2012), GACMAC Winnipeg 2013, Yellowknife Geoscience Forum (2014), Greenland-Nunavut Geoscience Workshop, Nuuk (2014)_ Media: CBC North radio and television, northern newspapers articles

Abstract Body: Inuit stone sculpture from the Arctic is highly regarded around the world as an icon of Canada. An ongoing collaborative reconnaissance project between the Government of Nunavut, Department of Economic Development and Transportation, and the Canada-Nunavut Geoscience Office has documented new and existing carving stone resources as part of the Nunavut Carving Stone Deposit Evaluation Program (NCSDEP).

Community consultations and guidance to sites by over 50 carvers have verified 70 poorly known traditional carving stone deposits. Including government mapping discoveries brought forward, 84 carving stone sites of various sizes were evaluated in the vicinity of 22 out of 25 communities in Nunavut. All sites have been characterized by stone quality, tonnage and composition. Non-talcose "artisan serpentinite" and "artisan marble" with Mohs hardness of 2 – 2.5 are the territorial-wide carving stones of choice.

Major artisan serpentinite deposits are associated with mafic-ultramafic rocks of the Archean Prince Albert Group, a 1000-km long supracrustal succession in eastern Nunavut. Elsewhere, artisan marble deposits are found where broadly distributed mafic-ultramafic magmatic events intrude fine-grained Proterozoic carbonate rocks. A 1200-km long domain of Neoproterozoic Franklin Magmatic Event sills and dikes formed skarn marble deposits locally from Coronation Gulf to Baffin Island.

The NCSDEP is interested in developing new collaborative partnerships with academia to advance the understanding of carving stone genesis in Nunavut. Suites of rock samples are available for the study of crustal fluid migration, regional metamorphism, mantle signatures, age-dating, asbestiform minerals in altered ultramafic rocks and skarn mineral alteration in carbonate rocks. Scientific evaluation of carving stone deposits should provide new insights into geological processes across Nunavut and add considerable value to the already impressive works of art created here.

Abstract ID: 34419

Final Number: MD44A-0227

Title: Contribution to the geologic study of the zone the South to Imiter center oriental Anti-Atlas

Presenter/First Author: Nouaman EL Aouad, Cadi Ayyad University, Marrakech,

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Abstract Body: Imiter deposit located in Jbel Saghro was exploited since the antiquity. It is a part of the Anti Atlas mountains, in the South of Morocco. The mineralized axes are known in the middle neoprotorzoic black metapelites, which contains magmatic injections as dykes at its bottom and intermediate part.
The zone of study located in the central South of the zone of the deposit. the aims of our study are i) detailled mapping of the zone ii) structural and metallogenic studies iii) exploration of western extension of the mineralized corridors.
The technics of mapping used in this project are: i) digital mapping based on satellite pictures and the images of Google Earth; ii) mapping of detail (method of karkours) of ground

While basing itself on the digital map; iii) petrographic study of the injections magmatic; vi) litho geochemistry of mineralized axes.

The South of the central zone of the Imiter field presents a high metallogenic potential. It contains the extension of the structure with carbonates which is affected by dextral fault and becames rich on oxides in its western part. The effect of the granitic intrusion of Taouzzakt is registered well by the metamorphism of greenschist facies in metapelite and dykes in the Southwest of the zone. This study pointed out tectonic gradient with flexible tectonic located toward the North of the zone.

Nearby the intrusion we noticed post-schisteuse folding oriented N70 °E. This gradient led under the

influence of the intrusion's temperature. Far from the intrusion the temperature is weak and resulted of faultings of direction NW, N20°E. On the other hand in the South, close up to the intrusion, the temperature is relatively high gave folded structures. Besides the silicification of sandstones nearby the intrusion, hydrothermal alteration and circulation has been observed.
The microscopic analysis of the thin sections of the magmatic injections and associated mineralized faults samples showed three types : i) ultrabasic injections with olivine and pyroxene far from the mineralized axes; ii) intermediates dykes nearby sulphides mineralized axes; iii) acids dykes associated to the mineralized axes.

Abstract ID: 34420

Final Number: MD44A-0228

Title: Geology of the Hardaban Zn-Pb deposit in Xinjiang, NW China, and its comparison to the Tekeli Zn-Pb deposit, Kazakhstan

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Co-authors: Chunji Xue, China University of Geosciences (Beijing), Beijing, China; David T A Symons, University of Windsor, Windsor, ON, Canada

Abstract Body: The recently discovered Hardaban deposit is located in the Precambrian strata of northern Xinjiang. It shows many similarities to the Tekeli deposit and has the potential to be a large SEDEX deposit. The Hardaban deposit is located in the northwestern margin of the Kazakhstan-Yili plate, which is sandwiched between the Siberian and Tarim cratons in the western Tianshan Mountains. Its strata are divided into a lower series of clastic rocks, a middle series of clastic-bearing carbonate, and an upper series of clastic rocks. Acidic intrusives occur mostly as large batholiths and alkaline intrusives occur as rather small and rarely exposed stocks. The attitude of the orebodies are conformable with the northeastward-trending host rocks. The orebodies are dark-gray to black and fissile with dolomitic clay and sulphide layering. The ores contain more than 25 different minerals but are mainly galena, sphalerite and pyrite. Tekeli is a large stratabound Pb-Zn deposit in the northeastern Tianshan area of Kazakhstan and is part of the Tekeli-Yili massif. The deposit is hosted in the deformed Tekeli suite of alternating coals, clays, siliceous-clayey shales and limestone horizons. Deformed sheets, sills and dikes of gabbro, basalt and diabase intrude the sediments. Overall the Hardaban and Tekeli lead-zinc deposits are very similar in depositional and tectonic environment and in geological and ore characteristics, implying a similar stratabound ore genesis. Presumably, the Tekeli lead-zinc metallogenic belt extends eastward into the Sailimu micro-block as part of the Hardaban Group.

Abstract ID: 34431

Final Number: MD44A-0229

Title: Characterization of selenium-rich minerals from the Sagar property, Labrador Trough, northern Quebec

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Abstract Body: The Sagar property, located within the Romanet Horst in the central part of the Labrador Trough, northern Quebec, Canada is a host to a number of mineral showings. Although numerous companies have explored the Sagar property, the genetic history of mineralization is poorly understood. The Sagar property has anomalous amounts of uranium, gold, copper, lead and zinc which have been interpreted to be part of an IOCG system. More recently, anomalous nickel, cobalt and selenium have been reported at the Viking showing, but the source of these elements is unknown. The objective of this research is to characterize the minerals from sample MXF-13-46 collected from the Viking showing and to determine if the mineralization at Sagar is consistent with an IOCG system. MXF-13-46 is composed of selenide minerals (40%) in a hematite matrix (60%). The selenide minerals characterizing the Viking showing include, penorseite $(Ni,Co,Cu)Se_2$, molybdemnite ($PbSeO_3$), umangite (Cu_3Se_2), and wilkmanite (Ni_3Se_2). Selenide minerals are less common in ore deposits than sulfide and telluride minerals despite the greater crustal abundance of selenium in comparison to tellurium. The abundance of selenide minerals comprising the Viking showing appear to have formed from lower-temperature hydrothermal fluids (<300°C), replacing selenium rich minerals that are stable at higher temperatures (>300°C), and the presence of a hematite matrix suggest that the Viking showing is part of a shallow, low temperature IOCG system.

Abstract ID: 34548

Final Number: MD44A-0230

Title: Granite-hosted W Mineralization in the Dajishan W-Ta-Nb Deposit, Nanling Range, Southeastern China

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Abstract Body: The Nanling Range, SE China, is one of the world's important Ta-Nb-W-Sn-Be metallogenic belts. Vein W, granite-hosted Ta-Nb and an unusual style of disseminated granite-hosted W mineralization are present in the Dajishan deposit. The W mineralization (wolframite and lesser scheelite) is developed as ore pods that are randomly distributed through the No. 69 muscovite albite granite (the 101 deposit). The 101 deposit is also the host to disseminated Ta-Nb mineralization. The genesis of this type of mineralization and its relationship with both granite-hosted Ta-Nb and vein W mineralization are enigmatic. At Dajishan, most micas in the ore pods are euhedral-subhedral lath-shaped crystals and have a Fe-rich phengite core and a Fe-poor phengite or lepidolite rim, whereas most micas in other portions of the No. 69 granite tend to be anhedral, radial aggregates of trilithionite crystals, and lack any evidence of compositional zoning. Wolframite crystals in the ore pods are all hübnerite, but two textural subtypes are present: one occurs as interstitial crystals without mineral inclusions, the other also occurs as interstitial crystals, but contains numerous mica and albite inclusions. All these crystals were developed in contact with micas and inherited some mica textures. Micas in the veins have similar composition to the cores of micas in the ore pods, but no compositional zoning was observed. Wolframite-group minerals in the veins show no obvious compositional differences from those in the ore pods. These data indicate that disseminated wolframite in the ore pods most likely formed, at least partly, through replacement of mica during interaction of the granite with W- and Li-bearing fluids, rather than from direct crystallization from late-stage granitic melts.

Abstract ID: 34746

Final Number: MD44A-0231

Title: Heavy Mineral Potentiality of the Kawar Char Island in the Bay of Bengal, South-West Bangladesh.

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Abstract Body: Heavy mineral deposits along the coastal belt and fluvial river bars of Bangladesh constitute a potential national asset. Economically exploitable heavy mineral deposits have already been discovered in the deltaic coastal zone of Bangladesh within the unconsolidated Holocene sediments. This study was undertaken to determine the occurrence, qualitative and quantitative analysis of heavy mineral suite of Kawar Char, located along the coastal belt of the Bay of Bengal, South-West Bangladesh. More than 100 surface samples and hand auger samples up to a depth of 10 ft in a grid pattern were collected to study the heavy minerals. Grain size analysis, bromoform separation and microscopic study of the non-magnetic samples reveal the presence of significant quantities of Zircon, Rutile, Garnet, Magnetite, Ilmenite etc. An attempt has been made to prepare lithological model and geological cross section of the studied area based on the mineralised zones. The study covers about 7.00 Km^2 of the area confirming a highly prospective zone (>15% heavy mineral content) of 1.00 km^2 located at the central part of the study area. The average depth of mineralised sand is about 5 ft. At present sedimentation in the island is active and field study suggests that, the prospective zone for mineralisation is increasing with the progressive sedimentation. This is the first approach to field visit the area and confirming the heavy mineral availability. Detailed work in Kawar Char Island may help to get the greater extent of mineralized sands along the coastal belt of South-West Bangladesh.

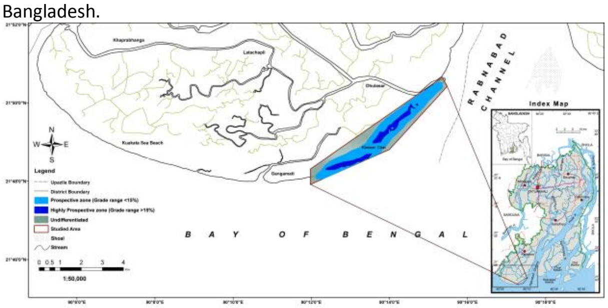

Fig. Map of the study area with different prospective zones.

Abstract ID: 36797

Final Number: MD44A-0232

Title: Cryptic Structural Controls on Metallogeny Patterns as Revealed by the Distribution of Heavy Minerals in Stream Sediments from the Flat River Area, Mackenzie Mountains, NWT.

Presenter/First Author: Hendrik Falck, Northwest Territories Geoscience Office, Yellowknife, NT

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Co-authors: Edith Martel, Northwest Territories Geoscience Office, Yellowknife, Canada; Stephen Day, , , ; Kelly Pierce, , ,

Published Material: Geochemical Data to be pubished as a NWT Open Report.Interpretation and geological discusion is unpublished.

Abstract Body: In 2014, a silt, water, and bulk stream sediment survey was conducted along the western Mackenzie Mountains by the Northwest Territories Geoscience Office and the Geological Survey of Canada, collecting material and observations from 190 sites. Regional stream sediment surveys have been carried out over much of the Canadian Cordillera using the National Geochemical Reconnaissance (NGR) methodology including a grab sample of silt-sized stream sediment, and a corresponding water sample, at a target sample density of one sample per 13 km^2. The methodology used also includes the collection of a coarser-grained and volumetrically-larger samples at one sample per 26 km^2 for heavy indicator minerals, which are picked for kimberlite indicator mineral grains, magmatic massive sulphide indicator minerals, and gold grains.

The results for the most recent survey demonstrate the Flat River region's anomalously high metal potential. For some commodities, such as tungsten and lead-zinc, this elevated endowment is well known and represented by two world-class deposits, Cantung and Howards Pass, respectively. However for other elements, intriguingly anomalous samples contain suites of minerals including gold, cassiterite and sapphire grains that are inconsistent with the known showing types, suggesting that further exploration for different mineralization styles is required in this area.

Even for the known mineralization, the geology of this region remains poorly understood. Structural controls, such as faults, have been suggested (Goodfellow + Jonasson, 1987; Hart + Lewis, 2006) as a mechanism for focusing economic mineralization but rarely have the faults been identified, nor has the history of those faults been defined to substantiate the hypothesis. Reconnaissance mapping and geophysical surveys along the March Fault have supported the interpretation of the fault as a long-lived crustal-scale structure, which played an important role in controlling the mineralization in the region.

Abstract ID: 35546

Final Number: MD44A-0233

Title: Regional Mapping Protocol, Descriptive Nomenclature and Field Database Coding for Iron Oxide Alkali-Alteration (IOAA) Ore Systems and their IOCG, IOA and Affiliated Deposit Types

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Abstract Body: Iron oxide alkali-alteration (IOAA) ore systems create the largest metasomatic (hydrothermal alteration) systems known within the continental crust. The metasomatic processes culminate into:

1) iron, vanadium and specialised-metal ores within iron oxide±apatite (IOA or Kiruna-type) deposits,

2) base-, precious-, specialised- and nuclear-metal ores or by-products within magnetite-, magnetite-hematite- and hematite-group IOCG deposits, and

3) polymetallic ores within certain skarns and albitite-hosted uranium deposits.

Each of these deposit types is a consequence of the systemic development of metasomatic facies across the upper crust as its geotherms rise abnormally during regional-scale ascent of highly saline high-temperature fluid columns. From depth-to surface, fluids strongly react with and transform intensely and pervasively precursor rocks over about 30x10x10 km to form a series of alteration facies with their own, newly acquired, bulk- rock and mineral composition, mineral assemblages, grain sizes, textures and even structures. In addition, veins, stockworks and breccias abound and fills are most commonly associated with extensive alteration haloes. Alteration can replace, cross cut, be transitional to, juxtaposed upon, superimposed upon precursor rocks or earlier alteration types. In the process, some units may 'disappear' from their stratigraphic sequence, being totally altered. Identifying and mapping these alterations are fundamental to modern geomapping for energy and minerals and for future exploration and deposit discovery as each alteration type vectors to its own deposit type and metal association.

This contribution illustrates the megascopic geological attributes of these metasomatic systems. Then it highlights the mapping protocols, nomenclature and field database codification system for mapping across the IOAA systems of the Labrador Trough (Québec) as part of the Geomapping for Energy and Minerals (GEM2) program in collaboration with its partner the Ministère des Ressources naturelles du Québec.

Abstract ID: 35858

Final Number: MD44A-0234

Title: The Capricorn Distal Footprints Project: an Orogen-Scale Approach to Mineral Systems

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Abstract Body: Exploration through cover is currently the biggest challenge facing the Australian minerals industry. With ~80% of the continent being covered by weathered material, much of Australia's mineral wealth still remains to be found. The Capricorn Distal Footprints project is a AU$17M collaboration between industry, the Geological Survey of Western Australia, academia and CSIRO to address this issue by examining the geophysical and geological footprints of ore deposits at multiple scales across the Capricorn Orogen in Western Australia.

The Capricorn Orogen is located between the Yilgarn and Pilbara Cratons, two of Australia's most prolific metallogenic provinces. Despite several gold and base metal discoveries, the Capricorn still remains largely underexplored. This project comprises six modules aimed at understanding the metallogenic evolution of the orogen and provide exploration models to aid future discoveries: (1) mineral systems evolution, (2) cover characterisation, (3) mineral hosts as distal footprints, (4) hydrogeochemistry, (5) geochemical mapping and lithospheric evolution, (6) 3D digital model and data integration. These themes combine regional geophysical interpretation (airborne electromagnetic, magnetics and gravity with magnetotellurics and passive seismic), to look at lithospheric architecture and its links to the geophysical expression of mineral systems, with hydrogeochemical, regolith, and resistate mineral studies around known deposits to gain insight into the key indicators of mineralisation, not just within a few hundred metres of the deposits but much further afield. This work is complemented by detailed microstructural and fault-scale analysis of comparable mineralised and barren fault zones to understand controls on the formation of, and signatures of mineral deposits across >10 orders of magnitude.

Abstract ID: 35212

Final Number: MD44B-0236

Title: Whole Rock Geochemical Signatures and REE Mineralogy of the Nechalacho Rare-Earth Element Deposit, NWT

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Abstract Body: The Nechalacho rare-metal (REE, Y, Nb, Ta, Zr) deposit, located in the Northwest Territories, is hosted by an altered layered nepheline syenite. Three distinct whole-rock geochemical signatures are evident. Two of these signatures have high P, of which, one has high heavy REE (HREE) (type 1) and one has low HREE, but high light REE (LREE) (type 2). The third signature has low P and high HREE, LREE and Zr (type 3). The type 1 and 2 signatures were found to represent abundant xenotime ((Y, HREE)PO_4) and monazite ($LREEPO_4$), respectively. The type 3 signature represents zircon and a variety of non-phosphate REE minerals, such as allanite, fergusonite ((Y, REE)NbO_4), or bastnäsite ($REECO_3F$). The results support the hypothesis that the ore mineralogy can largely be predicted from whole rock geochemistry. Phosphates are an important reservoir for the LREE at Nechalacho. Two main textural types of monazite have been recognized; one that is rod shaped and another that is blocky. Xenotime also occurs in various habits, such as rods and anhedral patches. The deposit is divided into Upper and Basal zones, the Basal Zone having a higher HREE/LREE ratio than the Upper Zone. It has been proposed that the LREE were transported from the Basal Zone to the Upper Zone by hydrothermal fluids and precipitated there as LREE minerals. Williams-Jones et al. (2012, *Elements*, v. 8, p. 355-360) predicted that a series of pulses of aqueous fluid transporting REE and P, passing through a nepheline syenite would precipitate monazite crystals that were progressively more depleted in HREE (relative to the starting fluid) with increasing distance from the source (height in the system). Preliminary LA-ICP-MS data for monazite does not support this model because the concentrations of HREE in monazite increase upwards in the intrusive body, which suggests, along with the textural variability of the phosphates, that the genesis of the LREE mineralization is more complex than the proposed models imply.

Abstract ID: 35387

Final Number: MD44B-0237

Title: The Saint-Honoré carbonatite REE zone, Québec, Canada: Combined magmatic and hydrothermal processes.

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Published Material: 12th Biennial SGA meeting - Sunday 11th through Saturday 17th august 2014

Abstract Body: A new model is proposed for the genesis of rare earth element (REE) mineralization at the Saint-Honoré alkaline complex. The originality of the proposed model is to combine both magmatic and hydrothermal crystallization of REE-bearing minerals. Actually, most of the REE mineralization models in carbonatites are based on a late stage hydrothermal activity, where REE are leached from primary minerals such as dolomite and apatite and subsequently deposited in late stage units. Such a model is in agreement with observations of the upper Fe-carbonatite REE mineralisation of Saint-Honoré alkaline complex. It shows characteristic textures of hydrothermal mineralization: polycrystalline clusters hosting bastnaesite crystallized radially from carbonate or barite crystals, the presence of halite and silicification within strongly brecciated units. However, in the deeper part of the Fe-carbonatite (below 1000 meters), bastnaesite inclusions in primary barite suggest an early magmatic crystallization of REE minerals before hydrothermal leaching. It is interpreted that hydrothermal activity was weaker in the deeper part (Cl-depleated, a progressive decrease with depth of secondary fluid inclusion trapped in carbonates, brecciation is significantly less intense), hence preserving the magmatic textures. This magmatic crystallisation of rare earth minerals could be an important factor in generating high volume world-class REE deposits. An example of magmatic world-class deposit is Mountain Pass in California where idiomorphic bastnaesite crystals were described. Furthermore, crystallization of primary barite could be an important exploration guide for REE in carbonatites because its presence seems to reflect favourable conditions to crystalize primary REE minerals.

Abstract ID: 36641

Final Number: MD44B-0238

Title: The Genesis of Heavy REE Mineralisation in the Lofdal Carbonatite Complex, Namibia

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Abstract Body: The rare earth element (REE) mineralisation in the 765 Ma Lofdal Carbonatite Complex, Namibia, is highly unusual. Whereas carbonatite-associated REE deposits are typically enriched in the light REE, Lofdal hosts an indicated mineral resource of 2.88 Mt total REE oxides at a cut-off grade of 0.1%, of which 76.3% are heavy REEs (HREE). This makes it one of the most HREE-enriched economic or potentially economic deposits in the World. Although the REE were initially assumed to be hosted by carbonatite dykes, textural relationships observed in the field, drill core and microscopically indicate that the REE mineralisation (xenotime-(Y)) is hosted by albitised rocks that formed along planar structures, and that these rocks were subsequently carbonated by hydrothermal fluids. This interpretation is supported by $\delta^{18}O$ and $\delta^{13}C$ values that are consistent with a hydrothermal rather than magmatic origin for the carbonate minerals. The paragenesis is albitisation followed by two generations of xenotime-(Y), overprinted by carbonate (calcite or dolomite). The carbonate-forming fluids may locally have remobilised the REE, but if this were the case, the remobilisation was minor. The first and most common mode of occurrence of xenotime-(Y) is in veinlets of biotite ± calcite ± pyrite that cut the albitite. A small proportion of xenotime-(Y) occurs in discontinuous veinlets (lenses) of apatite. A model is proposed in which early fluids released from a carbonatite magma rose along faults in the basement, albitising (fenitising) gneisses and later fluids fractured the albitites and deposited xenotime-(Y) with biotite, and locally apatite. The carbonating fluid is also likely to have originated from the carbonatite but we do not rule out the possibility that it was a formational water or a mixture of magmatic and formational water.

Abstract ID: 34382

Final Number: MD44B-0239

Title: IOCG-Type And Affiliated Deposits In The Romanet Horst, Labrador Through, Canada: Insights From Geochemical Fingerprint Of High Temperature Albitization

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Abstract Body: Because of their large sizes, simple metallurgy, diversified resources and high grades, Iron-Oxide-Copper-Gold-type (IOCG-type) and affiliated deposits can produce extremely profitable mines. Over a century of geological mapping and exploration work in the Romanet Horst, Labrador Through, Canada, currently suggests a high potential for such deposits. Hydrothermal alteration and brecciation is widespread and commonly associated with Fe-Cu-Au-Ag-U mineralization. In the present research, we focus on primitive high temperature albitization and its geochemical fingerprint. We compare and contrast the albitization and associated mineralization in the Romanet Horst Area with that in the Great Bear IOCG Magmatic Zone. The objective is to characterize the fluids associated with the primitive, high temperature sodic alteration, to establish links, if any, between these fluids and mafic feeder magmas, and to distinguish the albitization which is associated with mineralization from that which is not. It is our hope that the albitization fingerprint will become an exploration vector for IOCG-type and affiliated deposits.

Abstract ID: 33545

Final Number: MD44B-0240

Title: Mineralogical and Geochemical Constraints on the Mobilization and Mineralization of Rare Earth Elements in the Lala Fe-Cu-(Mo, REE) Deposit, SW China

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Published Material: these findings are submitted to a scientific journal, currently under review.

Abstract Body: The Lala Fe-Cu-(Mo, REE) deposit in Sichuan province, SW China, has a paragenetic sequence of Stage I of pre-ore Na-alteration, Stage II of magnetite and minor apatite, and Stage III of Cu-(Mo) sulfides and rare earth element (REE) minerals. REE minerals are monazite, parisite and bastnäsite with minor xenotime. They are generally associated with biotite, muscovite and calcite of Stage III, accompanying with K-Ca-carbonate alteration. In places where magnetite and apatite of Stage II are overprinted by minerals of Stage III, the apatite grains are commonly embayed or eroded, and contain abundant monazite inclusions with minor bastnäsite, calcite and sulfide minerals. These monazite-bearing apatite grains are similar to the metasomatized apatite reported in experiments, and thus are suggested to have formed from the Stage II apatite via a dissolution-precipitation process during of the Stage III fluids. Such a fluid metasomatism has mobilized and leached REEs from the primary Stage II apatite. For country rocks altered by the Stage III fluids (i.e. K-Ca-carbonate alteration), mass balance analysis indicates that up to 70% of their light REEs are also mobilized and leached out during alteration, and thus the country rocks are inferred to be important sources for REE mineralization in the Lala deposit.

Together with mineral assemblages of Stages II and III and previous fluid inclusion data, compositions of amphibole and biotite demonstrate that Stage III fluids have higher K, CO_2 (or HCO_3^- and CO_3^{2-})and HF/HCl fugacity but lower salinity and Na activity than Stage II fluids. We suggest that elevated K and CO_2 in Stage III fluids or associated K-carbonate alteration are possibly important for REE mobilization. The mobilized REEs from country rocks were inferred to be transported as chlorite-complexing before depositing as REE minerals at certain levels. Deposition of REE minerals was likely triggered by mixing with relatively low temperature, F-rich, and oxidized basinal brines and/or local interaction with carbonate hosts. We propose that the common association of REEs with Cu mineralization in many IOCG deposits are possibly ascribed to the specific nature of K-CO_2-rich Cu mineralizing fluids.

Abstract ID: 33553

Final Number: MD44B-0241

Title: REE mineralization in Sin Quyen Fe-Cu-REE-U-Au deposit, Northwest Vietnam

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Abstract Body: The Sin Quyen Fe-Cu-REE-U-Au deposit is localized in the Phan Xi Pang zone, northern Vietnam. Orebodies are hosted in the two-mica schist of the Proterozoic Sin Quyen Group, and consist mainly of massive and banded replacement ores. The paragenetic sequence of this deposit mainly includes sodic alteration (Stage I), Fe-REE-U mineralization associated with calc-alteration (Stage II), and Cu-Au mineralization associated with potassic alteration (Stage III). This sequence is similar to those of many IOCG deposits elsewhere.

The Sin Quyen deposit contain about 0.37 Mt (metal) LREE. REE minerals are dominated by allanite, with lesser amounts of monazite, chevkinite, aeschynite, REE-rich apatite, and REE-rich epidote. Among these minerals, monazite and chevkinite were formed in pre-ore sodic alteration stage; whereas allanite, REE-rich apatite, REE-rich epidote and aeschynite were formed in the Fe-REE-U mineralization stage. It is notable monazite has been variably replaced by apatite-allanite-epidote coronas, and chevkinite has been replaced by allanite and aeschynite. During these replacement reactions, REE and other trace elements, including Nb, Ti, P and U, display complex mobility.

LA-ICP-MS dating on monazite grains have yielded an U-Pb age of 812±10 Ma, which is broadly consist with the zircon U-Pb ages of regional felsic and sub-alkaline intrusions. In addition, bulk-ores have similar chondrite normalized REE patterns with those magmatic intrusions. These facts suggests that the REE mineralization may have a genetic relationship with regional felsic or sub-alkaline magmatism. The extensive occurrence of Cl-rich hornblende and biotite, combined with the scarcity of F or CO_2-rich minerals in this deposit, indicates that the fluids were rich in Cl but depleted in F and CO_2. Thus, REE may be transported dominantly as chloride complex. The presence of this Cl-rich ore-forming fluid has produced a distinctive style of REE mineralization in IOCG system.

MINERAL STRUCTURE, SURFACES, AND CRYSTALLOGRAPHY

Abstract ID: 36154

Final Number: MS22A-01

Title: Crystal and Electronic Structure of (Fe,Ni,PGE)-Pentlandites: Planetary and Economic Implications

Presenter/First Author: Jacques Kontak Desmarais, University of Saskatchewan, Saskatoon, SK

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Abstract Body: We aim to test the hypothesis that sulphide minerals such as pentlandite (Pn) are capable of preferentially uptaking platinum-group-elements (PGE) and playing a critical role in PGE mineralization. Our goal is to combine synchrotron X-ray absorption (XAFS) as well as Electron-energy loss spectroscopy (EELS) experiments along with electronic structure calculations to probe Pn crystallization processes that bear relevance to not only the formation of magmatic PGE deposits, but also models of planetary accretion and evolution.

Current models suggest that immiscible sulphide liquids form during the evolution of magmatic PGE deposits. As the immiscible liquid cools, sulphide minerals crystallize. One of the most economically important minerals in magmatic PGE deposits is Pn. Experimental observations show that palladium (Pd) preferentially partitions in Pn, whereas platinum (Pt) is incorporated into other phases. The contrasting behaviour between Pt and Pd is enigmatic, considering their apparently similar geochemical affinities. More recently, some authors have suggested the presence of PGE nanoclusters in the Pn lattice and the potential of Pn for hosting PGEs has come into question.

Pn occurs mostly as a ternary Fe-Ni phase, although abnormaly Fe-rich Pn has been reported to occur in meteorites. It is well known that the stabilities of solids depends largely on their configurational entropies and our modeling will take this into consideration using Special Quasirandom Structures (SQS) as implemented in a novel algorithm. This SQS approach will allow us to determine the optimal distribution of the Fe and Ni atoms by matching a specified set of correlations (or cluster functions) between neighboring atoms to the corresponding correlations of the perfectly disordered state. The optimal ordering of the Fe and Ni atoms will be determined over a wide range of Fe/Ni values, and their relative stabilities will be evaluated quantitatively. Subsequently, PGE (i.e., Pd and Pt) will be incorporated in the disordered lattices of Pn calculated from the SQS approach. Once the optimal ordering of the atoms has been determined, the electronic structures of Pn will be investigated and the ionic degrees of freedom will relax by solving the Kohn-Sham equations within the spin-polarized-generalized-gradient approximation.

Abstract ID: 34413

Final Number: MS22A-02

Title: The Relationship between Structural and Chemical Complexity of Boron Minerals with Geological Time

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Abstract Body: Boron minerals are among the most structurally and chemically complex naturally occurring inorganic compounds. Of the 280 B minerals approved by the IMA, there are 250 species with known structures for which the age of the earliest reported occurrence in the geologic record has been reported. The earliest B minerals are 3550 Ma metamorphic tourmalines in the Isua supracrustal belt (Greenland), but many ephemeral species are restricted to Holocene deposits. We have analyzed structural complexity with the program package TOPOS using complexity parameters that provide Shannon information content per atom and per unit cell [Min. Mag. 77 (2013) 275-326]. The average contents per atom and per unit cell are 3.92 and 338 bits, respectively (compare 3.23 and 228 bits, respectively, for all minerals). Qingsongite, cubic BN (2 bits), is the simplest.

There are 16 B minerals with information content per unit cell > 1000 bits. The structural complexity of rogermitchellite, $Na_6(Sr,Na)_{12}Ba_2Zr_{13}Si_{39}(B,Si)_6O_{123}(OH)_{12}\cdot9H_2O$ (2321 bits) and byzantievite, $Ba_5(Ca,REE,Y)_{22}(Ti,Nb)_{18}(SiO_4)_4(PO_4,SiO_4)_4(BO_3)_9O_{22}[(OH),F]_{43}\cdot1.5H_2O$ (1574 bits) results from chemical complexity based on the number of essential chemical constituents. However, chemically simpler hydrated Ca borates, e.g., ginorite, $Ca_2B_{14}O_{20}(OH)_6\cdot5H_2O$ (1506 bits), ruitenbergite, $Ca_9B_{26}O_{34}(OH)_{24}Cl_4\cdot13H_2O$ (1492 bits), alfredstelznerite, $Ca_4B_{16}O_{16}(OH)_{24}\cdot19H_2O$ (1359 bits), are also structurally complex, which we attribute to the interplay of borate polyanions and hydrogen bonding networks. The earliest complex borates are takéuchiite (1179 bits) and blatterite (1656 bits), which are reported uniquely from 1825 Ma deposits at Långban and Nordmark (Sweden).

Plots of information contents per atom and per unit cell versus the earliest reported occurrences of B minerals in the geologic record reveal a broad increase in complexity, but this trend could result from preservation bias due to the ephemerality of many hydrated borates.

Abstract ID: 35719

Final Number: MS22A-03

Title: Reassessment of the Parameterization of the Bond-Valence Model: Results and Applications

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Published Material: This is a culmination of my Ph.D. work. Small parts have been reported at: ACA 2013, Honolulu, HI (oral); IUCr 2014, Montreal, Qc (poster); IMA 2014, Johannesburg, South Africa (oral). The majority of the presentation is new material. A paper covering the presentation material is ready for submission.

Abstract Body: We have recently completed a bond-length dispersion analysis for atoms bonded to oxygen that has led to the collection of 188,797 bond distances from 33,543 coordination polyhedra originating from ~9650 unique crystal structure refinements. We use this data to evaluate 237 published pairs of bond-valence parameters for atoms bonded to oxygen. The range of deviations from the valence-sum rule as well as the average fit obtained from these parameters leads us to conclude that the parameterization of the bond-valence model is not satisfactory; we thus investigate for (1) new equations that can describe the relation between bond length and bond strength, and (2) the best way of deriving the bond-valence parameters of these equations. Following the determination of (1) and (2), we derive 137 new pairs of bond-valence parameters for ions bonded to oxygen using a new method of derivation, the GRG-RMSD (Generalized Reduced Gradient Root-Mean-Square-Deviation) method. We usually find small but consistent improvements in fit for all ions compared to the best published parameters, although some less common ions show a striking improvement; the RMSD from the valence-sum rule for $^{[4]}P^{3+}$ changes from 0.946 to 0.243 v.u., Re^{7+} from 1.000 to 0.276 v.u, Np^{6+} changes from 1.209 to 0.078 v.u, etc. Agreement for the anion bond-valence sums is also improved. Moreover, we find a positive correlation between coordination number and bond-valence sum for most multiple-coordination numbers-cations, where low coordination number configurations give low bond-valence sums and vice-versa. We also find a positive correlation between RMSD and mean bond-length for groups of ions with a similar crystal-chemical behaviour. This new parameterization adds a crucial level of confidence to the bond-valence method for use in bonding analysis and modeling. To that effect, we use the results of the bond-length survey to assign a range of bond-valences that ions can adopt, which we use to predict the full range of site occupancy of crystal structures.

Abstract ID: 35524

Final Number: MS22A-04

Title: The Effect of Growth Rate on Uranium Partitioning Between Calcite and Fluid

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Abstract Body: Elemental to calcium ratios in calcium carbonate minerals are being used to study environmental conditions at which crystallization occurred. In particular, foraminiferal U/Ca has been proposed as proxy for determining seawater carbonate ion concentration (CO_3^{2-}) (e.g. Russel et al., 2004). However the kinetic effect of U/Ca incorporation into calcite has been the subject of investigations but is not well understood (e.g. Ni et al., 2007). Therefore, this work is focused on the evaluation of growth rate and its effect on uranium partitioning between calcite and fluid.

The calcites produced during this study were crystallized isothermally from $NH_4Cl-CaCl_2$ doped with uranium by diffusion of CO_2 from ammonium carbonate source. This method yielded growth of large crystals (>1 mm in size) without stirring of the fluid. Growth rate of calcite (crystal extension rate) was monitored by sequentially spiking calcite-precipitating fluids with rare earth element (REE) dopants. The U/Ca was analyzed with SIMS at spots matching those where REE were determined using CAMECA ims 1270 ion microprobe at UCLA (USA). Elemental analyses of the fluids were performed using Thermo Element XR, ICP-MS at the University of Cambridge (UK).

Partition coefficients $K^U=(U/Ca)_{calcite}/(U/Ca)_{fluid}$ increases with increasing of growth rate (V). K^U increases by a factor of two when V increases from 0.01 to 0.14 nm/s and remained near constant at faster rates. Numerical simulations using the growth entrapment model (GEM) (Watson, 2004) and unified uptake kinetics model (UUKM) (Thien et al., 2014) explain the observed K^U-V trend.

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Abstract ID: 34917

Final Number: MS22A-05

Title: Characterization of Interfacial Processes in Soils with High Resolution Transmission Electron Microscopy and Focused Ion Beam Technology

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Published Material: Some of results were shown last year at the Goldschmidt conference but without any conclusions. A paper has been submitted to the journal "Geology"

Abstract Body: High resolution transmission electron microscopy (HRTEM) and focused ion beam (FIB) technology are used to characterize mineral surface coatings in upper soil horizons. The combination of both techniques allows deciphering past abiotic and biotic soil processes and thus the reading of environmental records preserved on the nanoscale. Key to the preservation of a rarely observed mineralogy and chemistry in the surface coatings are limited diffusion of elements in Fe-hydroxide coatings in combination with silicification events of nano- to micrometer size confined pore and interface spaces. The most intriguing features include petrified cocci in proximity to a structural analogue of green rust, pockets of jarosite encapsulated by amorphous silica and chains of biogenic magnetite. The observations in this study indicate that chemical processes in confined pore and interface spaces are often in disequilibrium with the bulk soil and that, Fe-silica-bearing coatings are excellent tracking tools for the evolution of the chemistry of soils and sediments.

Abstract ID: 34308

Final Number: MS22A-06

Title: Metals partitioning in soils by SEM-EDS-SDD mapping of the elements distribution: Applications for geochemical exploration and environmental sciences

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Abstract Body: Soils are composed of a mixture of components that play roles in metals binding: humic substances, oxides, carbonates, charcoal, detritals *etc*. Deportation of trace metals between these components is still not well documented and expected to depend on variety of environmental factors. Conventional analysis methods, such as partial or sequential extractions, provide information on metals abundance related to specific components, but are likely not as selective as indicated. The current objective is to determine the metal's binding sites in anomalous soils at the microscopic scale, mostly using scanning electron microscopy (SEM) with a backscattered electron detector (BSE) and last generation energy dispersive spectrometer (EDS-SDD). The experiment was carried out on a collection of soils from sites known to show various natural or anthropogenic metal enrichments. The mapping of chemical elements distribution allowed locating different metals phases and precipitation sites, even if metals were in trace amount. High magnification imaging and microanalyses were performed to characterize the nature of the chemical signal (organic matter, oxides, clays, residual minerals, *etc*.). Results show, for example, that copper in humic soil dominantly precipitates on organic matter up to a saturation point, where it start precipitation as distinct authigenic sulfides, and in a lesser extent to accumulates in iron and manganese oxides. Each metal has its own distinctive behavior. For the mineral exploration industry, knowledge of the metals partitioning and dispersion mode shall improve the deconvolution of the signal in order to locate their source and discriminate true from false anomaly. In regard of environmental sciences, a better comprehension of the metals binding sites will help to anticipate the associated risk and it shall provide important information to design the appropriate decontamination or remediation methods.

Abstract ID: 35190

Final Number: MS22A-07

Title: *In situ* characterization of gold in arsenopyrite combining large area SEM imaging and nano-scale HRTEM studies: an example from the Dome Mine, Timmins, Ontario

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Abstract Body: The *in situ* characterization of minerals associated with ore zones and geochemical anomalies is a novel tool that can increase exploration and extraction efficiency. The knowledge of how gold occurs within sulphide minerals (e.g., in the lattice or as nano-particles) is of great importance to mining companies in order to define effective extraction methods. Bulk rock and microprobe analyses alone lack the spatial resolution and sensitivity necessary to accomplish the required level of characterization. We present a suite of advanced SEM, FIB and TEM techniques that can be applied sequentially and quickly.

A sample from the Dome Mine in Timmins, Ontario was analyzed using large area SEM imaging, TEM specimen preparation, and high-resolution TEM (HRTEM) characterization. The primary gold hosting mineral at the Dome Mine is pyrite that contains free gold as inclusions, fracture filling, and along grain boundaries as well as "invisible" gold in arsenopyrite. Of special focus for this study was the gold associated with the arsenopyrite.

The samples were imaged in a Zeiss Sigma HDVP SEM using the large area imaging module Atlas 5. Overview mosaics with the BSE signals were acquired at a resolution of 100 nm/pixel. Areas of interest for TEM specimen preparation were additionally imaged at 15 nm/pixel. The image

mosaics were combined with µXRF elemental maps and FIB foils were extracted. HRTEM analyses of the extracted FIB sections reveal areas with complex zonation patterns in the arsenian-pyrite. Zones with irregular copper-rich inclusions alternate with zones of As-rich bands (50 to 400 nm in width). EDX line scans across arsenopyrite inclusions revealed the presence of Au bound to the crystal lattice of the arsenopyrite crystals.

The applied sequence of techniques enabled a quick and systematic characterization of gold mineralizations from a micro to the nanometer scale in a reasonable time.

Abstract ID: 34298

Final Number: MS24A-0279

Title: The Process of Serpentinization in Beni Bousera Massif (Internal Rif, Morocco)

Presenter: Amina Wafik, DLGR Laboratory (Unit associated to CNRST, URAC 43), Marrakech,

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Abstract Body: The Beni Bousera massif is part of the Sebtide units in the internal Rif (Morocco). It is mainly composed by mantle peridotites surrounded by crustal metamorphic series (kinzigites, micaschists, schists). Intensity of ductile deformation in the peridotites allows recognizing from bottom to top: 1) coarse grained porphyroclastic to granular spinel peridotites including spinel pyroxenites layers; 2) spinel porphyroclastic peridotites with layers of garnet pyroxenites; 3) garnet and spinel mylonites.

Serpentinization is superimposed on the ductile deformation. Following the exhumation, fluid circulations induced serpentinization of the peridotites. Serpentinization is concentrated at the top of the peridotites, along the mylonitized zone, and decreases towards the bottom of the massif. It is manifested by the formation of mesh texture and hourglass texture in foliation plans in the high serpentinized peridotites to brecciaed texture in low serpentinized peridotites. Pyroxene is still intact marked by few serpentine veins. This differential serpentinization reflects a low silica activity.

The study of the Raman shifts indicates that, in the low wavenumber region, four main peaks (near 230, 390, 690 and 1100 cm^{-1}) characterize the spectra of lizardite and chrysotile. The differences between chrysotile and lizardite spectra could be clearly identified by sharpness of the Raman lines. In particular, a single band at 1100 cm^{-1} is observed at chrysotile whereas several convoluted bands are observed between 1060 and 1100 cm^{-1} at lizardite. Therefore the serpentine showed a brecciaed texture in the bottom of the massif and the mesh texture, hourglass texture and vein texture in the top of the massif correspond to lizardite type, whereas the serpentine filling the fracture is a chrysotile.

Regarding the tectono-metamorphic evolution of Beni Bousera massif we can relate the serpentinization phenomenon to the thermal event between 19 to 14 Ma as defined by Zircon and Apatite Fission Track.

Keyword: Lizardite, Raman spectroscopy, thermal event, Beni Bousera,

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Abstract ID: 34309

Final Number: MS24A-0280

Title: Optimising Analyses of Geological Material with an Analytical Scanning Electron Microscope

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Abstract Body: The need to determine the precise composition of geological material is ever growing and the data widely used in multiple fields such as geochemistry and metamorphic petrology. Although routinely used, electron microscopes analyses are not always optimized nor is the surface of the sample perfectly prepared.

This study presents advances in scanning electron microscopy (SEM) coupled with an EDS (SiLi) detector on thin-sections of amphiboilte-facies pelitic schists and garnet grains therein. The purpose is to optimize the various operating parameters, such as probe current, accelerating voltage, working distance, live acquisition time and concentrations of major and trace elements within the sample. We present examples of optimized analyses and their limits for several applications including: 1) characterization of polished surface condition using secondary electron imaging; 2) zoning profile for major elements in garnet; 3) x-ray maps for major elements in garnet. In order to verify the possibility of quantification with this optimized method, our results are then compared to those obtained for the same samples using the electron microprobe, the customary instrument for such analyses. This methodology will further be used to optimize data acquisition for a new analytical SEM coupled with both WDS and EDS (SDD) detectors, acquired by the Centre for Characterization and Microscopy of Materials $(CM)^2$ of Polytechnique Montreal.

Abstract ID: 34447

Final Number: MS24A-0281

Title: Strain-Enhanced Diffusion in Feldspar: A Strain Speedometer?

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Published Material: Portions of this project were presented at the Structural Geology and Tectonics Forum in June 2014, Golden, CO, and at the Geotop Student Conferences in 2014 and 2015. None of these findings are under review and have not been recently accepted by any journal.

Abstract Body: Rocks in Earth's crust deform over many different timescales. The rate at which they deform (strain rate) cannot be directly measured in the rock record with present tools. Strain rate can be constrained in specific cases of dateable features such as syn-kinematic mineral growth or intrusions, but a generally applicable tool has not yet been developed. Previous studies on tourmaline show deformation-enhanced element mobility that could, in theory, be used to calculate the duration of deformation. Unfortunately, the required diffusion parameters are lacking for tourmaline and it is not a rock-forming mineral, rendering it unusable as a tool to infer bulk rock strain rate. Feldspars dominate the rheology of Earth's crust, diffusion parameters are known across a range of pressure-temperature conditions, and feldspars can grow with compositional zoning. Compositional zoning serves as a physical, and potentially chemical, strain marker. I combined strain measurements along a 500-meter-long strain gradient transect with element mobilities measured as a function of strain in zoned plagioclase phenocrysts. Major, minor, and trace element analyses on electron microprobe and laser ablation inductively coupled plasma mass spectrometry provide the necessary resolution for precise diffusion modeling at the low strains observed. Thermobarometry indicates that conditions of feldspar formation were 700 ± 30ºC and 190 ± 30 MPa, with no indication of later fluid overprint during deformation. Any divergent element mobilities in zoned plagioclase phenocrysts from this study are most likely a result of strain, and because fluids did not significantly mobilize elements, modeling changes in element mobilities can be used to yield an estimated duration of deformation. These results will be combined to inform a paleo-strain speedometer for the middle crust.

Abstract ID: 35616

Final Number: MS24A-0282

Title: Deformation, Phyllonitization and Associated Element Mobilization of Granitoid Rocks.

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Published Material: Presented as a poster with preliminary results at the Winter Conference 2015 in Stavanger, Norway. Hosted by the Geological Society of Norway.

Abstract Body: This study investigates the mobilization of the major and trace elements related to deformation and associated phyllonitization of the Fagervika granitoid. East of Trondheim, Norway lays the area of Bymarka, that is a part of an ophiolite complex that is dominated by greenstones and several felsic intrusives, including the Fagervika granitoid that is the largest. The granitoid extends approximately 7 km inland, from the shore of Trondheimsfjorden and southwards towards Skjelbreia Lake where it fingers out. Extensive detail mapping of the Fagervika granitoid in the area around Gråkallen reveals an area with varying degrees of deformation and associated phyllonitization, including occurrences of sulphide-bearing hydrothermal quartz in association with the deformation zones. Two types of deformation zones were recognized. 1. Millimetre to centimetre mica- and epidote-rich zones with dynamically recrystallized quartz. 2. Decimetre to meter wide zones with quartz, muscovite, little or no feldspar, except a few albite porphyroblasts and varying degrees of deformation, from protomylonite to mylonite. The least deformed samples have a magmatic texture, but the feldspars shows weak sericitization and saussuritization. With increasing degree of deformation, the feldspars disappear and muscovite appears, revealed by the loss of Na, Ca and Eu and gain of K. There is also a relationship between the relative amount of recrystallized quartz to clast ratio and the amount of trace element mobilization. Comparisons of the least and most deformed samples are shown by examining mineral assemblages and textures, along with quantitative geochemical and mineralogical data. Isocon diagrams and quantitative Rietveld will be used to infer which major and trace elements and minerals that have been mobilized during deformation. The next step will be to compare the geochemical data to microscopic investigations, and SEM, microprobe and laser data will be used to accurately determine the mineral chemistry of the different mineral phases. By using principles of geochemistry, the goal is to understand the element mobility path of the different elements and minerals in the granitoid during deformation.

Abstract ID: 35764

Final Number: MS24A-0283

Title: Discovering the Mineralogy of Nano-sized Particulate Matter in Smelter Impacted Regions: Transmission Electron Microscopy Studies of Focused Ion Beam Sections Taken from Rock Coatings

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Published Material: Published Journal Articles:Mantha, N. M., Schindler, M., Murayama, M., and Hochella Jr, M. F. 2012a. Silica- and sulphate-bearing rock coatings in smelter areas: Products of chemical weathering and atmospheric pollution I. Formation and mineralogical composition. *Geochimica et Cosmochimica Acta* 85: 254-274. Mantha, N. M., Schindler, M., and Kyser, K. T. 2012b. Silica- and sulphate-bearing rock coatings in smelter areas: Part II. Forensic tools for atmospheric metal(loid)- and sulphur-isotope compositions. *Geochimica et Cosmochimica Acta* 90: 221-241.Schindler, M., Mantha, N.M., Kyser, K.T., Murayama, M., and Hochella Jrsim M.F. 2012. Shining Light on Black Rock Coatings in Smelter-Impacted Areas. *Geoscience Canada.* 39(3): 148-157.CBC Radio interview, June 2012, Sudbury Ontario. URL: http://www.cbc.ca/news/canada/sudbury/scientist-unlocking-secrets-from-sudbury-s-black-rocks-1.1158083

Abstract Body: This study implements the use of High Resolution Transmission Electron Microscopy (HRTEM) and Focused Ion Beam (FIB) techniques for the investigation of nano-sized particulate matter and secondary mineral phases in black-rock coatings. These coatings occur in the vicinity of the smelter centres in Sudbury, Trail and Rouyn-Noranda, Canada, and are products of past emissions of sulphur dioxide (creating sulphuric acid) and particulate matter. HRTEM studies indicate the presence of emitted particulates and aerosols that became trapped in a viscous amorphous silica gel during coating formation. The identification of these phases gives insight on nano-sized particulate matter that is commonly undetected when examining soils and lake sediments. The HRTEM studies also show that the silica-rich coatings (a) suppress the transformation of secondary phases such as Fe-hydroxides and Fe-sulfates (e.g. jarosite minerals) towards thermodynamically stable phases such as goethite and hematite, and (b) limit the equilibration between pore spaces occupied by nano-sized particulate matter, secondary Fe-Cu-sulfates and jarosite group minerals, and trapped phyllosilicates such as clays and chlorite. The preservation and disequilibria of mineral phases in these silica coatings give insight into past environmental conditions during coating formation and the nature of past and present nano-sized particulate matter emitted by smelters.

Abstract ID: 36068

Final Number: MS24A-0285

Title: Structural accommodation of K at dravitic tourmaline's *X*-site: insight from Raman spectroscopy and single crystal X-ray diffraction

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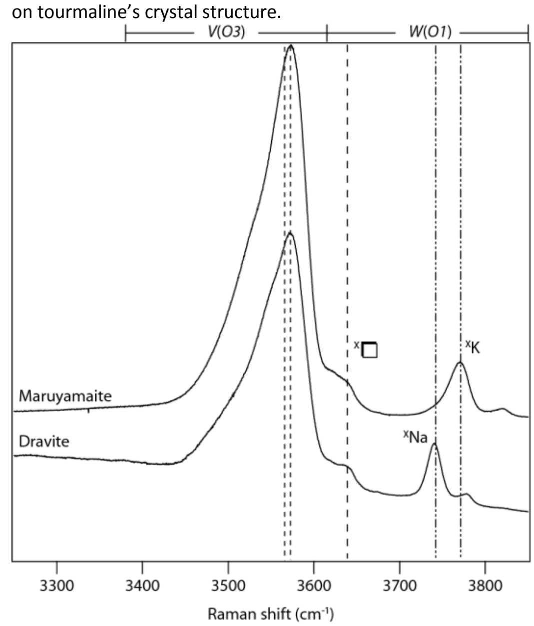
Published Material: The Raman spectra were presented at the IMA conference in Johannesberg, September 2014.

Abstract Body: Potassium incorporation in dravite increases with pressure, temperature, and its relative concentration in the crystallizing fluid, leading to K-dominant tourmaline (maruyamaite [$K(Mg_2Al)Al_6Si_6O_{18}(BO_3)_3(OH)_3O$]) forming at high-grade conditions given a K-rich fluid. The question remains of how the large K^+ ion influences tourmaline's crystal structure, particularly in comparison to the more common end-member, dravite [$NaMg_3Al_6Si_6O_{18}(BO_3)_3(OH)_3(OH)$]. In addition, most Raman spectroscopic studies have been conducted on natural tourmaline, which are solid solutions of multiple end-members. The presence of many site substitutions in these tourmaline leads to complicated Raman spectra, hindering unambiguous band assignments.

To understand how tourmaline accommodates the K^+ ion, we characterized synthetic maruyamaite by electron microprobe, single crystal and powder XRD, Raman and IR absorption spectroscopy. Our synthetic tourmalines have a constrained composition and correspondingly simpler Raman spectra allowing us to unambiguously assign the O-H stretching bands to specific site compositions. The incorporation of K in dravitic tourmaline expands the unit cell volume from a value of 1570 Å^3 for our dravite to 1588 Å^3 for our maruyamaite. In detail, the *X*-site polyhedra of the latter expand, with average <*X*-O> distances of 2.737(12) Å (cf. ~2.69 Å for dravite). The other coordination polyhedra are similar in size to dravite. Comparison of the Raman spectra of dravite and maruyamaite reveals K's effect on the local bonding environment. The Raman band assigned to the occupied *X*-site shifts from 3750 (dravite; ^{X}Na) to 3769 cm^{-1} (maruyamaite; ^{X}K), reflecting the shortening of the O-H bond in the *X*-site-neighbouring *W*(*O1)* site. In addition, the presence of vacancies at the X-site is common to all synthesized tourmaline, as indicated by a band at 3618 – 3622 cm^{-1}. The lower frequency of this band indicates that vacancies are associated with a lengthening of the O-H bond at the *W*(*O1*) site.

The investigation of Raman spectra of well-characterized synthetic tourmaline allows unambiguous band assignment. Moreover, the occurrence and relative positions of these bands combined with single crystal XRD provides insightful information about the effect of composition on tourmaline's crystal structure.



Abstract ID: 33497

Final Number: MS24A-0286

Title: Spherulitic and Cone-in-cone Concretions in Cambro-Ordovician Black Shales, Île-aux-Grues/Île-aux-Oies, Quebec, Canada: An Interpretation of Their Origin

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Published Material: Goldschmidt 2012 Montreal, submitted and published as abstract, but withdrawn before presentation.

Abstract Body:

Abstract ID: 35677

Final Number: MS24A-0287

Title: Trace Element Partitioning Between Fluorite and Hydrothermal Fluid

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Abstract Body: Trace elements composition in gangue fluorite - generally its patterns and ratios -has been widely used to determine the source of solutes in hydrothermal fluid when studying the genesis of hydrothermal ore deposits. This is under the assumption that the trace element composition of fluorite is representative of the hydrothermal fluid from which the fluorite precipitated. However, the trace element compositions of minerals are strongly affected by the partitioning behavior of these elements. Therefore, in order to obtain information on the trace element

composition of the hydrothermal fluid that no longer exists from fluorite, it is crucial to know the partition coefficients of the elements of interest between fluorite and fluid. It is well known that partition coefficients vary with physicochemical conditions, which can be predicted with Lattice-Strain model (see Blundy & Wood 1994). We are performing fluorite-fluid partitioning experiments to obtain a basic set of partition coefficients as a starting point to build a model using Lattice-Strain Theory, to extrapolate coefficients for any set of physicochemical conditions. We have successfully synthesized fluorite, verified by X-ray diffraction analysis, in aqueous solutions doped with trace elements at typical hydrothermal temperatures from 60 °C to 250 °C. Analysis of the trace elements concentration in synthesized fluorite and residual fluid from the 60 °C experiment using ICP-MS technique gave us the first set of partition coefficients, which are in general agreement with the data obtained by van Hinsberg (2010) using a different experimental approach. Once this model is built, natural fluorite crystals sampled in ore deposit will be analyzed for trace element content, and relevant partition coefficients will be applied to reconstruct the trace elemental composition of the ore-forming fluid.

Abstract ID: 36249

Final Number: MS24A-0288

Title: Effects of Viewing Geometry, Aggregation State, and Particle Size on Reflectance Spectra of the Murchison CM2 Chondrite

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Abstract Body: Several current missions will investigate 'dark' asteroids, whose spectra have weak or no distinct spectral features. Many non-compositional effects can influence reflectance spectra, complicating the analysis of such data from remote surfaces. Using a sample of Murchison CM2 chondrite, a series of absolute reflectance (across a 0.3µm–2.5µm range) spectra was collected, varying a range of these non-compositional parameters. In situ spectra of three samples with both saw-cut and fusion-crusted faces were taken; sub-samples of these slabs were then powdered to <150µm to investigate spectral homogeneity within a sample. To explore the effects of grain size, a series of measurements was taken in which the same sample was measured at progressively smaller grain sizes (1000, 500, 250, 150, 90, and 45µm). Mixtures of coarse (0.5-1mm) particles combined with varying amounts of <45µm fine particles taken from the same sample as well as homogeneous samples prepared with different powder-packing (regular, fluffy, and packed) techniques were measured to examine surface texture effects. Lastly, spectra of one <90µm sample were taken at different phase angles to better account for the wide variations in viewing geometry that are possible from spacecraft encounters. Intra-sample heterogeneity, while spectrally detectable, is relatively limited and generally within the range of variations exhibited by duplicate measurements of the same sample after repacking. Decreasing grain size causes a decrease in spectral contrast and increased visible spectral slope. Fine-grained particles appear to exert a disproportionately strong influence on spectral properties relative to their volume. Phase angle effects include increased visible slope with increasing phase angle, a trend that may reverse at very high phase angles (>~100°). Overall, it should be possible to make reasonable compositional interpretations of carbonaceous chondrite spectra and constrain some physical properties (e.g., grain size). The full spectral resolution data collected may also inform the interpretation of hyperspectral data returned from Ceres, Bennu, and other dark carbonaceous chondrite-like surfaces.

OCEAN SCIENCES

Abstract ID: 33184

Final Number: OS14A-0289

Title: The position of Anthropogenic Activities on Atlantic and Indian Oceans in Africa

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Published Material: Africa is the second largest and most populated continent after Asia. Geographically it is located between the Atlantic and Indian Oceans. Most of the Africa's most populated and industrialized cities are located along the coast of the continent facing the Atlantic and Indian Oceans, example of such cities include Casablanca, Dakar, Accra, Lagos, Luanda and Cape town all facing the Atlantic Ocean and cities like East London, Durban, Maputo, Dar-es-salaam and Mogadishu are all facing the Indian Ocean. As a result of the geographical locations of African Coastal Cities plus increase in their population, industries, sea port operations, petroleum exploration activities, trafficking of toxic wastes and improper waste management culture lead to the incessant increase in the pollution of the two oceans. NATURE OF POLLUTION OF THE ATLANTIC OCEAN i. The petroleum exploration activities going on along the coast of "Gulf of Guinea" region in countries such as Equatorial Guinea, Sao Tome and Principe, Gabon, Nigeria, Angola and others continuously causes oil spillages in the process of drilling, bunkering and discharging of petroleum products in the Atlantic Ocean.

Abstract Body: Africa is the second largest and most populated continent after Asia. Geographically it is located between the Atlantic and Indian Oceans. Most of the Africa's most populated and industrialized cities are located along the coast of the continent facing the Atlantic and Indian Oceans, example of such cities include Casablanca, Dakar, Accra, Lagos, Luanda and Cape town all facing the Atlantic Ocean and cities like East London, Durban, Maputo, Dar-es-salaam and Mogadishu are all facing the Indian Ocean. As a result of the geographical locations of African Coastal Cities plus increase in their population, industries, sea port operations, petroleum exploration activities, trafficking of toxic wastes and improper waste management culture lead to the incessant increase in the pollution of the two oceans.

NATURE OF POLLUTION OF THE ATLANTIC OCEAN

i. The petroleum exploration activities going on along the coast of "Gulf of Guinea" region in countries such as Equatorial Guinea, Sao Tome and Principe, Gabon, Nigeria, Angola and others continuously causes oil spillages in the process of drilling, bunkering and discharging of petroleum products in the Atlantic Ocean.

ii. The incessant degreasing of the Sea Ports "Quay Aprons" along the Coastal cities of Lagos, Duala, Libreville, Luanda, Cape Town etc are continuously polluting the Atlantic Ocean with chemicals which is affecting negatively the Ocean marine biodiversity of the Atlantic Ocean in general.

iii. Local wastes generated from the houses located in the coastal cities are always finding their ways directly or indirectly into the Atlantic Ocean. In fact this explains why plastic containers are always deposited by the Ocean along the African beautiful coastal beaches.
iv) Gas flaring activities in the gulf of guinea region is another source of pollution and even source of canalizing the ongoing climate change across the globe in the region. Because a report released by the renown non-governmental organization on environmental pollution the Netherlands

based Climate Justice Programme under the aegis of "friends of the Earth" indicated that the coastal region of Nigeria along accounts for 16 percent of the world's total flare.

Abstract ID: 33520

Final Number: OS14A-0290

Title: Evaluation of Satellite SST Data Using in situ Skin SST Measurements

Presenter/First Author: Lei Guan, Ocean University of China, Qingdao,

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Co-authors: Liqin Qu, , , ; Kailin Zhang, , ,

Published Material: Presented at PORSEC-2014.

Abstract Body: Sea Surface temperature (SST) is an essential indicator for climate change. High accuracy and stability of the satellite SST products are required for long-term climate data records of global SST. It is important to routinely collect in situ SST measurements for the evaluation and improvement of the quality of satellite SST products. The infrared SST autonomous radiometer (ISAR), made by the University of Southampton, has been deployed on the research vessel Dong Fang Hong II of Ocean University of China since September 2009. The ISAR designed with an accuracy of 0.1 K was calibrated at National Physical Laboratory, UK, in June 2009, through the Committee on Earth Observation Satellites (CEOS) comparison of Infrared radiometry in support of satellite calibration and validation for measuring SST for studies of climate change. The R/V Dong Fang Hong II operates mainly in the China Seas including Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea, for about 300 days per year. The skin SST measurements were collected during 33 cruises in the China Seas from 2009 to 2013. The satellite SST products are compared with shipboard measurements of skin SST. The results will be presented and discussed.

Abstract ID: 33747

Final Number: OS14A-0291

Title: Internal Waves Induced the Increase of Nutrients and Chlorophyll-a Concentrations in the Dongsha Atoll Continental Shelf

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Co-authors: S.-H. Peng, , , ; Y.-H. Wang, , ,

Abstract Body: Many studies have already reported that the internal waves were generated frequently in the Luzon Strait and propagated westward to reach or break down on the Dongsha Atoll continental shelf. We have conducted several cruises to measure hydrological (T, S, D) and biogeochemical (nutrients, Chl-a) conditions from two transects covering the slope, shelf break and shelf zones of Dongsha Atoll in the northern South China Sea (SCS). We found that the surface water off Dongsha Atoll was generally depleted with nutrients and its DIN/DIP ratio was quite low and similar to the typical ratio of surface water in the northern SCS. However, the concentrations of nutrients, Chl-a and particulate organic carbon (POC) were enhanced after internal waves (IW) induced upwelling and lifted cold and nutrient rich water to the surface. Meanwhile, the DIN/DIP ratio in the euphotic zone was significantly elevated and approached to that in the aphotic zone after a distinct event of internal waves. Such features can be seen in both eastern transect (M1-M6) and northeastern transect (NM1-NM4) particularly on the shallow zones near the Atoll. The effects of a down-welling (W2 Station) event on biogeochemical distributions can be evaluated through a short time-series observation of T, DO and nutrients at 50 m during the passage of IW. A 30-hour sequential observation shows that the upwelled IW can transport nutrients into surface layer and down-welled IW can transport DOC and POC into subsurface layer and affect carbon budget significantly. In addition, the moored station (IW Station) shows simultaneous changes of T and Chl-a at 40, 100 and 150m, indicating a significant effect of IW on T and phytoplankton biomass. The POC derived from the enhanced nutrients in surface did not likely accumulate on shelf sediments (<50 m), which may imply a transport of Chl-a and POC toward north-western regions. Preliminary data also show that the area was likely a sink of atmospheric CO_2 along the eastern transect (M1-M6).

Abstract ID: 33642

Final Number: OS14A-0292

Title: Impact on the Circulation in the Sumjin River Estuary under summer monsoon condition

Presenter/First Author: Young Jae Ro, Chungnam National University, Daegu,

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Published Material: Partial result were published in the Journal of Korean Coastal and Ocean Engineering Society.

Abstract Body: The Sumjin/Kangjin Estuarine System (hereafter, SKY) is one of most complex and the lastly remained natural system whose river runoff is drained into the South Sea of Korean Peninsula and is interconnected among Sumjin River, Kangjin Bay and Kwangyang Bay through very narrow channel. During the monsoon season, River runoff is around 300 to 500 % of normal condition. River runoff is dominant forcing for the estuarine circulation system in addition to tidal forcing with 4.5 meter range. Among many features, we have reproduced the tidal and residual current system with skill scores > 90 %. Very strong tidal current is reproduced with speed exceeding 3.5 m/s in the Noryang Channel and 2.5 m/s in the Changson Channel. Residual current shows very complex pattern with local eddy motions with radius around 2~3 km with clockwise and counterclockwise rotations.

In the Yeosu Channel where the longitudinal length is around 30 km, and cross-channel width around 5~8 km, the tidal current speed exdeeded 2.0 m/s during monsoon season. It also shows the asymmetry of current and salinity field due to deflection effect by the Coriolis Force.

Abstract ID: 35229

Final Number: OS14A-0293

Title: Seasonal and Inter-Annual Variations of Remotely Sensed Biogeochemical Parameters in Northern Gulf of Mexico and Their Correlations to the Size of Hypoxia

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Abstract Body: With the development of algorithms for many biogeochemical parameters in surface water, satellite remote sensing has become a useful tool for the study of marine ecosystems. The hypoxia (O_2 < 2 mol L^{-1}) in the northern Gulf of Mexico has been measured annually in summer for about three decades with shipboard methods. A systematic

study of other biogeochemical parameters and their relation with dissolved oxygen and systematic monitoring of the hypoxia size are essential for understanding hypoxia development and for evaluating the effectiveness of the proposed conservation remedies. Here, we report a study of seasonal and inter-annual variations of remotely-sensed area-weight-mean of sea surface chlorophyll a (*chl a*), colored dissolved organic matter (CDOM) index, particulate organic carbon (POC), particulate inorganic carbon (PIC), and attenuation coefficient at 490 nm (K_{490}) of the northern Gulf of Mexico. Area-weight-mean of *chl a*, CDOM index, POC, PIC, and K_{490} were derived from SeaWiFS data from September 1997 to December 2010. Each one of these biogeochemical parameters showed a strong seasonal cycle with a peak in the Spring and a valley in Autumn. In addition, a strong linear correlation between hypoxia size in bottom waters and area-weighted-mean of *chl a*, POC, and K_{490} in surface waters were observed. These correlations offer an alternative method for estimating hypoxia size from remote sensing data.

Abstract ID: 33758

Final Number: OS14A-0294

Title: SEASONAL VARIABILITY OF CARBONATE SYSTEM CHARACTERISTICS IN A CORAL REEF ECOSYSTEM, SOUTHERN TAIWAN

Presenter/First Author: Pei-Jie Meng, National Museum of Marine Biology and Aquarium of Taiwan, Pingtung,

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Co-authors: Chung-Chi Chen, NTNU National Taiwan Normal University, Taipei, Taiwan

Abstract Body: The objective of this study is to explore the seasonal variability of carbonate system parameters and to identify the factors affecting the pCO_2 in surface water of a coral reef ecosystem. The total alkalinity (TA), pH and calculated partial pressure of CO_2 (pCO_2) were measured in the water column from a total of 17 stations in the Nanwan Bay, southern Taiwan. The results of the study show that spring and winter hydrographical characteristics and vertical mixing of water column was different from the other seasons and therefore contributing to the discrepancy of data collected as correlation of temperature, salinity, carbonate system parameters for summer and autumn. The control factors of the pCO_2 in surface water during seasonal changes lead to the following conclusion. The non-temperature related effect during spring is greater than temperature related effects. The reverse is true for summer while both temperate and non-temperature related effects more or less offset each other in autumn. One point to note, non-temperature related effects are made up of not only the effect of biological but also vertical mixing of water column and the exchange of gases in the Nanwan Bay. According to calculations, the seasonal data of pCO_2 in surface water is namely 393.7, 406.3, 399.2 and 366.9 µatm, respectively. The seasonal sea-air differences in Δ*p*CO2 were -3.3, 14.3, 7.2 and -29.1 µatm, respectively. These data indicate that the Nanwan coral reef region is the source of CO_2 in the atmosphere during summer and autumn. The calculation an average sea gases flux of CO_2 is -0.98 $gCm^{-2}year^{-1}$ and the annual absorption of gases is -29.3t. In addition to seasonal variability and fluctuations in temperature, the results suggest that vertical mixing of water column, intermittent upwelling of water and the biological effect also account for the changes in the pCO_2 of the water column in this coral reef ecosystem.

Abstract ID: 33728

Final Number: OS14A-0295

Title: Flooding Effects on Organic Carbon Consumption in the East China Sea

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Abstract Body: A central motivation for this study was to reveal how flood effects on plankton community respiration (CR) in the East China Sea (ECS). In 2010, a devastating flood occurred in July in the Changjiang River; with mean monthly discharge of 60,527 $m^3 s^{-1}$. To compare, data was examined in July of 2009, when the riverine flow was low (mean monthly values = 33,955 $m^3 s^{-1}$). During flood, a tremendous amount of freshwater was delivered into the ECS, and low sea surface salinity (≤ 31 psu) covered almost two third of this continental shelf. High nitrate concentration in the ECS was also measured during the flood, and it was significantly higher than that of 2009 non-flood with mean ± SD values of 6.2 ± 9.8 and 2.0 ± 5.3 µM, respectively. Although primary production in the surface water was high in 2010 flood with mean ± SD value of 62.1 ± 33.8 mg C $m^{-3} d^{-1}$. Surprisingly, the mean value of Chl *a* was only slightly higher in 2010 than that of 2009, and bacterial biomass was even lower in 2010 compared to that of 2009. The CR was however still higher in 2010 than that of 2009, with mean (± SD) values of 105.6 (± 66.7) and 73.2 (± 76.9) mg C $m^{-3} d^{-1}$, respectively. To further explore, the difference (i.e., 2010 – 2009) of variables at the same station between two sampling periods were compared. Values of difference in CR was positively and negatively linearly regressed with that of differences in Chl *a* and fCO_2 (all $p \leqq 0.001$), respectively. These results imply that the flooding effect on higher CR during 2010 might be more attributed to phytoplankton. It also infers that the huge amount of fCO_2 absorption during 2010 flood was relative to strength of plankton activity, especially phytoplankton. These results all suggest that the devastating flood has significant effect on organic carbon consumption in the ECS. This impact might be even more pronounced when extreme rainfall events and flood magnitude have increasing dramatically throughout the world in last few decades.

Abstract ID: 36024

Final Number: OS14A-0296

Title: The Acidification Coupled with Eutrophication of the Coastal Waters of Bolinao, Pangasinan, Philippines

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Abstract Body: Ocean acidification is becoming a global concern due to its potential effects on marine resources. In coastal areas, an emerging problem is ocean acidification due to eutrophication resulting from human activities. The coastal water of Bolinao, Pangasinan, Philippines has become eutrophic due to increased nutrient loading from unconsumed fish feeds in fish cages. Mariculture is a big industry in Bolinao. In over a decade, the area has experienced decreased oxygen levels leading to hypoxia, fish kills, and algal blooms. The decomposition of organic matter from unconsumed fish feeds results not only to high nutrient buildup but also increased CO_2 and acidity in the area. Nutrients (ammonia, nitrate, nitrite, phosphate and silicate), total alkalinity (TA), dissolved inorganic carbon (DIC), pH, dissolved oxygen (DO), aragonite saturation state (Ω_{arg}) and partial pressure of carbon dioxide (pCO_2) were measured to determine the combined effect of acidification and eutrophication in Bolinao. Monitoring results have shown an increase in nutrients by 30% to 70% in over a decade. Total alkalinity (TA) data have a good correlation with salinity showing lower TA values in less saline waters. High DIC values were obtained from shallow stations with depth less than 5 meters. pH exhibited a clear seasonal cycle showing low pH values during the start and toward the end of the year while it increased from April to August. Lowest pH values were obtained from high residence time areas compared to areas which are near the opening of the channel. The eutrophic and acidified coastal waters of Bolinao are already affecting the seagrass and coral reef ecosystems in the area.

Abstract ID: 33772

Final Number: OS14A-0297

Title: Assessing the impact of tides and winds on the circulation of the Gulf of La Spezia with high-resolution, three-dimensional simulations

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Published Material: EGU2015 VIENNA. The results are not under review or published yet.

Abstract Body: The Gulf of La Spezia (Ligurian Sea, Northwestern Mediterranean) is characterized by a complex geometry and extends along a Southeast-Northwest axis with maximum width and length of 9 and 13 km, respectively. Water exchanges between the inner and outer parts of the Gulf are limited to two openings of a breakwater. The Gulf is site of intense harbor activities and subject to significant urban and industrial discharges from the town of La Spezia.

Despite its importance, the three-dimensional circulation of the Gulf of La Spezia is not well established. Recent observational efforts suggest a mean circulation scheme, which is not fully in agreement with the hypothesized three-dimensional baroclinic response to wind forcing. Previous numerical studies are either bi-dimensional or neglect the complexity of the Gulf using idealized geometries.

In this study, the three-dimensional open-source DELFT3D model is setup to assess the dynamics and the circulation patterns in the Gulf. A high-resolution horizontal grid (nominal spacing of about 50 m) is employed to fully resolve the complex real geometry of the region. Different simulations are run by varying the idealized forcing conditions. The first simulation aims at assessing the role of the semidiurnal tidal signal observed in the outer portion of the Gulf and with a sinusoidal oscillation with a period of 12 h and 25 min and a sea-level amplitude of 15 cm. In the second simulation, another oscillation of 70 min and amplitude of 5 cm is superimposed to the tidal signal to mimic the local seiche. A third simulation considers the addition of idealized sea breeze effects.

All simulations start at rest and with typical observed hydrographic initial conditions. The initial temperature (salinity) linearly decreases (increases) in the vertical. No-slip conditions are applied at all material boundaries and a Chezy coefficient of C=50 is used for the bottom frictional term. Horizontal viscosity and diffusivity are both set to a 0.05 m^2/s while a “k-Ɛ” turbulent closure scheme is used in the vertical.

Results and differences in the runs are quantified in terms of velocity at the two openings of the breakwater, residence times, erosion of the initial stratification as a measure of mixing. Realism of the different scenarios is validated against the observations taken in the area.

Abstract ID: 34375

Final Number: OS14A-0298

Title: Paleotempestology of Chezzetcook Inlet, Nova Scotia

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Abstract Body: A multi-proxy approach framework is presented to reconstruct the paleotempestology in Chezzetcook Inlet, Nova Scotia on the eastern Canadian seaboard. This study aims at identifying high storm activity periods, intensity and frequency of past tropical storms by using fossil remains, such as shells and foraminifera deposited on land or in fresh water basins from past storm surges. Sediment cores extracted from coastal lakes and marshes were chosen based on several criteria, such as elevation, distance from the Atlantic Ocean and the material composition of barriers. Several laboratory analyses are conducted on the sediment cores, for example x-ray, magnetic susceptibility, loss-on-ignition and grain-size. Future work will also include the study of other proxies including exploring the geochemistry of the past storms. Oxygen and carbon from individual tree rings will be extracted to establish storms' unique isotopic signatures and to validate sediment core findings.

Abstract ID: 36223

Final Number: OS14A-0299

Title: Turbulence in the Summertime Pycnocline

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Abstract Body: Microstructure measurements in the East China Sea allowed examination of turbulence influenced by summertime stratification in shallow (52 to 62 m depth) tidal basin, using 134 CTD and the dissipation rate profiles obtained during a 25-hour drift over a slightly slopping bottom. Turbulence in the pycnocline was highly intermittent, with spatially alternating layers of low (~ 10^{-9}) and enhanced (~ 10^{-7}) W/kg dissipation rate. An analysis of temporal variability of ε, eddy diffusivity K_N and squared buoyancy frequency N^2. Near the upper boundary of the pycnocline, majority of the dissipation and diffusivity extrema coincide with the extrema of buoyancy frequency, showing positive and negative (min-max) correlations. A negative correlation was mainly found in weakly stratified layers of the pycnocline and in a stratified upper portion of the BBL. The dependence of the dissipation on the normalized squared buoyancy frequency was very strong (the “-3” power) in a relatively narrow range of weak stratification when turbulence not only dissipated but also produced mixing that reduces the local buoyancy (density) gradient.

Analysis of the cumulative distribution functions (CDF) of the logarithm of the dissipation rate in the test area showed that the empirical CDFs can be successfully approximated by the generalized extreme value distribution for the areas of sharp pycnocline as well as less stratified transitional layers between the pycnocline and BBL and between the pycnocline and surface layer. This suggests that the generation and dissipation of turbulence in the summer pycnocline of ECS and adjacent startified layers can be considered as a result of extreme events such as random internal-wave breaking and sporadic instabilities. This turbulence occurred under light winds, being influenced by tidal currents in the BBL and internal waves in the pycnocline.

Abstract ID: 36013

Final Number: OS14A-0300

Title: PASSIVE ADVECTION AND REDISTRIBUTION OF HEAT IN WARMING OCEAN BASINS

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Abstract Body: An important parameter for the climate response to increased greenhouse gases or other radiative forcing is the speed at which heat anomalies propagate downward in the ocean. Ocean heat uptake occurs through passive advection/diffusion of surface heat anomalies and through the redistribution of existing temperature gradients due to circulation changes. Atlantic meridional overturning circulation (AMOC) weakens in a warming climate and this should slow the downward heat advection (compared to a case in which the circulation is unchanged). However, weakening AMOC also causes a deep warming through the redistributive effect, thus increasing the downward rate of heat propagation compared to unchanging circulation. Total heat uptake depends on the combined effect of these two mechanisms.

Passive tracers in a control and perturbed CO2-quadrupling experiments are used to investigate the relative effect of passive advection and redistribution. The spatial pattern and mechanisms of warming are examined. One feature of global warming appears to be the deeper heat penetration in the Atlantic than in the Indo-Pacific oceans. Even though our experiments display deep injection of a passive tracer in the deep-water formation region of the North Atlantic, most of the difference in speed of heat penetration is due to the redistribution term rather than this North Atlantic sinking. With further experiments we isolate the effect of weakening overturning on the heat uptake associated with passive advection. The separate effects of wind and salinity changes in changing circulation and the resulting effect on redistribution in the individual basins are also investigated.

Abstract ID: 33070

Final Number: OS23A-01

Title: Temperature and salinity effects as a climate change impact on flowering of the seagrass *H. stipulacea* along the coast of Tanzania

Presenter/First Author: Moses Joel Shimba, University of Dar es Salaam, Dar es Salaam,

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Abstract Body: Long term data sets on the phenology of Tanzania seagrasses either do not exist or have not been correlated with changing climate. The present investigation attempts to assess the influence of ocean physical parameters (temperature and salinity) on flowering of seagrass (*H. stipulacea*) as the means of determining and predicting the effect of climate change on sexual reproduction of marine plants. Flowers have not been reported for tropical seagrass *Halophila stipulacea* along the coast of Tanzania, Indo-Pacific, but after transplanting from Kunduchi intertidal mudflats to experimental cultures, flowers were observed. Staminate and pistillate flowers were produced at the temperature-salinity interactions of 24-28 °C/38-42 ‰ and 28-32°C/38-42 ‰ under 12 hr photoperiod (582 Lux) after twelve months in culture, but not at low temperature against low and mid salinity interactions at 20-24 °C/30-34 and 20-24 °C/34-38 ‰. A total of 79 flowers were recorded from January to December, 2013; where 54 staminate and 25 pistillate flowers were recorded throughout the experimental culture. Plants cultured at 24-28 °C/38-42 ‰ produced 25 staminate and 11 pistillate flowers, while plants at 28-32 ^{o}C/38-42 ‰ produced 29 staminate and 14 pistillate flowers, while none of the flowers observed in lower ranges of temperature against low and mid salinity interactions**.** It is concluded that temperature and salinity are the primary controlling factors involved in the flowering of *Halophila stipulacea*; and hence climate change is expected to cause a significant effect on seagrasses by affecting their reproductive ecology and physiology.

Abstract ID: 33816

Final Number: OS23A-03

Title: A Survey of Summer Coccolithophore Stocks and Diversity in the Western Edge of the Barents Sea

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Abstract Body: The Barents Sea, a shallow Arctic marginal sea, is particularly vulnerable to large-scale hydro-climatic changes associated with the polar amplification of climate change. Key oceanographical variables in this region are the seasonal development of sea-ice and the location and strength of physico-chemical gradients in the surface and subsurface water layers induced by the convergence of Arctic- and Atlantic-derived water masses. The biomass and taxonomic groups of phytoplankton species thriving in surface waters of the Barents Sea are therefore subjected to a large spatial and temporal variability according to the seasonal dynamics of the Arctic Front and changes in the structure of the upper water column (Signorini and McClain, 2009). Remote sensing imagery (e.g. Smith et al., 2004) confirmed the increasing success of calcifying haptophytes (coccolithophores) in the summer phytoplankton production of the Barents Sea over the last ca. 20 years, as a response to an overall larger contribution of Atlantic waters to surface and sub-surface waters, as well as to enhanced sea-ice melt-induced summer stratification of the photic layer. The present study provides a first thorough description of coccolithophore standing stocks and diversity in the western edge of the Barents Sea from surface and water column samples collected during August-September 2014 along a S-N transect from northern Norway to southern Svalbard, as part of the research cruise MOCOSED 2014 (SHOM - RV *Pourquoi Pas ?*). Census counts are discussed in view of the physical-chemical status of the photic layer as extracted from multisensor vertical casts and remote sensing. We aim here at filling some gaps in our knowledge on hydrological processes influencing the production and diversity of calcareous phytoplankton in polar environments.

Abstract ID: 35277

Final Number: OS23A-04

Title: Coastal eutrophication and biogeography in northeast United States (Maine to Delaware) estuaries as recorded by dinoflagellate cysts

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Abstract Body: We are investigating the use of dinoflagellate cysts (the fossilizable life stage of planktonic dinoflagellates) from sediments as a means to evaluate and monitor levels of cultural eutrophication. Nutrient concentrations in coastal waters do not always reflect the total amount of nutrients entering a water body, as they are rapidly taken up by phytoplankton and aquatic vegetation. One method to estimate nutrient input is nutrient loading models. Coupling nutrient loading models along with biological indicators that act as early warning signs in water quality degradation can be used to quantify the level of nutrient inputs that may be harmful to estuaries. Dinoflagellate cyst assemblages are known to reflect sea-surface conditions and are used in paleoenvironmental reconstructions to provide information on sea-surface temperature, salinity, productivity, and nutrient availability. Although previous studies have noted the impact of eutrophication on assemblages of cyst taxa in sediments, no study has compared empirical values of nutrient loading to cyst assemblages. We have assessed the relationship of cyst assemblages to nitrogen levels estimated from nutrient loading models and examined if this relationship varies with biogeographic province and type of estuary (riverine, lagoon, coastal embayment, and fjord). A total of 61 sediment samples from 23 estuaries collected by the EPA were analyzed. We found nitrogen loading and cysts produced by heterotrophic taxa are positively correlated when estuary type is accounted for. Nitrogen loading is also a statistically significant parameter influencing the spatial distribution of cyst assemblages in the study area, along with sea-surface temperature, tidal range, water residence time, grain size, and biogenic opal. In addition, the cyst signal clearly documents two biogeographic provinces, and supports studies of other marine organisms which delineate the boundary between the Acadian and Virginian provinces at Cape Cod.

Abstract ID: 35122

Final Number: OS23A-05

Title: Sedimentation in Hinchinbrook Entrance, Alaska, USA: correlations with wave energy on the Gulf of Alaska continental shelf

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Abstract Body: A high-resolution sedimentary sequence from Hinchinbrook Entrance (HE), Alaska is used to determine relationships between sedimentation and environmental factors, such as proxies for wave energy on the Gulf of Alaska continental shelf. The Copper River discharges into the northern Gulf of Alaska predominately during the summer (May to October), with the formation of a surface sediment plume that is largely advected westward into Prince William Sound through HE by the Alaska Coastal Current. During the winter (October to May), storms spawned by the Aleutian Low generate large waves with the potential to resuspend sediments on the shelf. Cores from HE show regular interlaminations of fine and coarse sediment that are interpreted as summer and winter annual deposition, respectively. Yearly layers are divided into measured summers and winters using XRF Sr/Pb as a proxy for grain size. Wave data from the Gulf of Alaska (NOAA NDBC) were transformed into proxies for wave energy, including bottom wave orbital velocities, bed mobility percentages and recurrence intervals for resuspension. The threshold for resuspension on the shelf is 0.19 ms^{-1} based on the mean d_{50} of shelf sediments. Bed mobility, frequency for resuspension, and mean bottom wave orbital velocities are higher in the winters compared to the summers. Thicker winter deposits at HE are present when wave energy on the shelf is higher. Sediments from HE have a cyclical pattern of winter and summer sedimentation, however the deposit thickness is ~6 orders of magnitude greater in the winter of 2001, during which time the average bottom wave orbital velocities along the Gulf of Alaska shelf were highest and the shelf was most mobile compared to any other season on record. The wave energy on the shelf appears to be controlling winter sedimentation into Prince William Sound, providing implications for reconstructing past winter wave energy on the Gulf of Alaska continental shelf beyond historical records.

Abstract ID: 35752

Final Number: OS23A-06

Title: Comparing Bayesian stable isotope mixing models: Which tools are best for sediments?

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Co-authors: Stephen A Macko, Univ Virginia, Charlottesville, VA

Published Material: I will be using my data that was published by Faux et al. 2011, but using different tools to analyse the data.

Abstract Body: Partitioning of contributions of organic components into a mixture has been a long term goal in organic geochemistry. Using stable isotope mixing based on a Bayesian models have received much attention as a means of coping with multiple sources and uncertainty in isotope ecology (e.g. (Phillips et al., 2014)), enabling the probabilistic determination of the contributions made by each food source to the overall diet of the organism in question. We have applied these techniques to marine sediments for the first time. The sediments of the Chukchi Sea and Beaufort Sea offer an opportunity to utilize these techniques for organic geochemistry. There are at least three likely sources of organic carbon that are contributors to the marine sediments: pelagic phytoplankton, sea ice algae and terrestrial material from rivers and coastal erosion, as well as considerable variation in the marine $d^{13}C$ values. Bayesian mixing models using bulk $d^{13}C$ and $d^{15}N$ data from Shelf and Basin allow for the probabilistic determination of the contributions made by each of the sources to the organic carbon budget, and can be compared with existing source contribution estimates based upon biomarker models (e.g. (Belicka & Harvey, 2009), (Faux et al., 2011)). With a variety of mixing models now available, this study compares results from SIAR, MixSIR and IsotopeR in order to suggest which tool is most appropriate for marine sediments.

Abstract ID: 33128

Final Number: OS31A-01

Title: Surge Dynamics of superstorm Sandy: Exposure of Metropolitan New York to Catastrophic Flooding

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Published Material: Physics of Estuaries and Coastal Seas (PECS), Porto de Galinas, Brazil Oct 2014. Not under review nor submitted for publication

Abstract Body: Superstorm Sandy made landfall in northern New Jersey at 2350 hr GMT on 29 October 2012. Serious coastal flooding resulted in significant loss of life and catastrophic property damage (~ $85 billion) for Metropolitan New York (NY), northern New Jersey (NJ) and coastal Long Island (LI). At least 286 people were killed along the path of the storm in seven countries. The track and intensity of the storm were relatively well-predicted a few days in advance by the National Weather Service's (NWS) National Hurricane Center (NHS). Observed flooding during Sandy overran the FEMA estimated 500-year flood risk contour in some coastal locations and resulted in FEMA's prompt removal of their flooding maps immediately after Sandy made landfall. This paper discusses simulations of the surface winds and sea level pressure from an ensemble of WRF-derived runs coupled to a 2D version of ADCIRC (Ocean Circulation Model) and SWAN- simulated wave field and their associated storm surge and coastal setups. By comparing a subset (11 member) of the WRF runs, the question of whether Sandy was a worst-case scenario is discussed.

Abstract ID: 35797

Final Number: OS31A-02

Title: Ocean Climate Change, Sea Level Increase and Tsunami Hazard Monitored in Real Time over Decades by Sensors on Submarine Telecommunication Cables

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Published Material: Preliminary data in abstract at AGU Dec 2013; no scientific journal publication submission yet

Abstract Body: Ocean climate change, sea level increase, and tsunami and slope failure hazards represent major factors in environmental change and threats, with profound global and regional socio-economic impacts. Advances in sensor technologies, cabled ocean observatories, and partnerships in submarine telecommunications industry, all combine to promote new Green Cable Systems in providing critical environmental data on regional and global scales. In 2012, three UN agencies, ITU/WMO/UNESCO IOC, established a Joint Task Force that advocates adding environmental sensors to trans-ocean and regional submarine telecommunication cables. JTF is now developing a Wet Demonstrator whereby a commercial grade cable with three repeaters and sensor packages (temperature, pressure, and 3-axis accelerometer), deployed for a year at c. 2000m water-depth, will show installation and operational reliability and data quality. One scenario uses a research cabled ocean observatory with a nearby cable maintenance ship for deployment (e.g. NEPTUNE/Ocean Networks Canada; RSN/Ocean Observatories Initiative or Aloha, US; DONET, Japan; EMSO, Europe), in-kind support, technical staff, and free release of real-time data. Environmental and economic benefits of such a demonstration, ensuring a quantum leap by industry to generate new real-time sensor data every 50-70 km along new and refurbished cable systems across different transects of the world's oceans, would be of profound importance. These advances address global issues affecting societies and future generations, and save vast resources from destruction because of imprecise tsunami hazard warning systems and sea-level change quantification. JTF proposes that for modest cost a new suite of real-time environmental data will be generated over decades to underpin public policy for management, safety, and regulation and for industrial and infrastructure planning.

Abstract ID: 33540

Final Number: OS31A-03

Title: Short- and Long-Lasting Ocean Circulation Changes Induced by an Extreme High-Latitude Volcanic Eruption

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Abstract Body: Large volcanic eruptions can have major impacts on global climate affecting both atmospheric and ocean circulation through changes in atmospheric chemical composition and optical properties. Since the residence time of volcanic aerosol is around 2-3 years for strong eruptions, it was generally believed that volcanic eruptions produce mainly short-term climate impacts. Therefore, wide attention has been given to the effect of large tropical eruptions on the atmospheric circulation, but only to a lesser extent to the oceanic circulation. Furthermore, high-latitude eruptions have been considered to have an impact only on the Hemisphere where they occur.

In this study, using a coupled ocean-atmosphere-chemistry model, we generate a 20-member ensemble simulation and we examine both short- (1-4 years) and long-term (60 years) effects of an extreme high-latitude eruption. In particular, we focus on systems of crucial importance for the global climate, such as the ocean's meridional overturning circulation and El Niño Southern Oscillation.

We found an El Niño-like response in the 6-8 months after the eruption (similar to the tropical eruptions) and followed by a transition to La Niña-like that peaks 24 months after the eruption. However, the increased likelihood of El Niño phase for a high-latitude eruption has a different explanation compared to tropical eruptions. In the latter case, an El Niño phase may be triggered by reduced surface radiation that smoothens the zonal SST gradient along the equatorial Pacific. While for high-latitude eruptions, changes in atmospheric dynamics in the northern hemisphere trigger a weakening of the trade winds over the western tropical Pacific hence leading to El Niño-like response.

We show for the first time how high-latitude eruptions also lead to long-term effects on ENSO changing both its period and its variability (Fig. 1, left panel). These long-term changes are connected to changes in the strength of the Atlantic Meridional Overturning Circulation induced by the eruption.

Our results show that impacts of high-latitude eruptions may well not be confided to the hemisphere where they occurred but spread globally via atmospheric-oceanic feedbacks (short-term) and via changes in the AMOC and ocean heat content (long-term, Fig. 1, right panel).

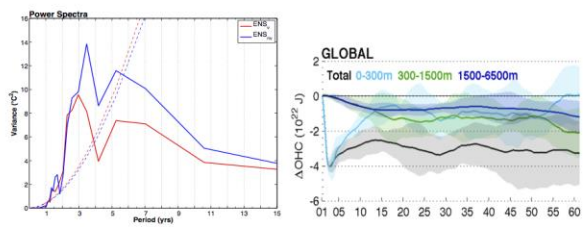

Figure 1: On the left, ENSO power spectrum (solid lines) and the least-squares best fit of a theoretical Markov "Red Noise" spectrum (dotted lines) at 90% confidence level for volcano – ENS_v (red) and no-volcano ensemble mean – ENS_{nv} (blue). On the right, integrated OHC (J) difference between ENS_v and ENS_{nv} from the surface to different indicated depths for the global ocean. The shadings represent the standard deviation of the ensemble difference. Note how the volcanic anomaly persists in the ocean after 60 years (black line).

Abstract ID: 34948

Final Number: OS31A-06

Title: Surface and Bottom Temperature and Salinity Climatology and Long-Term Changes along the Continental Shelf off the Canadian and U.S. East Coasts.

Presenter/First Author: Benjamin Richaud, Woods Hole Oceanographic Institution, Woods Hole, MA

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Co-authors: Terrence M Joyce, WHOI, Woods Hole, MA; Young-Oh Kwon, Woods Hole Oceanographic Institution, Woods Hole, MA

Abstract Body: Climatological studies of surface and bottom temperature and salinity have already been presented for different regions along the Canadian and U.S. shelves separately. Here, we merge data sets from the two regions. The first one consists of data from 1910 to 2010, on a large area going from the Scotian Shelf to the Labrador Shelf, the other one goes from Cape Hatteras to the Scotian Shelf, and begins as early as 1864. The resulting data set gives the location, depth and date of stations measuring surface and/or bottom temperature and/or salinity, bottom being defined as less than 10 meters from the bathymetry-given depth. Here, we will focus on the mean seasonal cycle along the shelf and the structure of the mean fields of surface and bottom temperature and salinity and their long-term temporal changes from 1950 to 2010.

Abstract ID: 35574

Final Number: OS31A-07

Title: The Role of Internal Tides in Patterns of Spatial Variability at Canyons

Presenter/First Author: Timothy F Duda, Woods Hole Oceanographic Inst, Woods Hole, MA

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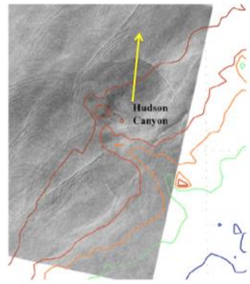
Co-authors: Weifeng Zhang, Woods Hole Oceanographic Insti, Woods Hole, MA; Arthur E Newhall, , , ; Karl Richard Helfrich, WHOI, Woods Hole, MA

Published Material: Some of the internal tide results were reported in a JPO paper* and the AGU Ocean Sci meeting 2014. The hybrid extension of the model is new. * Zhang, W. G., T. F. Duda and I. A. Udovydchenkov, Modeling and analysis of internal tide generation and beamlike onshore propagation in the vicinity of shelfbreak canyons, J. Phys. Oceanogr., 44, 834-849, http://dx.doi.org/10.1175/JPO-D-13-0179.1 , 2014.

Abstract Body: Canyons at the continental slope are places of notable biological activity when compared with adjacent areas. Spatial patterns of activity within canyons have also been noted. Probable contributing factors for the enhancement and the patterns are circulation, seafloor environment, and mixing-induced fluxes. Internal tides (ITs) near canyons have been identified as a probable contributor to mixing and secondary circulations. In addition, IT energy is not evenly distributed at canyons, offering a possible explanation for some of the spatial patterns. A full understanding of IT dynamics at canyons would offer the possibility of building a model framework to better understand differences between canyons, similarities between canyons, and response of canyon systems to seasonal cycles and dynamical episodes such as impinging eddies. Here, details of IT generation near continental slope canyons are presented. Both numerical and theoretical methods are used, and the agreement provides confidence in the results. A multiple-scattering mechanism explains spatial variation of IT generation. A distributed-source mechanism explains patterns of IT energy radiation. The estimated spatial distribution of IT-related mixing around canyons is addressed with a hybrid model of IT-driven nonlinear internal waves. The hybrid model consists of a KdV-family model governing IT evolution that captures the nonhydrostatic dynamics leading to nonlinear internal wave formation. Using the entire collection of models, the implications for spatially variable ecosystem character due to the modeled IT patterns are examined.



The arrow shows internal waves radiating from Hudson Canyon. This synthetic aperture radar satellite image published in *An Atlas of Internal Solitary-like Waves and their Properties* by C. R. Jackson(2004) motivated our work.

Abstract ID: 34982

Final Number: OS32A-01

Title: Results from the first Topo-Bathymetric lidar surveys of the Chiroptera II sensor: Improved geological mapping and coastal hydrodynamic models

Presenter/First Author: Timothy L Webster, Organization Not Listed, Lawrencetown,

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Co-authors: Kevin McGuigan, , , ; Nathan Crowell, , ,

Abstract Body: The Applied Geomatics Research Group (AGRG) within the Nova Scotia Community College (NSCC) acquired a new shallow water airborne topo-bathymetric lidar sensor and flew the first missions in September 2014. The survey areas consisted of several embayments along the Northumberland Strait. The low flow rates associated with the inner bays promote high volumes of sediment cover and bedrock features are rarely exposed. These sediments can be re-suspended in the water column during periods of increased wave activity, thus increasing turbidity and limiting the laser penetration depth. The reflectance of the seabed also effects the laser also effects the maximum depth achieved. The area near Cape John, Nova Scotia where Carboniferous sandstone rocks are exposed provides insights into how the sensor can enhance and extend structural information on geological maps. Traditional topographic lidar reveals a smooth terrestrial landscape with limited outcrop as a result of the deposition of glacial till. The bedrock is exposed along cliffs at the coast where limited bedding and structural measurements can be taken. The first attempt to survey was aborted on Sept. 25 because of high water turbidity levels and poor bathymetric lidar returns. However, after a day of reduced winds it was surveyed on Sept. 26 with penetration to 6 m water depth. The results revealed several previously uncharted features on the seabed including reefs. Other than near-shore sand bars, the offshore currents have scoured the seabed to expose the bedrock revealing bedding planes and fault structures. Details of the strike of the beds offshore reveal new details on the folding and faulting in this area and these new data can be used to update the existing geological map, NSDNR Map ME 1990-014. The circulation of water within sheltered bays is important for aquaculture site selection. The results of a hydrodynamic model using Mike-21 for Little Harbour, NS were compared between input data consisting of the original chart information based on a sparse distribution of soundings and the new lidar derived DEM. The results indicate the improved input elevation data produces a more refined and detailed set of outputs. The model results have not been validated against in-situ water levels or current measurements yet, although that is planned this field season.

Abstract ID: 34172

Final Number: OS32A-02

Title: Morphodynamics in Sediment-Starved Inner-Shelf Submarine Canyons (Pointe-des-Monts, Eastern Canada)

Presenter/First Author: Alexandre Normandeau, Université Laval, Québec, QC

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Co-authors: Patrick Lajeunesse, Université Laval, Québec, QC, Canada; Guillaume St-Onge, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada; Pierre Francus, Inst Nat Recherche Sci, Québec, QC, Canada; Michael Dietze, , , ; Daniel Bourgault, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada

Published Material: Part of this presentation was published :Normandeau, A., Lajeunesse, P., St-Onge, G., Bourgault, D., St-Onge Drouin, G., Senneville, S., Bélanger, S., 2014. Morphodynamics in sediment-starved inner-shelf submarine canyons (Lower St. Lawrence Estuary, Eastern Canada). Marine Geology 357, 243-255

Abstract Body: The activity and sedimentary processes in a series of inner-shelf submarine canyons located in the Lower St. Lawrence Estuary was examined using high-resolution multibeam bathymetry, backscatter and seismic data as well as by analyzing a ~9 m-long sediment core. The presence of crescentic bedforms, probably representing cyclic steps that were displaced upslope at the bottom of the canyons between 2007 and 2012 indicates that they are currently active through the remobilization of sediment by gravity flows. However, the shelf and shores of the region are characterized by the absence of sediment. Our results indicate that gravity flows currently eroding the canyon floors do not transport new material downslope coming from the shelf but rather remobilize *in-situ* deglacial sediments within the canyon thalweg. End-member modeling analysis performed on grain-size distributions reveals the presence of quasi-continuous flows within the canyons and the presence of only one turbidite. Based on these results, we suggest that frequent hydrodynamic processes and infrequent slope failures are responsible for sediment remobilization in these canyons, although their role in the upslope migrating crescentic bedforms is still unclear. This presentation provides further evidence that sediment supply is not a prerequisite for the origin and activity of inner-shelf submarine canyons.

Abstract ID: 34981

Final Number: OS32A-03

Title: Acoustic Imaging of the Transition from Fluvial Suspension to Density Underflow on a Marine Delta Lip

Presenter/First Author: John E Hughes Clarke, University of New Brunswick, Fredericton, NB

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Co-authors: Peter J Talling, National Oceanography Centre,, Southampton, Hamps, United Kingdom; Matthieu Cartigny, , ,

Abstract Body: The abrupt delta lip transition from continuous fluvial bedload and suspended load transport to episodic gravity-driven underflows has long been a focus of speculation. Hyperpycnal flows have been observed in lacustrine systems where there is minimal density contrast between the inflow and receiving watermasses. The same mechanism, however, is much harder to achieve given a typical 20-30 kg/m^3 contrast between fresh and salt water.

To directly address this process, repetitive surveys were conducted off the lip of the Homathko delta at 15 minute intervals around low-water when the off-delta sediment flux was most intense. Simultaneous bathymetry from 5 to 80m as well as acoustic volume scattering of the water mass was imaged using 90 and 500 kHz multibeams. A rapidly dipping optical backscatter probe was deployed to relate the volume scattering to suspended load.

The acoustic imaging clearly identified the highest suspended load in the overlying outflowing freshwater. The load never at any time approached the level at which it could result in direct hyperpycnal flow. Rather, the suspended load was seen to drop through the base of the freshwater layer into the underlying saltwater forming a near continuous descending flux. This avoids the need to overcome the bulk of the density contrast. Although the descending plume appeared continuous, the development of seabed surges in this flow was intermittent with only 2 surge flows in a single tidal cycle.

The simultaneous bathymetry indicated that just one of the delta lip chutes was intermittently active with both bulk accretion and deflation as well as upslope migrating bedforms. Beyond the mouth of the chute, however, only one flow was sufficiently powerful to cause bedform migration in the downstream channel. That movement was clearly correlated with the development of a discrete turbidity current flow visible in the water column imaging.

The presence of a near continuous descending plume, but only intermittent surges, suggests that there is an intervening step where the sediment flux builds up on the proximal delta lip, before initiating a subsequent flow. The details of that step remain imperfectly understood.

Abstract ID: 35137

Final Number: OS32A-04

Title: Understanding Sediment Flux Through Delta-top Channels Using Repetitive Multibeam and Hydrodynamic Modeling

Presenter/First Author: Danar Guruh Pratomo, University of New Brunswick, Fredericton, NB

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Co-authors: John E Hughes Clarke, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The growth of any delta is controlled by the available sediment flux from the feeder fluvial system. The manner in which that sediment moves through the tidally- influenced estuarine channels on the delta top will influence the mechanism of growth and collapse of the delta lip. This study addresses channelized delta top sediment transport on the Squamish Delta in Howe Sound, BC.

The termination of the Squamish River consists of a single channel that flows between flanking intertidal sand bars and over a mouth bar at the lip of the delta. There is a 3-5m tidal range that strongly modulates the flow in the channel and over the adjacent intertidal sand banks. The channel depth at low water ranges from 0.5 to-2m and thus multibeam surveys can only be carried out at high water. The delta front is growing rapidly with about 1 million m^3 of sediment being input from the river system annually.

In 2011, the delta top channel was surveyed every 3-4 days at high water, over a period of 4 months during which the river discharge waxed and waned and the tides ranged from springs to neaps. In 2012 and again in 2013, the channel was surveyed daily over a week while the tides increased from neap to springs. The multibeam data capture the instantaneous expression of both the long wavelength channel shape as well as the superimposed bedforms distribution (as preserved at high water). While the long wavelength shape changes over a time scale of about a week, it was clear that the individual bedforms could not be correlated from one tide to the next.

Preliminary observations off the delta lip clearly demonstrate that the current speeds on the delta top were strongly modulated by the tide, ranging from almost stationary at high water to in excess of 5 knots at low water. To quantify the bed shear stress associated with this modulation, a 3D hydrodynamic model was built to predict the flow within the river, the delta top, and adjacent fjord over the complete tidal cycle. This clearly shows that the sediment flux is dominated by the low water period when the off-delta flows are strongest. The peak intensity of those flows is in turn modulated by the spring-neap cycle. This matches complementary work using repetitive multibeam off the delta lip that shows that mass wasting on the delta front is highly correlated with the spring tide and low tide periods.

Abstract ID: 34428

Final Number: OS32A-05

Title: Evidence for Subglacial Meltwater Floods Through the Lake Ontario and Eastern Lake Erie Basins

Presenter/First Author: Michael C F Lewis, Geological Survey of Canada Atlantic, Dartmouth, NS

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Co-authors: Brian J Todd, Geological Survey of Canada Atlantic, Dartmouth, NS, Canada

Published Material: Partial results for Lake Ontario and Lake Erie separately were presented in NE Geological Society of America section meeting, 1996, Buffalo NY; Geological Society of America meeting, 1998, Toronto; and International Association of Great Lakes - Great Lakes Conference 1999, Cleveland OH. The complete interpretation of subglacial floods affecting Lake Ontario through eastern Lake Erie with connecting onshore evidence at 13.5 (16.2 cal) ka and ending at the cross-lake Norfolk Moraine is unique to this presentation. These findings and interpretation are not under review elsewhere, and have not been submitted to a scientific journal.

Abstract Body: Lakebed relief in deep water of eastern Lake Ontario, portrayed in conventional hydrographic charts, is dominated by linear WSW-trending ridges. The ridges had been interpreted variously in the early 1990s as Holocene fault scarps, and as streamlined glacial landforms. A multibeam sonar survey confirmed the trend of lakefloor relief, but showed that individual ridge features were not as long or as continuous as previously thought. The features are distinct, long (up to 6 km), narrow (100s m wide), subparallel ridges which stand up to 30 m above the surrounding lakefloor, and closely resemble erosional drumlins. Seismic reflection profiles indicated the ridge material is characterized by incoherent internal reflections and rests on a continuous unfaulted bedrock reflector. A piston core recovered stony, sandy diamicton (till), confirming the glacial origin of the relief-forming drumlins, and showed that they are draped with glaciolacustrine and postglacial lake sediments. The till is absent in places between ridges, suggesting the drumlins were formed by erosion from a former till sheet, and were probably sculpted by erosive subglacial flows of meltwater. Onshore digital elevation models reveal drumlins in the same orientation, suggesting the erosive meltwater flows continued WSW into the northern part of the eastern Lake Erie basin where seismic profiles and a borehole reveal an absence of till, except for thin remnants, and glaciolacustrine sediments resting directly on bedrock. This unconformable sequence terminates westward at the cross-lake Norfolk Moraine. An extensive cover of till remains atop a 45m-high bedrock escarpment in the southern part of the eastern Erie basin suggesting an ice cover was pinned there during the subglacial flows. Constraining chronological data indicate that these subglacial meltwater flows, which were effective agents in shaping lake bathymetry and land topography, occurred about 13.5 (~16.2 cal) ka.

Abstract ID: 34042

Final Number: OS33A-02

Title: Wave scattering by randomly distributed ice floes: diffusion approximation

Presenter: Hayley H Shen, Clarkson University, Potsdam, NY

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First Author: Xin Zhao, Clarkson University, Potsdam, NY

First Author Email: xinzhao@clarkson.edu

First Author Student?: No

Co-authors: Sukun Cheng, Clarkson University, Potsdam, NY

Abstract Body: Wave scattering by ice floes is critical to accurate prediction of ocean waves in the polar regions. Based on the Green function method, scattering from a single circular ice floe has been obtained in the past. The method consists of solving the elastic motion equations of one regular ice floe and matching the boundary conditions at the interfaces of ice and water. With the results for one ice floe, one can construct the integral kernel in the radiative transfer equation to simulate the wave scattering by an ice field. This approach is accurate but time consuming, hence difficult to implement into large scale operational wave models. We propose a simplified diffusion approximation method to calculate the radiative transfer equation for the wave scattering by randomly distributed ice floes. With this method, there is no need to calculate the integral kernel, but one additional diffusion equation for reflected waves needs to be solved. The diffusion approximation method will largely reduce the computational cost for implementing wave scattering into operational ocean wave model. The results from the diffusion approximation and the former exact method are compared for the evolution of wave directional spectra into an ice cover.

Abstract ID: 34166

Final Number: OS33A-03

Title: Sensitivity analysis of the viscoelastic wave-in-ice model

Presenter/First Author: Jingkai Li, Clarkson University, Potsdam, NY

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Co-authors: Sumona Mondal, , , ; Hayley H Shen, Clarkson University, Potsdam, NY

Abstract Body: In response to Arctic ice reduction, wave models have begun improving their capabilities for the ice covered waters. To study wave propagation under ice covers, the mechanical behavior of the ice cover needs to be modeled. A viscoelastic model has been proposed, which can reproduce all previous model results under appropriate limiting conditions, hence is a candidate for describing various ice conditions present in the marginal ice zone. Two material parameters contained in the viscoelastic model are the shear modulus and the viscosity which need to be inversely determined from field data. Thus it is necessary to know the sensitivity of the model on its parameters under different field conditions. In this study, the sensitivity analysis is performed using Latin Hypercube sampling and the analysis of variance technique. It provides the information on how significant the parameters and parameters' interactions are to the complex wave number and how the model behaves under different plausible wave and ice cover conditions. Implications of the model behavior to the effectiveness of using an inverse method to predict the model parameters are discussed. These implications are also verified by utilizing field data and a brute force search on the viscoelastic model to

determine the model parameters. The same sensitivity analysis of a simpler viscoelastic model is performed too. Such studies can be helpful in informing the design of field campaigns that aim to characterize and measure these parameters. The method used is general. It may be applied to test other models of wave-in-ice as well as models in other fields.

Abstract ID: 34628

Final Number: OS33A-04

Title: Characterizing the behavior of gravity wave propagation into a floating or submerged viscous layer

Presenter/First Author: Sukun Cheng, Clarkson University, Potsdam, NY

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Co-authors: Hayley H Shen, Clarkson University, Potsdam, NY

Abstract Body: Due to the reduction of sea ice cover, wave activities have increased in the Arctic region. There is a need to expand the current global wave models to this partially ice covered region. Ice covers change dynamically in response to the wind, wave, and ocean current forcing. Their mechanical properties also change corresponding to their physical composition. A viscoelastic sheet has been recently proposed to model different types of ice cover. In this model, two parameters are used to reflect both the elastic and viscous properties of a deformable and dissipative ice cover. The mathematical nature of this model, which is based on simple linear waves and a simple linear viscoelastic constitutive law, turns out to be very complicated. There are multiple modes co-existing in the resulting dispersion relation. To help understand the physical meaning of this model, we compare it with studies conducted in wave propagation through a mud floor. This problem has a substantial body of literature. The difference between water wave through an ice cover and through a muddy floor is that one deals with a floating material and the other with a submerged material. The mathematical structure and solution procedures are very close to each other. In this work we report the comparison of these two different problems. We show the differences and similarities between them and investigate if phenomena found in one are also present in the other.

Abstract ID: 34659

Final Number: OS33A-05

Title: Characteristics and changes of sea-ice floe size distribution in Chukchi and Beaufort Seas in fall 2014

Presenter/First Author: Yu Wang, Clarkson University, Potsdam,

Presenter/First Author Email: ywang@clarkson.edu

Co-authors: Benjamin Holt, NASA Jet Propulsion Laboratory, Pasadena, CA; William Rogers, Naval Research Laboratory, Stennis Space Center, MS; Jim Thomson, University of Washington, Seattle, WA; Hayley H Shen, Clarkson University, Potsdam, NY

Abstract Body: Incoming wave fields impact sea ice floe size distribution, which may further impact sea ice melt rates and ice growth.In the changing Arctic, the presence of surface waves and properties of surface waves are changing due to the increase in open water fetch. We use fine resolution satellite data from MEDEA and LandSAT8, which have resolutions of 1m and 15m, respectively, to determine floe size distribution and floe geometry with image processing techniques during a period in August and September 2014 in the Chukchi Sea and Beaufort Sea. Changes in floe size and floe geometry are examined before, during and after a wave event observed by SWIFT buoys.The cumulative floe size number distribution $N(d)$ is introduced to depict the floe size distribution, where N is the number of floes per unit area that are no smaller than diameter d. The result shows that $N(d)$ follows an approximate power law.To determine the underlying power law without the effect of a truncation error, a modified cumulative floe size distribution is obtained.Changes of the floe size distribution are evaluated before and after wave events.

Abstract ID: 35904

Final Number: OS33A-07

Title: Impact of multidecadal Atlantic meridional overturning circulation variations on the Southern Ocean

Presenter/First Author: Liping Zhang, Princeton University, Plainsboro, NJ

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Co-authors: Thomas L Delworth, NOAA, Boulder, CO

Abstract Body: The impact on the Southern Ocean (SO) of multidecadal variations of the Atlantic Meridional Overturning Circulation (AMOC) is investigated using a suite of simulations with a coupled ocean-atmosphere model. We find that the AMOC can influence the SO via two primary pathways: (a) a slow ocean pathway, and (b) fast atmospheric teleconnections. On multidecadal timescales, a stronger than normal AMOC leads to a weaker than normal column averaged south-north density gradient in the ocean between the North Atlantic and the Southern Ocean. This leads to a weakening of deep convection in the Southern Hemisphere (SH) and the Antarctic bottom water (AABW) cell. The spin down of the AABW cell leads to subsurface warming and surface cooling in the SO. The SO cooling could feedback to the overlying atmosphere, inducing intensified westerly winds and thus a strengthened Deacon cell. The westerly wind response further amplifies the initial SO surface cooling by enhanced latent heat loss and through northward Ekman transport, forming a local positive air-sea feedback. In terms of atmospheric teleconnections, warming of the tropical North Atlantic (TNA) due to a strengthened AMOC can directly trigger propagating atmospheric Rossby wave trains to the SH, inducing a low pressure response over the SO and thereby cooling the near-surface ocean. The TNA warming also contributes to a La Niño-like SST cooling over the tropical Pacific Ocean. This influences the SO via the Pacific South Atlantic teleconnection pattern, thereby inducing low atmospheric pressure and cooling of the upper ocean in the SO over the Amundsen Sea region. The opposite is also true when the AMOC weakens. The strong linkage between the AMOC and SO variability on multidecadal time scale has implications for understanding the causes of the recent SO cooling. Our study here suggests that evaluating the causes of recent SO variability should take into consideration not only local processes but also remote forcing from AMOC variations.

Abstract ID: 36468

Final Number: OS33A-08

Title: Investigation of Intertidal Flats with Multiple Freuqency Fully-Polarimetric SAR (Synthetic Aperture Radar)

Presenter/First Author: Wooil M Moon, University of Manitoba, Winnipeg, MB

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Co-authors: Junjun Yin, Tsinghua University, Beijing, China; Duk-Jin Kim, Seoul National University, Seoul, South Korea; Kyung-Ae Park, Seoul National University, Seoul, South Korea

Published Material: The material to be presented is a progress report of an on-going research project. Thus, some of the material was published in refereed journal and also presented at CGU conference in May 2014. But the material to be presented will be mostly new obtained from the newly acquired ALOSand ALOS-2 PALSAR data over the study areas.

Abstract Body:

Abstract ID: 34182

Final Number: OS34A-0242

Title: Holocene Mass Movements in a Canadian High Arctic Lake, East Lake, Melville Island

Presenter/First Author: Alexandre Normandeau, Université Laval, Québec, QC

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Co-authors: Gabriel Joyal, , , ; Patrick Lajeunesse, Université Laval, Québec, QC, Canada; Pierre Francus, Inst Nat Recherche Sci, Québec, QC, Canada; Scott F Lamoureux, Queen's University, Kingston, ON, Canada; François Lapointe, Inst Nat Recherche Sci, Québec, QC, Canada

Published Material: The same abstract will be presented at the conference: Submarine Mass Movements and Their Consequences in New Zealand. The results are under consideration for the publication in the conference book.

Abstract Body: East Lake, located at Cape Bounty (Melville Island, Canadian High Arctic), was mapped using a high-resolution swath bathymetric sonar and a 12 kHz sub-bottom profiler, allowing imaging for the first time the widespread occurrence of mass movement deposits (MMDs) in a High Arctic Lake. MMDs are mostly located on steep slopes not influenced by high sedimentation rates. The marine to lacustrine transition in the sediment favours the generation of mass movements where the underlying massive mud appears to act as a slip surface for the overlying varved deposits. Based on acoustic stratigraphy and backscatter intensity data, we have identified at least 2 to 3 events that triggered failures in the lake during the last 2000 years. Based on the proximity of the lake to the Byam-Martin Seismic Zone, the location of the MMDs far from sediment input and the possible correlation between a turbidite layer in a sediment core and a recorded earthquake, seismicity could be responsible for sediment failures in the lake basin.

Abstract ID: 36718

Final Number: OS34A-0243

Title: Geomorphology of seismically-induced mass-movements in lakes of south-central Québec

Presenter/First Author: Annie-Pier Trottier, Laval University, Quebec,

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Co-authors: Patrick Lajeunesse, Université Laval, Québec, QC, Canada; Alexandre Normandeau, Université Laval, Québec, QC, Canada; Antoine Gagnon-Poiré, Université Laval, Québec, QC, Canada

Abstract Body: Although Late-Quaternary sediments in lakes located within or near the Charlevoix-Kamouraska and Western-Québec seismic zones are known to have been intensely remobilized by seismic event since deglaciation, postglacial mass movements in lakes of southern Québec inundated by the Champlain Sea and located more than 70 km from these seismic zones remain poorly documented. Recent high-resolution swath bathymetry and acoustic stratigraphy surveys undertaken in four lacustrine basins of south-central Québec (lakes St-Joseph, Aux-Sables, Mékinac and Maskinongé) revealed the widespread occurrence of mass movement deposits and morphologies associated with postglacial seismic activity. Swath bathymetry data at a resolution of 0.5 to 1 m allows the observation in great detail of various morphologies associated with mass movements, such as failure scarps, lobe-shaped deposits, hummocky surfaces, compression ridges and gullies. Subbottom profiles and sediment core data show many rapidly deposited layers which have been dated to ~1000 years BP in Lake Maskinongé, ~915 years BP in Lake-aux-Sables and ~760 years BP in Lake Saint-Joseph. Our results indicate that at least one seismic event triggered mass movement in these four lakes during the last ca. 1000 years. Further analysis and dating of sediment cores will allow determining whether these mass movement deposits recorded the same regional seismic event or different events related to different seismic zones.

Abstract ID: 36441

Final Number: OS34A-0244

Title: Lacustrine Geomorphology and Sedimentary Processes in the Eastern Arm of Manicouagan Reservoir, Québec

Presenter/First Author: François-Xavier L'Heureux Houde, Université Laval, Québec, QC

Presenter/First Author Email: francois-xavier.lheureux-houde.1@ulaval.ca

Co-authors: Patrick Lajeunesse, Université Laval, Québec, QC, Canada

Abstract Body: High resolution multibeam bathymetric and sub bottom profile data were acquired for the first time in 2014 in former Lake Manicouagan, a 60 km long and 3 km wide fjord-lake located in the eastern half of the Manicouagan crater, that is now submerged under 135 m of water in the Manicouagan hydroelectric reservoir. The acquired multibeam echosounder data allowed the production of a complete and full-bottom coverage bathymetric map of the lake area before its flooding at 5m-pixel resolution. This new data provides an invaluable opportunity to analyse the Late Quaternary evolution of this large and deep lacustrine basin and the geomorphological impacts of the recent rapid and high amplitude rise in lake level. Multibeam data allowed the observation of disintegration moraines, sublacustrine fans, gullies, mass movement deposits and crescent-shaped bedforms as well as preserved river beds, fluvial terraces, deltas and strandlines flooded after the construction of the Manic-5 (Daniel-Johnson) Dam in 1970. The multibeam data is complemented by 3.5 and 12 kHz subbottom profiles and short coring samples. Our data suggest that the flooding of the crater basin generated widespread sediment failures in the deglacial and postglacial sedimentary units along the steep slopes of former fjord-lake Manicouagan. The new bathymetric data also allows identifying Lake Manicouagan as one of the deepest lake of eastern North America, which reached 315 m in depth before its flooding.

Abstract ID: 36518

Final Number: OS34A-0245

Title: Late Quaternary Evolution of Fjord-Lakes Pentecôte, Walker and Pasteur (Québec North-Shore, Eastern Canada)

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Abstract Body: High-resolution bathymetric data acquired using a multibeam echosounder and an interferometric side-scan sonar in 2011

and 2014 allowed mapping the sublacustrine geomorphology of three fjord-lakes of the Québec-North Shore region (eastern Canada) for the first time. Detailed bathymetric maps with a 1 to 3 m resolution produced during these surveys allowed the observation of deep V-shaped bedrock valleys, morainal banks, deep and circular depressions (kettles?), disintegration moraines, slide scars, mass movement deposits and crescent-shaped bedforms. These lakes, located near Younger Dryas morainic systems, were flooded during the Goldthwait Sea postglacial marine transgression and contain sedimentary archives that recorded paleo-environmental changes that have occurred since the last glaciation. Acoustic sub-bottom profiles acquired using a bi-frequency Chirp echosounder (3.5. & 12 kHz), together with sediment core data, reveal the presence of six sedimentary units: bedrock and/or ice-contact sediments (U1), glaciomarine silts and clays (U2), rhythmically laminated silts and clays, possibly varves (U3), mass movement deposits (U4), fluvial deposits (U5) and organic-rich postglacial sediments that contain series of rapidly deposited layers (U6). This poster unveils the results of these underwater mapping surveys and demonstrates their significant contribution to the understanding of Quaternary geological evolution and sedimentary records of deep formerly glaciated lacustrine basins.

Abstract ID: 35115

Final Number: OS34A-0246

Title: High-resolution near-shore geophysical survey using an Autonomous Underwater Vehicle (AUV) with integrated magnetometer and side-scan sonar

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Co-authors: Joe I Boyce, McMaster University, Hamilton, ON, Canada

Published Material: less than 25% of content reported in oral presentation at SHA conference 2014

Abstract Body: Autonomous underwater vehicles (AUVs) give many advantages over traditional boat-towed survey methods, including the ability to operate under most sea states, and the ability to collect data at very high spatial resolution, which is a significant benefit for archaeological investigation. Integration of magnetometer sensors on AUVs has been problematic due to the magnetic interference produced by the AUV thrusters and electronics. In this study, we evaluated an AUV-deployed magnetic survey system consisting of an Overhauser magnetometer (Marine Magnetics *Explorer*) mated to a portable AUV (OceanServer *Iver2*). To eliminate magnetic interference from the AUV, the magnetometer was tethered to the AUV with a 5m tow cable, as determined by static and dynamic instrument testing, which indicated no detectable magnetic influence at this distance. The system was evaluated in a survey collected over a shallow water test area in Lake Ontario near Toronto, Canada and compared directly with the results of a conventional boat-towed magnetic survey. The AUV magnetic data have equivalent long-wavelength accuracy to the boat-towed data as determined by tie-line error analysis. The AUV data were shown to have less high frequency noise, and were able to identify a number of small ferromagnetic targets that were undetected in the boat-towed magnetic data.

Abstract ID: 35114

Final Number: OS34A-0247

Title: Landform-sediment assemblages in a fjord and cross-shelf trough system: Scott Inlet and Trough (NE Baffin Island, Canada)

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Co-authors: Patrick Lajeunesse, Université Laval, Québec, QC, Canada

Published Material: The results were presented in the Artic Change 2014 meeting. They are not under review neither in any journal.

Abstract Body: Multibeam echosounder, subbottom profiler and sediment core data acquired since 2003 by the CCGC Amundsen together with seismic records and core samples from the Geological Survey of Canada allow the reconstruction of Late-Quaternary ice flow and glacial history in the fjords and cross-shelf trough of the Scott Inlet area (northeastern Baffin Island, Arctic Canada). These combined datasets also provide a great opportunity to document a high-latitude fjord-to- continental slope glacial landsystem that has been strongly influenced by ice streaming during the last glacial episode.

The study area can be divided into two physiographic regions: the Clark and Gibbs fjords and the Scott cross-shelf trough. In the fjords, multibeam mapping reveals a morphology that alternates between sills (bedrock or morainic) and sedimentary basins, with the presence of moraines from the side valley glaciers. Offshore Scott Inlet, a deep (800 m) and large (30 km) cross-shelf trough incise the continental shelf. This trough is characterized by traces of a large paleo-ice-stream with an onset zones located off Clark and Gibbs fjords. Five sedimentary units have been identified on the seismic data: 1- A basal unit with a non-penetrable reflector that can be either bedrock or a basal till; 2- A unit with a series of parallel horizontal high amplitude reflections (observed in Clark Fjord); 3- A semi-transparent unit having little or no parallel reflections (Davis Strait silt); 4- A transparent unit corresponding to hemipelagic deposits that is present in the shelf trough (Tiniktartuq mud); 5- A series of parallel horizontal high amplitude reflections interpreted as estuarine sedimentation.

During the last glaciation, the Scott cross-shelf trough favored the formation of an ice-stream that extended upstream into the inner sections of Clark and Gibbs transferring large volume of glacial ice and glacigenic sediments to the continental slope to form an extensive trough-mouth fan. Deglaciation of the continental shelf from a late Foxe glacial maximum was completed by 15 ka BP. Ice retreat within the fjord occurred by steps as moraines sills represent periods of ice stabilisation during deglaciation. Ice retreat to the fjord heads is thought to have been completed by 8-9 ka BP. Sedimentation similar to present-day conditions have then been reached.

Abstract ID: 35124

Final Number: OS34A-0248

Title: Seismic Stratigraphy Since the Late Miocene of the Near Shore New Jersey Margin Between Barnegat and Manasquan Inlets, New Jersey

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Co-authors: Gregory S Mountain, Rutgers Univ, Piscataway, NJ

Abstract Body: In the summer of 2013, researchers from Rutgers University and the New Jersey Geological and Water Survey conducted 590 km of boomer seismic profiles 0-6 miles off the NJ coast between Barnegat and Manasquan Inlets. In the fall of 2014, 30 vibracores were taken to determine stratal relationships correlated to the seismic data. The seismic data show three main depositional units. The oldest unit is comprised of Upper Miocene fine quartz sand and silt with occasional interbedded clay layers, and characterized by prominent parallel reflectors that dip southeast. These strata are capped by an erosional surface that dips south-

southeast and crops out at the seafloor near the northern extent of the survey area. This surface is overlain by as much as 20 m of complexly arranged Pleistocene gravels, sands and silts with irregular reflectors traceable for distances of only 0.5 km or less. NE-trending Holocene ridges detached from the shoreface comprise the third and youngest depositional unit. Most ridges are isolated elongate features 5-10 km long and 1 km wide. All rest on a level reflector separating them from Pleistocene strata in most of the survey area, and from Miocene strata along the northern limit. The ridges are relict late-Pleistocene light grayish-white, well-sorted, fine-grained quartz sand deposited during periods of episodic sea level rise since the last glacial maximum and reworked by present day hydrodynamics. The parallel dipping reflectors of the Miocene suggest continuous delta-front marine deposition. Glacially-forced post-Miocene sea-level fall cut deeply into these strata, and sediments were not preserved at this nearshore location again until Late Pleistocene. Transgression since the Last Glacial Maximum and development of the adjacent barrier island landscape has resulted in minimal new sediment contribution to the nearshore. In its absence, relict sands have been reworked into ridges under a complex interplay involving ebb-tidal deltas, storms and longshore currents.

PLANETARY SCIENCES

Abstract ID: 35968

Final Number: P11A-01

Title: Impact Melt Emplacement, Cooling, and Crystallization in the Sudbury Igneous Complex

Presenter/First Author: C Michael Lesher, Laurentian University, Sudbury, ON

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Published Material: The last part was presented at the 2014 GAC-MAC meeting. This ties things together with the first two parts.

Abstract Body: Models for emplacement of mineralized quartz diorite dikes and cooling/crystallization of the Main Mass of the Sudbury Igneous Complex suggest that the dikes were emplaced during the crater modification stage, that the Main Mass cooled slowly from a superheated state, and that the mineralization exsolved from Main Mass during crystallization. Offset dikes have inclusion- and sulfide-poor QD margins and inclusion- and sulfide-rich IQD cores, implying emplacement of IQD into the semi-molten cores of QD dikes and therefore extremely rapid generation of IQD. During crater excavation impact melts are generated in a central melt pocket, injected into surrounding broken rocks, and driven upward and outward. Movement is reversed during formation of the central uplift, but returning melt is laden with fragments. Thus, it is more likely that QD was emplaced during melt excavation and that IQD formed by incorporation of fragments during formation of the central uplift. Incorporation of fragments into IQD and inclusion-rich Sublayer Norite would have rapidly cooled the melt to the liquidus. Contact ores are separated from the Main Mass by Sublayer Norite; although some sulfides may have percolated through partially-crystallized Sublayer, successively crystallizing norites would have isolated the ores from the melt, so observed depletion trends in upper norites may also reflect accumulation of sulfides in Sublayer and lower norites, not just the ore-forming process. Geochemical-petrographic data for traverses across the North and South Ranges show differences in composition across the melt sheet and that it was derived from at least two melts: 1) one that formed South Range Sublayer and Quartz-Rich Norite, and 2) one that formed overlying South Range Melanorite and Upper Norites, and North Range Mafic and Felsic Norites. Several models are being investigated: 1) inflow of melt from peripheral parts of the system (outer part of observed impact basin or a second impact basin), 2) collapse of the inner peak ring, and 3) collapse of crater walls.

Abstract ID: 33281

Final Number: P11A-02

Title: Geochemical Variation Along Strike of the Hess Offset Dyke at the Sudbury Impact Structure, Canada

Presenter/First Author: Eric Pilles, University of Western Ontario, London,

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Co-authors: Gordon Richard Osinski, University of Western Ontario, London, ON, Canada; Joshua Bailey, , , ; David Smith, , ,

Abstract Body: The Sudbury Impact Structure is a 1.85Ga impact structure located on the contact between the Superior Province Archean granite-greenstone terrain to the North and the Southern Province Huronian Supergroup to the south. The Offset Dykes extend radially outward from – and concentrically around – the Sudbury Igneous Complex (SIC), which is a ~3-km thick differentiated impact melt sheet. The Hess is the longest of the concentric Offset Dykes, with a strike length of ~60 km. It is located ~12–15km northwest from the SIC, hosted in the Superior Province. The Hess is up to 60m wide and is composed of two phases: an inclusion-poor granodiorite along the margins of the dike and an inclusion-bearing granodiorite in the centre of the dike.

There is very little difference in major element geochemistry when comparing the two phases, and only minor variations in trace elements. However, the matrix of the inclusion-bearing phase is notably enriched in light REEs compared to the inclusion-poor phase. This observed variation is minimal compared to the differences found along strike of the Hess – from the westernmost end in the Ermatinger Township to the northernmost end where the Hess intersects the Foy.

The samples closer to the west end of the dyke were more depleted in Si, K, Li, Ba, and light REEs; and more enriched in Ti, Fe, Mn, Mg, Sc, and V compared to the samples located near the Foy-Hess intersection. The samples located near the middle of the dyke show anomalous variation as well. At some locations they are more consistent with results from the west end samples, and at others they are more consistent with results from samples near the intersection. The reason(s) for these geographical variations in composition are currently being explored.

Abstract ID: 33969

Final Number: P11A-03

Title: Electron Microprobe Analysis of Sudbury Breccia from the Creighton and Coleman Mines, Sudbury Ontario: Constraints on the Extent of Hydrothermal Modification of Magmatic Footwall Ni-Cu-PGE Sulphide Mineralisation.

Presenter/First Author: Jonathan O'Callaghan, University of Western Ontario, London,

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Co-authors: Gordon Richard Osinski, University of Western Ontario, London, ON, Canada; Robert Linnen, University of Western Ontario, London, Canada; Peter C Lightfoot, Vale, Sudbury, ON, Canada

Abstract Body: The Sudbury Igneous Complex (SIC) represents the remains of a ~200-km diameter impact crater, formed 1.85 billion years ago. Ore deposits associated with the impact structure can be subdivided into

contact, footwall and offset types, and represent the end products of magmatic and hydrothermal processes. Footwall Ni-Cu-PGE deposits are hosted within zones of Sudbury breccias (pseudotachylitic), near to contact ore deposits at the margin of the SIC. Our study focuses on the application of ICP-MS and electron microprobe analyses of a suite of Sudbury breccia samples collected proximal to active mines in the North and South Ranges of the Sudbury Basin. We investigate subtle geochemical variations to mineralogy in barren and mineralised breccia matrix from different lithologies, and use this information to constrain the relative roles of magmatic and hydrothermal processes in the modification of primary Sudbury breccia and better understand the footwall ore deposits.

Our research has identified ilmenite-magnetite with titanite rims within breccia <10cm from footwall mineralisation in the McCreedy East 153 orebody at Coleman Mine. This assemblage is consistent with both high fO_2 and high fH_2O conditions. Samples from near the footwall orebodies at Creighton Mine contain heterogenous titanite that may be associated with later metamorphic alteration. In Sudbury breccia samples from Creighton mine, we also observe evidence of partial assimilation of host granite in hand-specimen and have identified two species of titanite, one showing Al/Fe substitution indicative of the presence of F-OH at the time of formation, and a second low Ti, low Al/Fe variety that may have been derived from the host granite. For the first time we also report chlorine zonation in amphibole at Creighton mine, similar to zonation features reported in the Fraser mine in the North Ranges.

Abstract ID: 35478

Final Number: P11A-04

Title: The Age of the Carswell Impact Structure

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Co-authors: Anthony N Lecheminant, , Manotick, ON, Canada; Carl Alwmark, , , ; Laurence Page, , , ; Anders Schérsten, Department of Geology, Lund University, Lund, Sweden; Ulf Söderlund, Lund University, Lund, Sweden

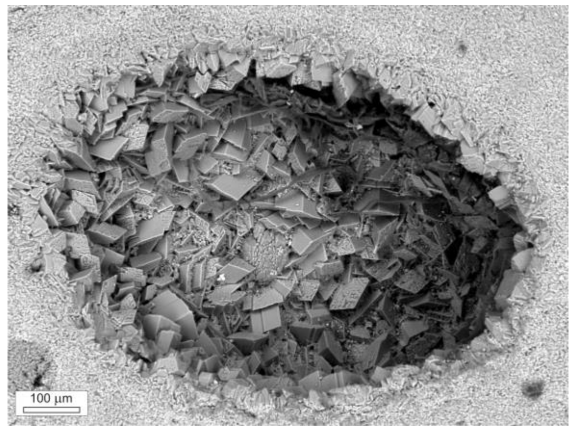
Abstract Body: A significant proportion of the ~60 confirmed and suspected impact structures in North America could be related to the Early/Middle Ordovician impact spike of L-chondrite meteorites [1]. First identified in various meteorites, and then in the stratigraphic record of southern Sweden, the onset of this event is now pegged at *ca.*470 Ma [2]. Based on numerous smaller Ordovician craters (e.g., Lockne, Brent), it is assumed that the event also resulted in a transient increase in the flux of larger fragments to Earth [e.g., 3].

Some important questions remain: 1) when was the exact onset of this event; 2) are there any big impact structures related to this event that remain in the geological record; and, if so, 3) how did the Earth system respond to these larger impacts?

In Canada, potential candidates for larger impact structures of approximately the right age are Carswell, Slate Islands, and possibly Charlevoix. None of these structures is well dated. Here we address the age of the large (~40 km) Carswell structure, which impacted the Paleo- to Mesoproterozoic Athabasca Basin of northern Saskatchewan. We have collected a suite of impact breccias from in and around the central core of the structure, ranging from fully melted and quenched melt rocks to partially melted pseudotachylites and intensely brecciated basement rocks. All contain shock features. Some of the breccias that show advanced melting contain gas vesicles formed during post-impact quenching and crystallization. These vesicles are lined with pristine quartz and adularia crystals (see image: mid-grey triclinic rhombs are adularia). It is from these pristine adularia crystals that we have obtained high-quality Ar-Ar plateau ages of 481±1 Ma. This age records the cooling and hydrothermal activity in the target area, immediately post-impact.

The precise adularia age of 481 Ma finally dates the large Carswell impact. Although we do not yet know the nature of the impactor, it appears that this large impact is remarkably close in time, but nevertheless ~5-10 Myr too old, relative to the accepted onset of the L-chondrite impact event.

References: [1] Bleeker, 2011, GAC Annual Meeting, Ottawa, Abstract vol. 34, p. 19; [2] Korochantseva et al., 2007, Meteoritics & Planetary Science, vol. 41, p. 113-130; [3] Ormö et al., 2014, Scientific Reports, vol. 4, article no. 6724.



Abstract ID: 36673

Final Number: P11A-05

Title: Examining Infrared Reflectance Spectra of Shocked and Unshocked Granites from Lake St. Martin Impact Structure: Implications for Detection on Mars.

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Published Material: Lunar and Planetary Science Conference The Woodlands Texas March 2014

Abstract Body: Evidence for granitoid rocks on Mars has been obtained through remotely sensed imagery and spectroscopic data from the central uplifts of two craters near Syrtis Major. By investigating how to identify such materials with remote sensing techniques we can enhance the ability to detect exposed granitic and granitoid outcrops on the Martian surface. In order to do so, a spectroscopic-structural-compositional study of unshocked, shocked, and melted granites has been conducted. Samples were retrieved from various locations and depths at the Lake St. Martin (LSM) impact structure in central Manitoba. The goal of this study is to relate the spectral data to shock levels in order to better understand the possible effects of shock on the detectability of granitic rocks on Mars. The LSM samples have been analyzed using Fourier transform infrared reflectance spectroscopy, X-ray diffractometry (XRD) and X-ray fluorescence (XRF) spectroscopy.

Infrared spectra of the unshocked granitic country rock have a region of enhanced reflectance between ~1250 and 900 cm^{-1} which show a number of superimposed and unresolved peaks that are consistent with the unshocked nature of these materials. The granitic melt samples have a less strongly-featured interval of higher reflectance between ~1250 and 900 cm^{-1} which can be explained by the amorphization of silicates through shock. The shocked but unmelted samples have spectral features that are intermediate between the unshocked and melted granites, as can be expected, with more resolvable features on the reflectance hump than the melted spectra. By relating the spectral-structural-compositional data in terms of shock and melt we can gain a better understanding of how granitic rocks respond to impact shock and the effects of impact on their detectability by various remote sensing instruments.

Abstract ID: 34199

Final Number: P11A-06

Title: New Ar-Ar Dating of the East and West Clearwater Lake Impact Structures, Québec, Canada – Evidence for Two Separate Impact Events

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Published Material: Schmieder M. et al. (2015) New $^{40}Ar/^{39}Ar$ dating of the Clearwater Lake impact structures (Québec, Canada) – Not the binary asteroid impact it seems? *Geochimica et Cosmochimica Acta* 148, 304–324.http://www.sciencedirect.com/science/article/pii/S001670371400595X Phys.org/ScienceNetwork WA: http://phys.org/news/2014-10-scientists-debunk-clearwater-lakes-formation.html; http://www.sciencewa.net.au/topics/technology-a-innovation/item/3156-scientists-debunk-clearwater-lakes-formation-theory/3156-scientists-debunk-clearwater-lakes-formation-theory Spiegel Online, Germany: http://www.spiegel.de/wissenschaft/natur/meteoriten-ort-in-kanada-wurde-zweimal-getroffen-a-996562.html (in German) Der Standard, Austria: http://derstandard.at/2000007389514/Ein-und-dieselbe-Stelle-zweimal-von-kilometergrossen-Asteroiden-getroffen (in German) University of Heidelberg News: http://www.uni-heidelberg.de/presse/news2014/pm20141027_ein-kosmischer-doppelschlag-der-keiner-war.html (in German)

Abstract Body: For 50 years, the two Clearwater Lake impact structures in Québec have been considered as a typical crater doublet formed by the impact of a binary asteroid. New $^{40}Ar/^{39}Ar$ dating of melt rocks from the ≥36 km West Clearwater Lake (WCL) impact structure yielded two Early Permian plateau ages with a weighted mean age of 286.2 ± 2.2 (2.6) Ma (2σ; MSWD = 0.33; P = 0.57). $^{40}Ar/^{39}Ar$ results for two chloritized melt rocks from the ~26 km East Clearwater Lake (ECL) impact structure produced age spectra suggestive of extraneous argon. The age spectra corrected for the trapped argon component and inverse isochron plots consistently yielded ages around ~460–470 Ma for ECL, reproducing the $^{40}Ar/^{39}Ar$ results by Bottomley et al. (1990) and contradicting an earlier Rb–Sr age of 287 ± 26 Ma. The Ar-Ar dates obtained from four different melt samples across the melt sheet favor an Ordovician age for the ECL impact and impact-induced hydrothermal overprint. WCL and ECL, moreover, show different natural remanent magnetizations indicating separate geologic histories. Whereas WCL has no resolvable geochemical impactor traces, the ECL melt rocks carry a strong (possibly L-) chondritic impactor signature. The WCL impact affected a thin layer of Ordovician target carbonates; such rocks are absent in the ECL impact breccia, which is overlain by >100 m of post-impact sediments. Biostratigraphic dating of the fossil-poor post-impact deposits at ECL is currently underway. In the light of the new $^{40}Ar/^{39}Ar$ dates and in combination with the paleomagnetic and geochemical findings, the close spatial arrangement of WCL and ECL is probably pure coincidence. The two impact structures seem to represent a 'false doublet' struck by impacts ~180 million years apart. ECL possibly represents one of several impact structures in North America and Europe potentially related to the Ordovician L-chondrite breakup event ~470 Ma ago.

Abstract ID: 35739

Final Number: P11A-07

Title: Impact-generated Hydrothermal Activity at the East and West Clearwater Lake Impact Structures

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Co-authors: Gordon Richard Osinski, University of Western Ontario, London, ON, Canada

Published Material: Preliminary results from this study will be presented at LPSC 2015.

Abstract Body: The Clearwater Lake complex is located in northern Quebec, Canada (56°10 N, 74°20 W). Originally thought of as a double impact structure dated at ~290 Ma, recent dating re-evaluated East Clearwater to have formed at ~470 Ma. Hydrothermal alteration has previously been noted at both structures but not investigated closely. We have examined drill core samples from the impact melt sheet of East Clearwater and field samples from West Clearwater to characterize and compare hydrothermal alteration and mineralization at both impact structures. The core from East Clearwater penetrates ~45 m of the impact melt sheet. Alteration is not common in the impact melt rock as a whole and mineralization is concentrated near the top of the melt sheet in a highly vesicular zone. Cavities are filled primarily with quartz mineralization and illmenite, galena, and millerite are common throughout. Sphalerite and chalcopyrite were identified closer to the middle of the sequence whereas magnetite and hematite are more commonly seen at greater depth. Calcite appears within the vesicular zone but is also more common at greater depth. At West Clearwater quartz-filled vugs and concentrated zones of vesicles occur within the impact melt rocks. Similar to the vesicular zone within the East Clearwater melt sheet, two outcrops within impact melt rock of West Clearwater have ~2-5 m highly vesicular zones. Vesicles here are also filled with quartz, calcite, and clay minerals yet the sulphide mineralization common in East Clearwater is not immediately evident at West Clearwater. Despite differences in the overall colour of the impact melt rocks at these locations the amygdales at both outcrops have pink, red, and dark purple haloes from their rims up to twice the diameter of the amygdale at the centre. A striking difference to East Clearwater however is the pervasive alteration evident in the impact melt rocks with their overall red colouration. The differences in colour between the impact melt rocks and the localised zones around the filled vesicles might represent different episodes of alteration. Further geochemical and fluid inclusion studies will be carried out to characterize the possible origin and evolution of the hydrothermal system generated by the impacts at this site.

Abstract ID: 35697

Final Number: P11A-08

Title: Geophysical Investigation of Charity Shoal Structure: A Suspected Impact Crater in northeastern Lake Ontario

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Published Material: magnetic results presented at Large Impact 2013

Abstract Body: The Charity Shoal structure (CSS) is a 1.4 km diameter, 20 m deep circular basin located northeastern Lake Ontario. The CSS has been interpreted as an Ordovician-age meteorite impact based on multi-beam imaging of the lakebed but details of the crater's subsurface structure were unknown. In 2011 detailed magnetic and sub-bottom chirp seismic (>400 line km) surveys were conducted across a 9-km^2 area of Charity Shoal to investigate its subsurface structure. In 2014, a boomer seismic (1-2 kHz) survey was conducted over the same area to image the basin fill.

Total magnetic intensity (TMI) data reveal a large (>1400 nT) magnetic anomaly centered over the crater basin and a ring-like magnetic high (40-50 nT) corresponding with the basin rim. Depth to basement below the structure was estimated at ~600 m using extended Euler deconvolution. Forward 2-D models verify that the observed TMI anomaly requires a deep (>450 m) depression in Precambrian basement or a source body (e.g. diatreme) with a remanent magnetization opposing the main field. Boomer seismic profiles revealed >60 m of stratified glacial/post-glacial sediments overlying Paleozoic limestone bedrock. Apparent offsets in the bedrock surface may indicate the presence of high-angle faults. Magnetic and seismic results are not consistent with formation of the CSS as a shallow glacial erosional or karst feature or an early postglacial (Younger Dryas) impact event as proposed in previous work. Modelling and geophysical results are most consistent with an origin as a diatreme or pre-Paleozoic meteorite impact in the Precambrian basement.

Abstract ID: 34605

Final Number: P12A-01

Title: Reconstruction of shock conditions and recovery paths in shock melt veins and pockets in martian and chondritic meteorites

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Co-authors: Chi Ma, California Institute of Technology, Pasadena, CA; John R Beckett, California Institute of Technology, Pasadena, CA; George R Rossman, Caltech, Pasadena, CA

Published Material: Discovery of bridgmanite, the most abundant mineral in Earth, in a shocked meteorite, O. Tschauner, C. Ma, J. Beckett, C. Prescher, V. Prakapenka, G.Rossman, Science 346, 110-1102, DOI: 10.1126/science.1259369 (2014)

Abstract Body: Recent advancements in micro-diffraction analysis in combination with SEM- and EPM-based chemical analysis provide us with a rapidly increasing set of high-pressure metamorphic minerals that occur in shocked meteorites. This includes bridgmanite (1), ahrensite (2), tissintite (3), liebermanite (4) and others. I will briefly introduce the methodology of synchrotron-diffraction/spectroscopy based identification and characterisation of shock-generated high pressure minerals. Then I will show how the high-pressure mineral paragenesis, their spatial distribution, and constraints from shock-physics provide us with surprisingly narrow constraints for peak shock conditions, and shock release paths (in P-T space). Finally, I will address the issue of shock duration in martian meteorites such as Tissint and in ordinaray chondrites.

1: Discovery of bridgmanite, the most abundant mineral in Earth, in a shocked meteorite, O. Tschauner, C. Ma, J. Beckett, C. Prescher, V. Prakapenka, G.Rossman, Science 346, 110-1102, DOI: 10.1126/science.1259369 (2014); 2: Chi Ma, Oliver Tschauner, John R. Beckett, Yang Liu, George R. Rossman, Stanislav V. Sinogeikin, Jesse S. Smith, Lawrence A. Taylor, Geochim Cosmochim Acta #082614, in revision; 3: IMA No. 2013-027, 4: IMA2013-128

Abstract ID: 36132

Final Number: P12A-02

Title: Volatile Elements in the Tissint Meteorite: Evidence for a Geochemical Signature for Martian Near-surface Alteration Preserved in Shock-generated Melt Pockets.

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Co-authors: Christopher D K Herd, University of Alberta, Edmonton, AB, Canada; Erin L Walton, Grant MacEwan University, Edmonton, AB, Canada; Yang Chen, JPL/NASA/Caltech, Pasadena, CA; Yang Liu, , ,

Published Material: Results from this work will be presented at the Lunar and Planetary Science Conference in March, 2015.

Abstract Body: Tissint contains an abundance of shock-generated melt glass formed by a variety of mechanisms including grain-boundary frictional melting, concentration of shockwaves along boundaries of minerals with contrasting shock impedance, and void collapse. Four shock melt pockets containing glass were analyzed by EPMA and SIMS. Melt pockets analyzed are basaltic in composition, consistent with the melting of local igneous phases; no excesses of P, Cl, or F are observed that could indicate a melted regolith component. H_2O content within glass ranges from <100 ppm to several thousand ppm. Cl exhibits a strong correlation with H_2O in shock melt glass, suggesting that Cl followed H_2O when introduced into the rock. This strong correlation is not observed for H_2O and F or P; H_2O and Cl concentrations within Tissint glass cannot be explained by melting igneous apatite and are most likely a remnant geochemical fingerprint of aqueous processes affecting the rock near the Martian surface after the rock's igneous crystallization. δD for Tissint melt glass exhibits a negatively-sloping trend against $1/H_2O$, indicating a mixing line between two reservoirs. High δD values for these reservoirs are consistent with Martian sources of water such as the crust and atmosphere and suggest an absence of terrestrial contamination. In one melt pocket, H_2O concentration decreases and δD increases when approaching a vesicle; this may be a function of prolonged cooling that allowed H_2O time to devolatilize to the vesicle before quenching completed after the peak shock wave passed. Conditions of melt pocket formation may contribute to local-scale variations in shock melt composition: void collapse is the most likely mechanism to trap alteration products as these materials would be concentrated in voids within the pre-shocked rock. Volatiles in these voids also contribute to preferential melting by suppressing the local solidus. It appears that some shock melt pockets in Tissint contain a geochemical signature characteristic of Martian alteration products, preserved primarily in H_2O and Cl concentrations. The distribution of such melt pockets is likely heterogeneous as the precursors to these melt pockets (voids and cracks hosting alteration products) were

likely heterogeneously distributed in the rock prior to shock melting induced by impact.

Abstract ID: 36720

Final Number: P12A-03

Title: Characterization of Mineral Assemblages Associated with Shock Veins in L5 Chondrite Dhofar 1970

Presenter/First Author: Sabrina McCarthy, MacEwan University, Edmonton, AB

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Abstract Body: The purpose of this research was to investigate a previously unstudied L5 chondrite, Dhofar 1970, available through loan from the University of Alberta Meteorite Collection. Dhofar 1970 was strongly affected by shock metamorphism, which caused small volumes of the rock to melt, forming a complex network of 10-1200 µm thick shock veins and isolated shock melt pockets. This study focuses on characterizing the composition and microtextures of minerals associated with Dhofar 1970 shock veins. Using a combination of optical microscopy, SEM, EMPA and Raman spectroscopy, the following minerals were identified: olivine, ringwoodite, jadeite, maskelynite, majorite and magnesiowüstite. Deformation in host rock minerals, including complete transformation of plagioclase to maskelynite, classify Dhofar 1970 as S6 or very strongly shocked. Majorite, observed as 1-3 µm size equant crystals has co-crystallized with magnesiowüstite from the shock melt. When compared to published experimental work on mineral stability and identical mineral assemblages in shock melts of other well-studied chondrites, this assemblage indicates Dhofar 1970 experienced a pressure of 18-25 GPa and temperature of 2000-2400 ^{o}C during impact collision. This estimate of shock conditions is significantly lower than estimates of ~55-75 GPa derived from the shock classification for ordinary chondrites. This discrepancy is attributed to the shorter duration of shock recovery experiments compared to those experienced by naturally shocked rocks and by reaction kinetics which are greatly enhanced close to hotter portions of the rock within and adjacent to the shock veins. Round clasts within the shock vein were also documented, with Fe-rich ringwoodite rims and Fe-poor olivine cores. Identical textures reported from Peace River and Y-74445 chondrites were interpreted to have formed by fractional crystallization. The textures documented in this study support solid-state transformation, which requires longer time for diffusion of Fe-Mg between ringwoodite and olivine.

Abstract ID: 35293

Final Number: P12A-04

Title: Shock Processes in Solar System Zircon

Presenter/First Author: Desmond Moser, Western University, London, ON

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Published Material: This is an invited talk that is a mixture of unpublished results (50%) and an overview of data presented at Goldschmidt 2013 in Florence and the Large Impacts workshop in Sudbury in 2013.

Abstract Body: Zircon is an extremely durable and refractory phase, now known to survive intense shock metamorphism, tectonic recycling and the erosion of continents and craters. It occurs throughout the Earth's lithosphere, and is increasingly being studied in returned or meteoritic samples of crusts of the Moon, asteroids and, most recently, the ancient highlands of Mars. This expansion to extraterrestrial materials has partly been driven by advances in electron microscopy that allow precise mapping and contextualization of grains as small as one micron in polished thick sections, techniques such as EBSD that afford mapping of lattice orientations, misorientations and high pressure polymorphs in micro-grains at angular and spatial resolutions of 0.2 degrees and 50nm, respectively, and the parallel advances in micro- to nano-scale isotopic analysis by SIMS, laser methods and atom probe tomography (APT). In this talk I will present examples of the growing diversity of shock processes recorded in zircon chemistry and/or microstructure from a range of deformation-temperature pathways experienced by inner solar system samples. Case studies will include; the ~250 km wide Vredefort impact structure, a natural laboratory for terrestrial shock processes in accessory minerals across a gradient of ~1000 degrees and 60 GPa where some zircons record the entire shock loading and unloading sequence, lunar zircons from Apollo and meteoritic samples that show features analogous to those at Vredefort, the 4 Ga population of meteorite NWA 7475 now being explored as our first zircons from the martian regolith, as well as shock-generated zircon in melt bodies on Earth and proximal to launch-melt pockets in 180 m.y. shergottite. The full potential of zircon as a recorder of the nature and timing of shock metamorphic processes is yet to be realized, and its future role will be discussed with regard to improving early bombardment chronologies that relate to the evolution and habitability of planetary crusts.

Abstract ID: 34624

Final Number: P12A-05

Title: Shock Veins in Terrestrial and Extraterrestrial Materials: Examples from the Steen River Impact Structure and NWA 8159 Martian Augite Basalt

Presenter/First Author: Erin L Walton, Grant MacEwan University, Edmonton, AB

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Co-authors: Thomas G Sharp, Arizona State University, Tempe, AZ; Jinping Hu, Arizona State University, Tempe, AZ

Published Material: A portion of this material will be presented at the LPSC conference in March 2015 (although the abstract has yet to be assigned to an oral / poster presentation)

Abstract Body: It is well documented that many meteorites contain shock veins where high temperature and high pressure minerals have been discovered. It is widely accepted that these veins are analogous to terrestrial micro-pseudotachylites, reported from only a few impact structures including Manicouagan, Ries and Vredefort. The importance of shock veins is twofold: 1) the minerals formed by crystallization from impact melt or solid-state transformation can give us a better understanding of the pressure-temperature conditions during shock, and 2) comparison between shock veins in terrestrial impact structures, where stratigraphic position within the crater is known, and shock veins in meteorites, can help provide context to impact ejection mechanisms. However, if shock metamorphism recorded in the meteorite occurred in a larger impact event prior to ejection, then comparison allows us to draw conclusions regarding the pre-ejection location on their parent body. The high pressure mineral inventory of thin shock veins from the central uplift of the 25-km diameter Steen River impact structure (SRIS) in NW Alberta and nearly identical features in a newly recognized type of martian meteorite – NWA 8159 augite basalt – have been characterized using SEM, EMPA, Raman and TEM. In the SRIS, shear-induced shock veins cut across the metamorphic fabric of a plagioclase-amphibole-biotite-quartz gneiss. Large mm-size grains of ferro-pargasite have undergone a nearly isochemical phase transformation to almandine garnet with 36% majorite component. This amphibole-garnet transformation is observed only in those grains in direct contact with the shock vein and in small fragments entrained within the vein. Likewise, plagioclase-maskelynite transformation is only observed near to the shock veins. The opaque, fine-grained, granular matrix of the shock vein contains euhedral almandine garnet with 11% majorite component and other minor phases such as

pyroxene and stishovite. The high-pressure mineral inventory of shock veins from the SRIS is similar to, but distinct from, veins in NWA 8159 where Na-rich almandine-grossular garnets (38% majorite) have crystallized with clinopyroxene (jadeite-ferroan augite s.s.) and stishovite. Shock pressure and temperature estimates for both rocks are within the range ~15–23 GPa.

Abstract ID: 35725

Final Number: P12A-06

Title: Labradoritic Hollandite in the Central Uplift of the Manicouagan Impact Structure

Presenter/First Author: Suporn Boonsue, University fo New Brunswick, Fredericton, NB

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Co-authors: John G Spray, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The mineralogy, texture and formation of new phases associated with shock veins developed in the central uplift of the Manicouagan impact structure, Canada, have been studied using micro-Raman spectrometry and analytical field emission scanning electron microscopy. The shock veins were formed in anorthositic and gabbroic gneisses as thin fracture-microfault systems during the contact/compression stage of crater formation at 214 Ma. The shock veins comprise an amorphous to nano-micro crystalline matrix, which may exhibit fluidal textures, hosting wall rock mineral fragments of hornblende, augite, plagioclase and garnet. Here we report the existence of high-pressure polymorphs of plagioclase (labradoritic-hollandite) that have been observed in natural terrestrial rocks. The chemical composition of the polymorph is $(Ca_{0.54},Na_{0.46})Al_{1.6}Si_{2.4}O_8$, which is compatible with the composition of the host rock labradorite. In many cases the labradoritic-hollandite (Lab-Holl) coexists with stishovite. The Lab-Holl displays intense Raman bands at 695-697 and 376-378 cm^{-1}, characteristic of a jadeite-structured phase with a broad band at ~997 cm^{-1}. The spectrum also consists of the superimposed Raman bands at 485 and 523 cm^{-1}, close to that of host rock labradorite (481 and 509 cm^{-1}). We suggest that the shock impedance contrast between components, and rarefaction, are responsible for shear failure or fracture and in situ shock melting of local portions of the host rock with associated crystallizing quench phases within the shock veins. The formation of high pressure phases is interpreted to be the result of the solid-state transformation of labradorite and/or direct crystallization from a labradorite melt. The development of mosaic-fractured stishovite crystals and neocrystallites of Lab-Holl with interstitial glass indicate metastable conditions in the melt veins due to the spatially and temporally heterogeneous shock process. The coexistence of the Lab-Holl and stishovite sets an upper bound for shock pressure in the shock vein to near 23 GPa.

Abstract ID: 34442

Final Number: P12A-07

Title: Manifestation of shock in plagioclase from shatter coned gneisses, Manicouagan impact structure.

Presenter/First Author: Lucy M Thompson, University of New Brunswick, Fredericton, NB

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Published Material: I have previously presented preliminary microscopy and field observations associated with this work at Charlotte GSA and 2014 LPSC. This will be the first time presenting the Raman and FESEM work.

Abstract Body: The intensity of shatter cone development within intermediate gneisses of the Manicouagan impact structure increases along a transect from 27 km through to 12 km radius from the centre. Quartz and oligoclase within the shatter coned gneisses reveal an associated increase in the intensity of recorded shock deformation from the edge of the structure towards the centre.

Quartz grains within gneisses at 27 km rarely exhibit single sets of decorated PDFs. Oligoclase exhibits minor fracturing and development of fine planar features within twins. At a 15 km radius from the centre of the structure, multiple orientation, decorated PDFs are ubiquitous within quartz grains and multiple orientation, fine scale planar features are well developed within twins in oligoclase. In thin section, the gneiss has a "cloudy" appearance, owing to the preponderance of planar features in both the plagioclase and quartz. The shatter coned gneisses at 12 km radius, are even darker in thin section. Quartz grains exhibit high densities of multiple orientation, decorated PDFs, which give the grains a "toasted" appearance. Oligoclase grains also exhibit high densities of multiple orientation planar features within twins and the development of extensive isotropic, glassy-looking domains.

Shatter cones from the anorthositic gneiss central uplift at Manicouagan, 4 km radius from the centre, exhibit fractured labradorite grains. The intensity of the fracturing increases towards shatter cone surfaces. Fine scale, multiple planar features within twins, are only manifest in labradorite grains immediately adjacent to shatter cone surfaces.

This work summarizes the results of a Raman and FESEM investigation of oligoclase and labradorite grains from shatter cones at Manicouagan. This will allow a better understanding of the mechanisms of shatter cone formation, as well as the response of plagioclase to shock. Future work will aim to further constrain and calibrate shock in plagioclase.

Abstract ID: 35267

Final Number: P12A-08

Title: Shocked Biotite in Natural and Experimental Systems

Presenter/First Author: Natalie Deseta, Wits University, Johannesburg,

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Abstract Body: Shocked anhydrous minerals (e.g., plagioclase, Kspar, quartz) has been well documented using both natural and experimental samples. The goal has been to determine the initial shock and/or shock recovery pressure under which such minerals break down as a means to estimating the shock pressure conditions incurred by impacted materials. However, the behaviour of hydrous minerals, such as biotite, under shock conditions has not been well characterized. Hydrous minerals are common constituents in terrestrial rocks, and their presence may influence the shock recovery process within the bulk rock, as both a source of shock impedance contrast and fluids in the system. Research on the high-grade metapelites of the Vredefort Dome has suggested that the breakdown of hydrous minerals such as biotite within the host rock may have been a significant source of fluids in the shocked target rock.

Shock recovery experiments, using samples of migmatitic metapelites from the Etive aureole in Scotland as an analogue for the Vredefort Dome metapelites, were carried out at the Ernst-Mach-Institut, Germany. SEM-BSE data indicate that the breakdown of biotite to release fluids facilitated shock-related deformation by explosively injecting contiguous minerals (garnet, plagioclase, kspar, quartz) with fluids, locally fracturing some and facilitating the fusion of others. The biotite itself formed shock fractures perpendicular to (001), as well as having undergone intragranular vesiculation, sintering, shredding and extreme strain localization at increasing degrees at each shock pressure tested (from 12.5, 18, 25 34, 40

to 56 GPa). Shredding of the biotite structure appears to be due to a combination of shearing perpendicular to (001) and internal shock reflections that generated complex interaction between melt and kink bands. In comparison with natural samples from the Vredefort Dome, which are thermally overprinted, the microtextures of biotite shocked from 34 GPa upwards are comparable. Whether biotite occurs as an accessory mineral or as a principal mineral in the target rock assemblage, its break down under shock is likely to be a significant source of fluids in the system and a facilitator of damage to proximal phases under high secondary shock pressures.

Abstract ID: 35540

Final Number: P12A-09

Title: Implications of a hyperboloid transient cavity model for impact craters

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Co-authors: John G Spray, University of New Brunswick, Fredericton, NB, Canada; Lucy M Thompson, University of New Brunswick, Fredericton, NB, Canada

Published Material: Findings were submitted in part as an abstract and presentation to the May 2014 Annual General Meeting of GAC-MAC held in Fredericton, N.B. Findings have yet to be submitted for review.

Abstract Body: The hyperboloid model for the transient cavity stage of terrestrial hypervelocity impact craters is based on the position of shock features in two deep drill holes spaced 200m apart at the centre of the Brent crater. In the centre ~650m of breccia emplaced during late stage collapse overlies a 40m thick melt layer that is taken as the upper section of the ~100m thick lining of the residual transient cavity. Little melt is found 200m from the centre. In both holes shock levels diminish in the underlying 60m of breccia with a high apparent rate of attenuation of shock pressure versus depth from about -50 to -20, ending at the limit of total fragmentation where the shock level is about 5-10 GPa and the attenuation drops towards -2. The hyperbolic profile that satisfies these and other constraints has an eccentricity of about 1.6 and projects to the estimated original surface to give a diameter of 3.6km and a depth of 1.05km. This form resembles small fresh lunar craters and experimental craters formed by hypervelocity impacts into sand targets. The hyperboloid form can be applied to larger complex craters with little modification indicating no fundamental change in crater mechanic s and target properties at the simple to complex transition. This has important implications for the morphology and modification processes associated with complex craters. Compared to paraboloid models the rim is more subdued and near-surface motions are at lower inclinations, thereby placing more importance on radial displacement rather than ejection and implying buckling and slumping mechanisms for the formation of rings found outside the main rim, particularly in stratified targets. These results have direct implications for the modeling and understanding of the impact cratering process and highlight differences between explosion and impact craters.

Abstract ID: 35511

Final Number: P12A-10

Title: Post-Shock Oscillatory Slip: Displacement and Vibration Melting without Offset

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Abstract Body: A series of experiments have been performed on Westerly granite using linear friction welding apparatus. For this application, two 24.8 x 47 x 63.5 mm machined blocks of the granite were brought into contact along their 24.8 x 63.5 mm faces. Westerly granite is a medium grained quartz-orthoclase-plagioclase (An<20)-biotite igneous assemblage, with accessory/secondary chlorite, clinozoisite, epidote, titanite, zircon, apatite and opaques. The friction apparatus was operated at a frequency of 20 Hz, an amplitude of 1 mm (wavelength of 4 mm), for 8.33 s, under a load of 5 kN. Total displacement was 666.40 mm and the mean velocity 80 mm/s. Following the experiment, the samples were mounted in epoxy and diamond-saw cut, and polished thins made of the slip face sections. The thin sections were examined using binocular and petrographic optical microscopes, and an Hitachi SU-70 field emission scanning electron microscope equipped with an energy-dispersive X-ray spectrometer. Oscillatory slip caused comminution and localized melting. Also, the transfer and "welding" of material occurred between the sliding faces. Two zones of damage are noted: a central partial melting zone (<300 microns wide) and a subsurface comminution/fractured zone developed either side of the slip surface (up to 50m microns wide). The partial melting zone comprises more rounded fragments, which are dominated by quartz, bonded by a submicroscopic matrix (seemingly amorphous). Biotite underwent breakdown via "bubbling" and dehydration, and has been preferentially incorporated into the melt. Orthoclase then plagioclase follow, leaving predominantly quartz with some plagioclase as clasts. Oscillatory slip may explain the production of friction melts in faults displaying negligible offset: the effective displacement can be substantial, yet the apparent slip is minimal. A scenario for facilitating this type of behaviour in nature can be sonic and subsonic vibrations associated with seismic events, including the post-shock phase of hypervelocity impact.

Abstract ID: 34876

Final Number: P13A-01

Title: Rosetta Lander – Philae: First Landing and Operations on a Comet

Presenter/First Author: Stephan Ulamec, German Aerospace Center DLR Cologne, Cologne,

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Co-authors: Jens Biele, German Aerospace Center DLR Cologne, Cologne, Germany

Published Material: Status on Lander after November has been reported before. However, new information will be made available on results by May 2015!

Abstract Body: Philae is a comet Lander, part of Rosetta which is a Cornerstone Mission of the ESA Horizon 2000 programme. In August 2014 Rosetta did rendezvous with comet 67P/Churyumov-Gerasimenko (CG) after a 10 year cruise. Both its nucleus and coma have been studied allowing the selection of a landing site for Philae. Philae was separated from the Rosetta main spacecraft on November 12, 2014 and touched the comet surface after seven hours of descent. After several bounces it came to rest and continued to send scientific data to Earth. All ten instruments of its payload have been operated at least once. Due to the fact that the Lander could not be anchored, the originally planned first scientific sequence had to be modified.

Philae went into hibernation on November 15th, after its primary battery ran out of energy. Re-activation of the Lander is expected in spring/summer 2015 when CG is closer to the sun and the solar generator of Philae will provide more power.

The paper will give an overview of Separation, Descent and Landing, news on the search for the final landing spot as well as Lander Operations after separation. We will also report on the status regarding a probable re-activation of the Lander, by May 2015.

Rosetta is an ESA mission with contributions from its member states and NASA. Rosetta's Philae lander is provided by a consortium led by DLR, MPS, CNES and ASI.

Abstract ID: 35480

Final Number: P13A-02

Title: ROSINA/DFMS and IES Observations at 67P/Churyumov-Gerasimenko: Ion Neutral Chemistry in the Coma of a Weakly Outgassing Comet

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Abstract Body: In August 2014, the Rosetta spacecraft encountered comet 67P/Churyumov-Gerasimenko at a distance of 3.5 AU from the Sun. Since then, the spacecraft has been observing the development of the coma around the comet. The spacecraft has a host of in situ instrumentation that includes the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) instrument suite and the Ion and Electron Sensor (IES). Part of the ROSINA suite is an ion and neutral mass spectrometer, the Double-Focusing Mass Spectrometer (DFMS). Most often, DFMS makes high mass resolution measurements of the neutral composition of the developing coma of the comet. However, the mass spectrometer is sometimes operated in an ion mode that makes in situ measurements of key components of the ion composition of the coma. This talk focuses on these ion measurements that were made far from the Sun, when outgassing is weak and there is minimal ion-neutral chemistry in the coma. The mass ratios of newly created cometary ions are consistent with this minimal ion-neutral chemistry. Ion and electron observations of the solar wind from IES indicate that no contact surface formed upstream of the spacecraft and that newly created cometary ions are ultimately picked up by the solar wind. In this talk, the ion measurements are described and compared with ionospheric models. The implications for cometary interactions with the solar wind from 3.5 to 2.5 AU from the Sun are derived from these comparisons.

Abstract ID: 35906

Final Number: P13A-03

Title: The plasma environment of 67P/Churyumov-Gerasimenko probed with the Rosetta orbiter: Current Observations

Presenter/First Author: Marilia Samara, NASA Goddard Space Flight Center, Greenbelt, MD

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Published Material: Findings related to IES have been presented at the Fall AGU meeting in San Francisco in December 2014.

Abstract Body: Rosetta is the first spacecraft to ever orbit a comet and closely monitor its nucleus activity and coma development as it travels through the inner solar system. Currently Comet 67P/Churyumov-Gerasimenko (67P/C-G) is still relatively far from the Sun (> 2.5 AU), and consequently, plasma activity was expected to be low or negligible. However, the first six months of measurements made with the Rosetta Plasma Consortium Ion and Electron Sensor (RPC-IES)—a dual top-hat electrostatic analyzer that measures the 3D fluxes of electrons and ions from ~4 eV to ~20 keV—have revealed a dynamic plasma environment that is both rich and diverse. The density of the plasma near the comet will increase as it approaches the Sun, and Rosetta will have an unprecedented opportunity to follow the evolution of the plasma environment close to 67P/C-G resulting in new insights and questions. We provide a summary of current observations and future questions that IES and RPC may address with new data as activity grows with the comet's approach to perihelion.

Abstract ID: 36610

Final Number: P13A-04

Title: Millimeter and Submillimeter Observations of comet 67P/C-G with the MIRO Instrument

Presenter: Paul Von Allmen, NASA Jet Propulsion Laboratory, Pasadena, CA

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Published Material: Some of the results to be presented (e.g. total gas production and average thermal properties) have been accepted for publication by the journal Science, and have been discussed at the Fall 2014 AGU meeting. This presentation will focus, however, on analyses currently underway involving higher spatial and temporal resolution.

Abstract Body: The Microwave Instrument for the Rosetta Orbiter (MIRO) makes millimeter and submillimeter observations of the nucleus and coma of Rosetta's target comet. This presentation summarizes the instrument, its observations, and our team's scientific analyses to date. MIRO makes continuum measurements at 190 and 563 GHz (1.6 and 0.5 mm) to study the thermal and electrical properties of the nucleus near-surface (depths from ~1 millimeter to 10 centimeters). MIRO also makes spectroscopic measurements of 8 lines near 560 GHz (H_2O, $H_2{}^{17}O$, $H_2{}^{18}O$, CO, NH_3, and three CH_3OH transitions). The abundance, gas velocity, and temperature of those species are measured as functions of time and location. To interpret its data, the MIRO team has developed sophisticated nucleus and coma models. Our goal is to understand the dominant physical processes that create the coupled nucleus-coma system.

MIRO began measuring water in the coma on 6 June 2014, at a heliocentric distance of 3.9 AU. By October (3.3 AU from the Sun), the total production rate had increased a factor of 6. Water production varies both with location on the nucleus and time-of-day. At the time of this writing, H_2O and $H_2{}^{18}O$ have been clearly measured, with detections of $H_2{}^{17}O$ and CH_3OH. We will report on our composition measurements and on the time and spatial variability of nucleus outgassing. Our analysis of spectral data uses a non-LTE coma model, accounting for the boundary layer at the nucleus, regions dominated by gas collisions, electron collisions, and radiative processes.

MIRO's continuum channels have detected the nucleus since 19 July 2014, and the nucleus has been spatially resolved since early August. All surface regions appear to have a very low thermal inertia, as expected for a porous, dusty layer. We see variability in properties horizontally and with depth, and will present our latest results. MIRO has developed a 3-D nucleus thermal/radiative model to assist in observation planning and interpretation.

Abstract ID: 36693

Final Number: P13A-05

Title: Analysis of Methanol Spectral Lines Obtained with the Microwave Instrument on the Rosetta Orbiter (MIRO) for Comet 67P/Churuymov-Gerasimenko.

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Abstract Body: Since the early summer 2014, the Microwave Instrument on the Rosetta Orbiter (MIRO) has been measuring emission from the coma of 67P/Churyumov-Gerasimenko in the sub-millimeter channel at 562 GHz and the millimeter channel at 190 GHz. The high-resolution spectrometer in the sub-millimeter channel is tuned to molecular lines of H_2O, CO, CH_3OH and NH_3. We will discuss the analysis of the three methanol lines at 553.146 GHz, 568.566 GHz and 579.151 GHz and present estimates of the gas abundance in the coma relative to water. The line shape analysis relies on our non-local thermal equilibrium radiative transfer software. Some of the key parameters needed to determine the population of the rotational levels, which enter the radiative transfer calculation, are the state-to-state collision coefficients between the methanol and water molecules. We have calculated theses collision coefficients using a dipole-dipole interaction Hamiltonian and first order perturbation theory for the collision process. Collisional cross-sections between rotational levels in the vibrational ground state will be given in ranges of gas temperature and density present in the coma.

Abstract ID: 33982

Final Number: P14A-0302

Title: Evidence Of Metasomatism In The Lowest Petrographic Types Inferred From A Na-, K, Rich Rim Around A LEW 86018 (L3.1) Chondrule.

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Abstract Body: Ordinary chondrites (OCs) represent the most abundant extraterrestrial materials and also record the widest range of alteration of primary, pristine minerals of early Solar system material available for study. Relatively few investigations, however, address: (1) the role of fluid alteration, and (2) the relationship between thermal metamorphism and metasomatism in OCs, issues that have been extensively studied in many other meteorite groups e.g., CV, CO, CR, and enstatite chondrites. Detailed elemental abundances profiles across individual chondrules, and mineralogical studies of Lewis Hills (LEW) 86018 (L3.1), an unequilibrated ordinary chondrite (UOC) of low petrographic type of 3.1 returned from Antarctica, provide evidence of extensive alteration of primary minerals. Some chondrules have Na-, K-, rich rims surrounded by nepheline, albite, and sodalite-like Na-, Cl-, Al-rich secondary minerals in the near vicinity within the matrices. Although, limited evidences of low temperature (~250°C) fluid-assisted alteration of primary minerals to phyllosilicates, ferroan-olivine, magnetite, and scapolite have been reported in the lowest grades (<3.2) Semarkona (LL3.00) and Bishunpur (LL3.10), alkali-rich secondary mineralization has previously only been seen in higher grade >3.4 UOCs. This preliminary result suggests highly localized metamorphism in UOCs and widens the range of alteration in UOCs and complicates classification of petrographic type and extent of thermal metamorphism or metasomatism. The work in progress will document the micro-textures, geochemistry (Ba, Ca, REE), and isotopic composition (oxygen, ^{26}Al-^{26}Mg) of mineral phases in chondrules and adjoining objects to help us understand the formation scenario and delineate possible modes of metamorphism in UOCs.

Abstract ID: 34164

Final Number: P14A-0303

Title: Field- and Frequency-Dependence of Magnetic Susceptibility of Ordinary Chondrites in Low Fields

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Abstract Body: Increasingly, magnetic susceptibility measurements are being used to rapidly and non-destructively characterize stony meteorites, and a meaningful database of measurements is already available. However, current data have been acquired by susceptibility meters that operate at only a few field strengths and frequencies.

The University of Toronto Electromagnetic Induction Spectrometer (UTEMIS) is a prototype instrument that measures AC complex susceptibility over a range of 35 frequencies between 90 Hz and 64 kHz by harmonic analysis of periodic signals at six different base frequencies. A very weak exciting field is employed (typically <10 A/m peak-to-peak) so a near linear magnetization response is expected, but the amplitude of the excitation signal can be varied by a factor of 15 to test this. With this instrument, the magnetic susceptibility of 27 ordinary chondrites from the LL, L, and H classes was measured over the entire UTEMIS spectral range and with variable exciting field strengths. The results have been analysed and compared with data measured with a SI-2B commercial susceptibility meter at 2 frequencies (825 Hz and 19 kHz). Systematic variation of susceptibility with both applied field and frequency were observed; susceptibility increasing with excitation amplitude and falling somewhat with increasing frequency.

Varying the applied field permits the apparent susceptibility to be separated into a field-dependent term, putatively contributed by the multi-domain ferromagnetic grain fraction, and a field-independent term likely contributed by the diamagnetic, paramagnetic, and single-domain ferromagnetic grains. Among the ordinary chondrites measured, a positive dependence of susceptibility on exciting field with increasing metal content is widely observed. The LL class displays little dependence with field strength, whereas the H class displays ubiquitous field dependence. Intermediate field dependence is found in the L class.

The degree of frequency dependence also varies with metal content; the H chondrites display a maximum of up to 17% measured from 810 to 64 kHz the L chondrites of up to 8%, and the LL chondrites up to 3%.

Abstract ID: 35598

Final Number: P14A-0304

Title: Effects of Thermal Metamorphism on Spectral Properties of a Carbonaceous Asteroid Regolith Simulant

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Abstract Body: Thermal processing has been invoked as a possible cause of some of the spectral features of the B-type near Earth asteroid Bennu, the target of the upcoming OSIRIS-REx asteroid sample return mission. In particular, thermal metamorphism may explain the anomalous 'blue' spectral slope (i.e., increasing reflectance towards short wavelength). It is expected that, to first order at least, the regolith of Bennu will resemble known carbonaceous chondrite meteorites (though it will very likely differ in detail). We have developed a regolith simulant consisting of nanophase magnetite (5%), natural serpentine (85%), shungite (5%; shungite is a refractory organic mineraloid), and troilite (5%). This mixture was designed to simulate the composition of CM2 chondrites largely in terms of phases expected to have the greatest influence on CM spectral properties; CMs are one of the most common carbonaceous chondrite types. The simulant was heated under partial vacuum (10-70 mbar) with a dry N_2 purge. The samples were heated at 100ºC increments from 100ºC to 1200ºC. X-ray diffraction data were collected at each heating stage, before and after heating, along with reflectance spectra covering 350-2500 nm. Overall reflectance increased with heating. Spectral changes include loss of OH-related spectral features above 700ºC, consistent with the dehydroxylation of serpentine. Enstatite and forsteritic olivine were observed by XRD at 900ºC. Hematite formed at the expense of magnetite beginning at 600ºC, but was less apparent with increasing temperatures and nearly undetectable above 1100ºC. It appears that heating alone cannot account for the spectral properties of Bennu, perhaps indicating that alternative mechanisms (e.g., enhanced aqueous or hydrothermal alteration, space weathering) or physical properties (grain size, compaction state) must be explored.

Abstract ID: 36015

Final Number: P14A-0305

Title: 3D petrography of Enstatite achondrites via micro computed tomography scanning (µCT)

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Abstract Body: Enstatite achondrites are thought to have formed under highly reducing conditions, and are composed of enstatite, plagioclase, native iron (kamacite), troilite and various trace phases. Understanding the petrogenesis of these rare meteorites may provide information about early planetary formation processes, particularly in the region of the solar nebula near the proto-Sun. µCT allows for non-destructive analysis of meteorite samples and provides three dimensional imaging of internal density structures. Enstatite achondrite samples including Zaklodzie, NWA 4301, Itqy, Hvittis, NWA 8751, and Abee were imaged with the Locus RS-9 scanner, at an X-ray tube voltage of 80 kVp and a tube current of 0.45 mA. 900 views were collected at angular increments of 0.4º around the samples. The aforementioned meteorites were selected in order to observe and compare 3D structures of enstatite achondrites having different formation mechanisms. µCT images of the enstatite achondrites studied reveal density contrasts between high and low attenuation phases, and also show the overall distribution of metal and silicate throughout the samples. µCT may also be used to identify the weathering extent of the samples which is useful when trying to analyse the least altered material or when trying to identify where to cut the sample for thin section preparation. Threshold value limits were selected for high intensity and low intensity phases and were compared to reported values in literature. Although µCT cannot yet discern between each individual phase present in the samples, it is possible to determine a combined modal percent volume for metal + sulphides and silicates + plagioclase. Isosurface rendering of high-intensity phases was used to visualize the distribution, size, shape and interconnectedness of metal grains in the samples which may help further understand their petrogenetetic sequence.

Abstract ID: 34509

Final Number: P14B-0306

Title: Structural Characterization of the Sudbury Impact Structure, Canada using current remote sensing datasets

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Co-authors: Gordon Richard Osinski, University of Western Ontario, London, ON, Canada

Abstract Body: This study uses current high resolution spatial and spectral orbital datasets to determine the extent and characterize structural features around the Sudbury impact structure, ON, Canada. With an apparent diameter anywhere from 150 to 290 km, the impact structure is proposed to be a multi-ring complex impact structure. Several ring structures have been hypothesized around the crater structure, extending 90 – 200 km beyond the main basin area. Due to the extensive post impact deformation and tectonism, this study focussed on areas north and west extending ~150 km beyond the Sudbury Igneous Complex (SIC). Lineament trends were extracted using automatic extraction algorithms on shaded relief maps (using DEMs, 30 m resolution), and Landsat-7 ETM+ SWIR data. Linear edge enhancement and directional filtering methods were applied to the data to enhance the edges of drainage systems, landforms, and linear features prior to extraction. Landsat-7 band 5 was determined to be the most suitable band for lineament extraction. A more comprehensive set of lineaments were extracted from shaded relief maps with different sun azimuth directions (between 0^o–315^o). The extracted lineaments were statistically analyzed to determine lengths, densities to generate rose diagram, and assess lineament density. In total 13,287 lineaments were extracted with feature lengths ranging from 1 to 9000 m. The lineaments were then compared to known geology in order to determine the source of deformation - either resulting from the main impact event or from later deformation. Three structural trends were observed from plotting rose diagrams- a majority trending north-south and northwest-southeast direction. A minor trend running northeast-southwest. Future work will include analyzing band ratio composite maps using Landsat 8, ASTER, and Radarsat data in order to extract lineaments, determine structural trends, types of lineament, and investigate any evidence of radial and concentric structures.

Abstract ID: 35333

Final Number: P14B-0307

Title: Impact Melt Veins in the Central Uplift of the West Clearwater Lake Impact Structure, Northern Quebec, Canada.

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Published Material: This material was part of a poster presentation at the Lunar and Planetary Science Conference in The Woodlands, Texas during the week of March 16-20.

Abstract Body: The West Clearwater Lake impact structure is a ~290 Ma impact structure located in Northern Quebec at 56°08'N 74°18'W, approximately 125 km east of Hudson Bay. Phaneritic plutonic target rocks of the Superior Province were impacted, resulting in a ~30 km diameter structure with a series of central islands. The process of impact cratering is still not fully understood, specifically, how the uplift of underlying rocks in the centre of large complex craters occurs. This study intends to investigate central uplifts; particularly impact melt veins and dykes observed in the uplifted target rocks of the West Clearwater Lake impact structure. Researchers have hypothesized that impact generated melt has played a role in the weakening of rocks in the crater floor, allowing for the central uplift process to occur. Melt is thought to lubricate faults, allowing for blocks to be more susceptible to displacement. Whether this melt is formed by the initial shock of the impact or due to frictional melting is unknown. The aim of this research is to better understand the formation processes of these melt veins and dykes.

We have used electron dispersive spectroscopy techniques and optical microscopy to analyze the chemical composition, petrography and mineral structure of three melt vein samples retrieved from the central islands in West Clearwater Lake. In order to determine the processes by which these melt veins formed, petrography and geochemistry data of both the host rock and melt veins have been acquired and used for comparative analysis. This will allow for a better understanding of the role of melt on central uplift formation on Earth and other planetary bodies.

Abstract ID: 35108

Final Number: P14C-0308

Title: Rosetta Mission Status Update

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Published Material: This is a mission overview abstract, and will provide an overview of where the mission has been abd is going.

Abstract Body: The Rosetta Mission is the third cornerstone mission the ESA programme Horizon 2000. The aim of the mission is to map the comet 67-P/Churyumov-Gerasimenko by remote sensing, to ex-amine its environment insitu and its evolution in the inner solar system. The lander Philae is the first device to land on a comet and perform in-situ science on the surface. Nearly 10 years after launch in 2004, on 20th January 2014 at 10:00 UTC the spacecraft woke up from hibernation. Following successful

instrument commissioning, Rosetta successfully rendezvoused with the comet. Following an intense period of map-ping and characterisation, a landing site for Philae was selected and on 12 November 2014, Philae was suc-cessfully deployed. This presentation will provide a brief overview of the mission up to date and where we stand in main science phase, which began with Philae's separation. It will also provide a look forward. IT is given on behalf of ALL Rosetta mission science, in-strument and operations teams.

Abstract ID: 35777

Final Number: P14C-0309

Title: Shedding Light on Comet 67P/Churyumov-Gerasimenko - New Shape and Topography Results

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Published Material: November 2014 DPS meeting. Shape and topography from early mapping phases.

Abstract Body: The 2015 Joint Assembly coincides with the autumnal equinox of comet 67P/Churyumov-Gerasimenko. Since August 2014, we have been mapping the surface of the comet, producing three dimensional topographic maps at one meter spatial resolution. These maps have been ingested into APL's Small Body Mapping Tool, enabling us to study the geology of 67P/CG in three dimensions and in its proper gravitational context. Until now, a significant portion of the comet has been in permanent shadow, but in the weeks before the meeting most of its surface will be revealed to ROSETTA's OSIRIS cameras. We shall present an almost complete topographic map of the surface of the comet, which will allow an accurate measurement of the nucleus density.

Abstract ID: 36627

Final Number: P14D-0310

Title: Impact Induced Ballen Fracture Networks and their Formation in SiO2 Clasts

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Abstract Body: Rocks affected by meteoritic impacts display impact-related microtextures as the result of shock processes, as well as the associated extreme temperatures. So-called "ballen" is a form of microfracture network observed exclusively in SiO_2 polymorphs. Ballen formation is expressed in the literature as a series of multiple steps and transformations between the low- and high polymorphs of quartz and mainly cristobalite; (Path 1) a solid-solid transition: a-quartz à diaplectic glass and then formation/crystallizationà β-cristobalite à α-cristobalite/ α-quartz; (Path 2) a solid-liquid transition: α-quartz à lechatelierite à β-cristobalite/β-quartz ballen à α-cristobalite/α-quartz. All variations of this model require multiple steps and transformations that would eliminate any pre-existing micro-structures, such as planar deformation features (PDF). PDF-bearing ballen were described and characterized under the optical microscope, as well as using electron microprobe and Raman spectroscopy. All ballen-bearing clasts were observed in impact melt-bearing breccias from the following impact structures Popigai, Siberia Russia; Mistastin and Deep Bay, Canada; and were always included in impact melt glass or vitric clasts. The PDF appear to be continuous through the cracks, as well as continuous between ballen-ridden parts of the clast and clear parts of the same clast. An additional formation mechanism of ballen fractures is proposed as the result of the above observations where ballen fractures form due to thermal shock without the need of the cristobalitization process and an amorphous phase. Our observations are in agreement with such a mechanism. In addition, we suggest that ballen development has no direct or indirect association to pressure levels and is only indicative of extreme thermal gradient. Finally, ballen although strongly suggestive of meteoritic impact it is not a diagnostic indicator and has been reported in other settings such as fulgurites.

Abstract ID: 35094

Final Number: P21A-01

Title: The Non-Destructive Measurement of Meteorite Density and Porosity

Presenter/First Author: Daniel Turner Britt, Univ Central Florida, Orlando, FL

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Co-authors: Guy J Consolmagno, , , ; Robert J Macke, , ,

Published Material: This reviews the method and results that have been presented over the last 15 years.

Abstract Body: There are 44 compositional types, subtypes, and metamorphic grades of meteorites which represent an invaluable resource of "free" geological material from asteroids. The measurement meteorite density and porosity, provides fundamental data on asteroid physical properties and insight into their structure and evolution. Until the late 1990's measurements of meteorite density and porosity used the standard geological techniques. For bulk volume and bulk density, the sample was weighed first in air and then suspended in water. This method gives a good estimate of the bulk density, but does not take into account any penetration of the water into the pore space. Another approach for bulk density was to cut the meteorite into a standard cube. To determine porosity some workers used penetrating fluids like carbon tetrachloride to access internal void spaces. The major drawback of these methods is the contamination the meteorite, which increases its weathering and potentially damages its use for future studies.

Consolmagno and Britt (1998) developed a method for the measurement of meteorite bulk densities using glass beads instead of water. The glass bead method, combined with helium gas pycnometry minimizes sample contact and thus contamination. Since then, the combination of glass beads for bulk density and helium gas pycnometry for porosity has become the standard for meteorite physical property measurements. The new developing standard is the use of 3-D laser scanning for bulk volume allowing for very minimal contact with the meteorite during the measurements.

Abstract ID: 36689

Final Number: P21A-02

Title: Characterization of Meteorites by Focused Ion Beam Sectioning: Recent Applications to CAIs and Primitive Meteorite Matrices

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Abstract Body: Focused ion beam (FIB) sectioning has revolutionized preparation of meteorite samples for characterization by analytical transmission electron microscopy (TEM) and other techniques. Although FIB is not "non-destructive" in the purest sense, each extracted section amounts to no more than nanograms (~500 μm^3) removed intact from locations precisely controlled by SEM imaging and analysis. Physical alteration of surrounding material by ion damage, fracture or sputter contamination effects is localized to within a few micrometers around the lift-out point. This leaves adjacent material intact for coordinate geochemical analysis by SIMS, microdrill extraction/TIMS and other techniques. After lift out, FIB sections can be quantitatively analyzed by electron microprobe prior to final thinning, synchrotron x-ray techniques, and by the full range of state-of-the-art analytical field-emission scanning transmission electron microscope (FE-STEM) techniques once thinning is complete. Multiple meteorite studies supported by FIB/FE-STEM are currently underway at NASA-JSC, including coordinated analysis of refractory phase assemblages in CAIs and fine-grained matrices in carbonaceous chondrites. FIB sectioning of CAIs has uncovered epitaxial and other overgrowth relations between corundum-hibonite-spinel consistent with hibonite preceding corundum and/or spinel in non-equilibrium condensation sequences at combinations of higher gas pressures, dust-gas enrichments or significant nebular transport. For all of these cases, the ability of FIB to allow for coordination with spatially-associated isotopic data by SIMS provides immense value for constraining the formation scenarios of the particular CAI assemblage. For carbonaceous chondrites matrix material, FIB has allowed us to obtain intact continuous sections of the immediate outer surface of Murchison (CM2) after it has been experimentally ion processed to simulate solar wind space weathering. The surface amorphization and loss of OH produced by the irradiation provides important clues regarding space weathering on primitive asteroids such as the OSIRIS-Rex target 101955 Bennu.

Abstract ID: 35809

Final Number: P21A-03

Title: Investigation of Changes in Sample Density During Impact Processes Using X-Ray Analysis

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Abstract Body: Meteorites have been used as analogs for asteroids in experiments to study the results of catastrophic disruption. Samples with a variety of sizes, projectile velocities and material compositions have been shot and the resulting debris used to compare outcomes [1]. Currently there is interest in looking at changes in the physical properties of these same materials as a result of impact. To date we have investigated density, but are also looking at compression strength and speed of sound. The densities of 32 pieces of pumice from 8 shots were compared to the density of an unimpacted sample of pumice. There was a decrease from 0.90 g/cm^3 to an average of 0.77 + 0.09 g/cm^3. The range of densities for the individual pieces was 0.56 to 0.93 g/cm^3. The %RSD varied from 2 to 16% when measuring 3 to 6 pieces from the same shot. There does not appear to be a correlation between the density and the original sample size, the projectile velocity or extent of disruption (measured by the largest remaining fragment size). The X-Ray information can also be useful in studying changes in the texture of samples and in the porosity when exposed to processes such as impact disruption. We have previously shown there is no change in the layering texture of a highly porous pumice sample when exposed to impact disruption [2] and are investigating the effects of impact on the porosity of an ordinary chondrite.

References: [1] Flynn G. J. et al. (2009) *Planet. and Space Sci., 57,* 119-126; [2] Flynn G. J. et al. (2014) *Planet. and Space Sci.,* in review.

Abstract ID: 33958

Final Number: P21A-04

Title: Non-destructive analyses of Martian meteorites using Raman Spectroscopy

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Abstract Body: Raman spectroscopy is an important tool to study highly shocked extraterrestrial materials. It provides complementary measurements of the short-range order phenomena in solid matter to other microstructural techniques to unravel the complex petrogenic history of these rare samples. Spectroscopy is of particular utility in studying amorphous materials such as maskelynite, metamict minerals and melt glasses and can also detect structural changes due to shock and inclusions of volatile or glassy material. Raman spectroscopy is also ideal in identifying high pressure polymorphs (e.g. the SiO_2 polymorphs) and weathering products. Characterization of the minerals present, with particular attention to the regions where it forms aids in the interpretation of the *P-T* formation conditions of the rocks. This could help answer the question whether high pressure phases are due to local (small-scale) pressure spikes or larger-scale pressures experienced by the whole rock.

Some recent work on martian meteorites have demonstrated the importance of detailed mineralogical characterization in interpreting geochronological data. Using a HORIBA Jobin Yvon LabRAM ARAMIS integrated confocal micro-Raman system with three excitation wavelengths of 532, 633, 785 nm we have non-destructively characterized a chemically diverse suite of martian meteorites. Through the use of our automated mapping stage and autofocus we are able to create mineral maps of areas much larger than generally achievable with Raman instruments. These maps can then be used for modal measurements allowing primary phases, and secondary weathering phases, to be quantified. Of particular interest were U-bearing phases such as zircon, baddeleyite, apatite-group minerals and merrillite as targets for subsequent studies.

Abstract ID: 36018

Final Number: P21A-05

Title: Nebular Conditions in the Early Solar System from the 3D Tomography of Chondrules.

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Abstract Body: Chondrules are millimetre-sized igneous melt droplets formed in the early Solar System over 4.5 Gyr ago, and preserved in chondritic meteorites. Molten silicate droplets form spheroidal shapes due to a minimization of surface energy. In microgravity, a droplet may become perfectly spherical if no internal or external forces act during cooling and crystallization, but non-spherical shapes can arise if a droplet is perturbed by any number of forces during or after solidification. Many processes and diverse conditions in a range of nebular settings may be involved in chondrule formation. One key feature is the geometric shapes of chondrules themselves; the departure from perfect sphericity may provide clues for possible formation mechanisms. Here, X-ray micro-computed tomography (CT) was used to obtain the 3D shapes of >100 distinct chondrules in a 1 in^2 slab of the CR2 chondrite NWA801 at 50 µm/voxel resolution. For each chondrule, orientations of the three orthogonal symmetry axes and the lengths of the principal semi-diameters, A, B and C were determined by defining a minimum of 54 independently distributed points on the chondrule surface. A best-fitting ellipsoid was then calculated for each chondrule, characterized by a centre $\mathbf{X}_i$, and a symmetric 3×3 matrix $\mathbf{B}_i$. Axial ratios between $1.1< A/C<1.9$ and $1.0<B/C<1.3$ were observed with a clear preferred orientation of the short axes and the girdle pattern for the long axes. Thus some minor compaction (~10%) has acted on the chondrules. However, a range of original "nebular" shapes are present, from spheres, to oblate and prolate spheroids. Chondrule rotation (oblate sphereoids) or exposure to a ram-pressure headwind (prolate) could account for departures. Other forms may have been produced by ductile mergers. An alternate explanation may be that the chondrule shapes were produced by droplet vibration caused by melting of precursor dustballs in a nebular shock event.

Abstract ID: 36337

Final Number: P21A-07

Title: Volumetric Analysis and Phase Discrimination in Meteorites by Medical X-Ray Micro-CT

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Abstract Body: Micro-Computed Tomography (µCT) enables access to spatial compositional and textural information in meteorites, to inform further investigation without the need for destructive analysis. Furthermore, high resolution images of meteorites attained in biomedical micro-CT scanners (GE eXplore Locus and GE eXplore speCZT at Robarts Research Institute) can be quantitative, with applicable correction. We report quantitative estimates for metal plus sulfide in H chondrites, as well as silicate phase discrimination in olivine diogenite, after image correction using a semi-empirical linearization of X-ray projection data using a custom calibration phantom to correct for beam hardening and scatter. Data from four meteorites are compared: Bassikounou H5, Gao-Guenie H5 and Grimbsy H4-5 ordinary chondrites and NWA 5480, a coarse-grained olivine diogenite. The chondrites demonstrated excellent agreement between % volume composition of dense metallic inclusions (metal plus sulfide) from corrected µCT images, as compared to literature values, point counting by reflected light microscopy, and SEM imaging (LEO 440 SEM at Surface Science Western), respectively. Silicate phases could not be discerned in the ordinary chondrites because of their fine-grained nature. By µCT, it is possible to distinguish the mineral phases in coarse-grained NWA 5480 (grains of mm size) using the large contrast between radiodensities of the different phases. The three most abundant phases in NWA 5480, enstatite, forsterite and chromite, as identified spatially by *in situ* µXRD analysis of the surface (Bruker D8 Discover), could be correlated to distinguishable mineral phases by µCT. Thus for this coarse-grained achondrite, the silicate minerals enstatite and forsterite could be distinguished easily by the lower radiodensity of the former. Medical CT imaging cannot reliably distinguish between sulphide and metal phases (both saturate) nor between silicates except in cases where the sample is coarse-grained.

Abstract ID: 35871

Final Number: P21A-08

Title: Non-destructive markers of parent body aqueous alteration in carbonaceous chondrites based on magnetometry and X-ray diffraction of mm-sized meteorite fragments

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Abstract Body: We present a methodology for studying Fe-rich alteration assemblages, and its application to the study of aqueous alteration in C-rich asteroids. The more primitive chondrites are also the most altered. Early water-rock interactions probably occurred in their asteroidal parent bodies after ice that accreted with rocky materials have melted. In CM chondrites, serpentinization processes predominate and serpentines present a large diversity of compositions in the Si-Fe^{2+}-Fe^{3+}-Mg-Al system. The parameters controlling the variations are still poorly understood and may involve kinetic factors. It is important to evaluate bulk mineralogical changes in chondrites as alteration proceeds in order to understand the reaction pathways during alteration. X-ray diffraction (XRD) has proven useful although it gives limited information on complex solid solutions. In a recent study we showed that low-temperature (2-300 K) magnetometry was a powerful tool for evaluating the mineralogical changes in Fe-rich serpentines, and to estimate the proportions of other Fe-rich phases. We combined this approach with XRD using a microfocus (<100 µm beam) high brilliance rotating anode X-ray generator to evaluate the mineralogical changes among 100's of µm to mm size fragments of the Paris chondrite, the least altered CM known so far. Alteration is heterogeneous in the Paris chondrite, with mm to cm size domains where primary chondritic components are better preserved. This feature gives a unique opportunity to evaluate the reactions involved by comparing more or less altered

areas. Our results suggest that the (Fe^{2+},Fe^{3+})-rich serpentine cronstedtite, which formation may be kinetically favoured, is the predominant early alteration phase. They yield new constraints on Fe partitioning during alteration, which imposes an important control on dihydrogen production during serpentinization in terrestrial systems, and probably also in extra-terrestrial ones. Our results also help understanding the Al budget during alteration, which is still poorly known. Therefore, the present non-destructive approach allows 1) a quick identification of alteration products and 2) an evaluation of mass transfers during alteration, which may help understanding the fluid flow pattern in chondritic parent bodies.

Abstract ID: 33264

Final Number: P24A-0311

Title: TOPOGRAPHIC ANALYSIS OF FLUVIAL LANDFORMS WEST OF NEWCOMB CRATER (MARS) FROM HRSC-MARS EXPRESS STEREO IMAGERY

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Abstract Body: Based on Mars Express HRSC stereo imagery (resolution of ~10m/pixel) and DEMs (resolution of ~75m/pixel), well-developed fluvial valleys are mapped in highly cratered terrain dated of Noachian (t>3.6 Gyr), especially in Noachis Terra, west of Newcomb crater. The 2D organization of valleys is very similar to that observed in terrestrial fluvial basins. The exponent n of Hack's law is a well-known parameter for determining the distribution of valleys or stream inside their watershed. This scaling law is an empirical power law relationship between the drainage basin area and the length of the stream, measured from the mouth of the basin to the crest of the drainage divide along the stream channel. Whatever the area of watersheds, the mean exponent n is ~0.7, which is very close to values for terrestrial valley networks. The valley depth, which is relief between the valley bottom and the interfluve summits, is <500 m, with a mean value of 100 m from HRSC DEMs. There is a spatial evolution of valley depth between heads and outlet at each given Strahler order, with a systematic increase in depth with a higher Strahler order for valleys debouching into plains like on Earth. The volume of valleys reaches a few 10s of km3, which is relatively significative even in arid conditions and implies a large volume of liquid water in a river sustained during a minimum period of time of 100 kyr. The quantitative assessment of fluvial valleys provides new items for their formation processes. During the Noachian period, the main erosive process is a sustained fluvial activity due to rivers fed by precipitation, whatever the precipitation comes from rainfall or snowfall and subsequent melting.

Abstract ID: 34800

Final Number: P24A-0312

Title: Numerical modelling of river deltas on Titan and the Earth

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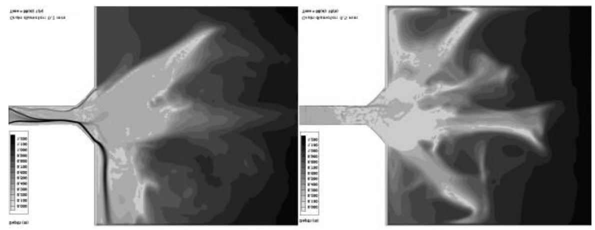
Published Material: Part of the results is to be presented at EGU 2015 and LPSC 2015 meetings.

Abstract Body: Fluvial processes change the landscape by removing surface material from one place and depositing it in another. Beside Earth, terrains shaped by fluvial activity are known from Mars and Titan. When the river enter the standing body of water, the material carried by the flow is deposited, creating specific landforms such as river deltas. Several factors are known to affect the shape and development of these deposits. The sediments might contain different mixtures of clay, sand or gravel-sized grains depending on the terrain and distance from the source, due to natural sorting of rocky material in streams and rivers. We investigated the role of grain size in shaping the river deltas in terrestrial and Titanian environment using numerical approach. This work is an extension of Witek and Czechowski (2015, Planet. Sp. Sci. 105, 65–79). The gravity and the chemistry are substantially different on these celestial objects, but the underlying physics is the same. We found many similarities in evolution of river deltas in both environments, such as the dependence of the delta slope and surface area of the delta plain on the grain size. In particular, the slope is smaller and larger part of the delta is submerged for smaller grains (silt, fine sand).



Abstract ID: 33885

Final Number: P24B-0313

Title: Graben-fissure systems in the Mead Quadrangle, Venus

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Abstract Body: Detailed mapping of graben-fissure systems (the surface expressions of underlying dyke swarms) in a portion (10°-20° N, 30° -50° E) of the Mead Quadrangle is part of a systematic global effort to identify regional radiating systems (linked with known and cryptic magmatic centres), circumferential systems (linked with corona) and linear systems (linked with rifting).

A total of 32 different graben-fissure systems were mapped within the study area. Five are radiating systems, four of which (with maximum radii of 930, 210, 180 and 500 km) are associated with Pavlova, Didilia, Isong, and Ninmah corona, respectively. The fifth (with a maximum radius of 500 km) focusses on c. 37.1° E, 11.7° N, marked by a small edifice. An additional radiating system (1400 km in radius and spanning about 130 degrees of arc) has been identified based on converging trends from two spatially separate graben-fissure systems; its focal point (c. 39.5 ° E, 19.9°N) is not associated with any central volcanic/tectonic edifice and represents a newly-recognized cryptic magmatic center. Pavlova and Didilia coronae have graben-fissures along their annuli and these are interpreted as parts of circumferential systems. Additional systems are located on the corona annuli but these have trends that are oblique to the local trend of the annuli (neither normal nor parallel to it) and are therefore not part of radiating or circumferential systems genetically related to the coronae. Instead they are interpreted as part of older regional graben-fissure systems that are preserved in the uplifted corona annuli, but elsewhere are largely covered by lava flooding. An east-west linear system, in excess of 1800 km long and 900 km wide, is inferred to be the oldest in the study area, by the degree to which it is flooded by lavas.

Abstract ID: 36614

Final Number: P24B-0314

Title: Determining Relative Ages of Structural Features Around Irnini Mons, Venus - A Comparison of Type Locations to Resolve the Timing of Cross-cutting Features

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Published Material: Poster presentation at the 2015 Lunar and Planetary Science Conference in Houston, TX.

Abstract Body: Irnini Mons, a volcano in central Eistla Regio at 14ºN, 16ºE, is roughly centered on the V-20 quadrangle of Venus. While Eistla Regio as a whole is known to have the highest degree of polyphase deformation on Venus, the area immediately around Irnini Mons is particularly complex, even at the 1:5,000,000 scale of the quadrangle map. The arrangement of cross-cutting tectonic structures indicates a detailed and multipart stress history, which suggests Irnini Mons is an ideal location to identify distinct patterns of changes in stress orientation over time, as well as to ascertain the deformation associated with the volcano relative to the deformation of the local regional plains. A thorough investigation of the distribution and orientation of the numerous structures around Irnini Mons at the highest possible resolution (75 m/pixel) is likely to reveal the relative timing of the structures and thus shed light on the deformation history of this region of Venus. However, the complicated nature of these structures and their relationship to each other makes it difficult to resolve relative ages holistically across the map. For this reason, we attempt to determine the relative ages of structures within four distinct type locations within the region, fitting the outcomes of these analysis into an analysis of relative timing of structures within the greater mapped area. For this study, we build upon previous mapping and the determination of structural ages for four type locations spanning across the northwest and southeast regions of the map in an attempt to resolve the timing of features within an entire swath of the map stretching from the northwest corner to the southeast corner. Previous mapping in this area provided examples of how this high-resolution structural mapping may differ from the V-20 map and we will build upon this work by focusing on the high-resolution structural mapping of the four type locations described above.

Abstract ID: 34595

Final Number: P24B-0315

Title: Effects of mechanical layering on magmatic reservoir failure and magma propagation within the Venusian lithosphere

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Published Material: AGU 2013 and LPSC 2014

Abstract Body: Failure of magmatic reservoirs and propagation of magma is controlled in part by the state of stress within the lithosphere. Such stresses are induced by a range of loadings (e.g., gravitational, magmatic and tectonic). In addition, the response of the lithosphere to these loadings depends on its physical properties. Magmatic reservoirs and lithospheric stress states on planetary bodies have been studied using homogeneous lithospheres mainly composed of crustal material. However, planetary lithospheres may include substantial fractions of mantle material. The mechanics of a heterogeneous lithosphere may influence the failure of a magmatic reservoir and the propagation of the magma. To explore this scenario, we created two-layered axisymmetric elastic models made of mantle and crustal components using the COMSOL Multiphysics, in which a stiffer and denser mantle is underlying a softer and lighter crust. A spherical reservoir was created at the contact between the two layers. In these models, we analyzed magma reservoir stability, the amount of overpressure needed to reach failure, and the type of resulting intrusions within the two-layered lithosphere for three distinct environments: 1- lithostatic; 2- upward flexure due to a rising mantle plume; and 3- downward flexure due to a basaltic shield volcano. The results show that the difference in stiffness (>10%) between the crust and the mantle focuses the failure of the magmatic reservoirs at the mantle-crust contact. The resulting failure is driven by the in-plane stress tangential to the chamber, favoring lateral sill injections. In cases with flexure, magma chambers may become unstable (i.e., require no additional overpressure to fail) depending on the crust/mantle ratio. In some cases, we observed that failure of the magma chambers can be driven by the (out-of-plane) hoop stress favoring radial dike intrusions. The stability of magmatic reservoirs and the type and orientation of magmatic intrusions on Venus are influenced by the state of stress and heterogeneities within the lithosphere. Using our result, we can infer the potential crust/mantle ratios of the Venusian lithosphere in a particular tectonic environment in order to sustain stable and viable magmatic reservoirs and generate radial dikes as observed on the surface of Venus.

Abstract ID: 36306

Final Number: P24B-0316

Title: Volcanism on Venus and Titan : Constraints from Present and Future Radar Observations

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Abstract Body:

One of the most pressing questions about our sister planet is the degree of present-day volcanism. Estimates range from around 0.01 km^3/yr to roughly that of the Earth, 10 km^3/yr, some three orders of magnitude. I consider how well a future radar mapper, with a resolution equal to or better than Magellan (~120m), might constrain this rate. Were such a mission to fly in the 2020s, three decades of volcanic change on the surface will have accumulated. I use observed lava volume/area relationships from terrestrial volcanoes to estimate the area change that may have occurred, and consider the issue of detection of new flows against old. In essence, a volcano may choose a new flow from a 'palette' of radar colors, and only if a new flow is the same (to within measurement accuracy) of the one(s) on which it is superposed. Again, terrestrial data offers some insights into how random the color selection may be. It is of note in this context that part of Venus' surface was imaged twice by Magellan, albeit with a relatively modest separation in time : the lack of any identifiable temporal change places a (probabilistic) constraint on the eruption rate. (Similar considerations confront Titan, but there the repeat coverage is rather small).

Microwave radiometry is another approach that might indicate present-day or recent volcanism; unlike near-infrared observations which only

sense the upper surface and therefore only active lavas, microwave thermal emission may probe deeper, older flows. Again, terrestrial examples, and the search for volcanism on Titan with the Cassini radar radiometer, inform the application of this technique to Venus.

Abstract ID: 34870

Final Number: P34A-0249

Title: Major, trace element, and isotopic study of the Lonar Crater, India: new insights into the geochemical imprint of impact cratering on basaltic targets

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Abstract Body: The 1.88 km diameter Lonar crater, hosted on the Deccan basalts, India, has age estimates ranging from 50-500 ka. Being a rare terrestrial impact crater on basalts, it provides a unique opportunity to study the geochemical imprint of impact cratering on basaltic host rocks which is relevant to other terrestrial planets, the Moon, as well as asteroids. We measured concentrations of 43 elements using ICPMS in recently collected samples of the target Deccan basalt, impact melts and spherules at Lonar. Compared to the basalt, the impact melts (tektites) are enriched in Rb, K, Ba, Pb, Mn, Cr, U, Th, as well as light REEs (La, Ce, Pr, Nd). The spherules broadly show similar geochemical characteristics as the melts. In addition, the spherules are depleted in P, enriched in Cr, Ni, and some heavy REEs like Tm and Lu, but markedly depleted in Mn compared to the target basalts. For most of these elements, the difference in concentrations between the target basalts and impactites is more than 20% and as high as 100%. We have also measured Sr and Nd isotopic compositions of the basalts, melts and spherules using TIMS and our data overlap with previously published data for the Lonar rocks that argued for melting of the Archean basement beneath the Deccan basalts during impact. The impact melts as well as spherules show more radiogenic Sr and less radiogenic Nd isotopic composition compared to the target basalts. The Sr isotopic composition co-varies with the Rb/Sr as well as K/Ca ratios while the Nd isotopic composition shows a positive correlation with the Sm/Nd ratio. Enrichments of Rb, Ba, K, Th, U, Pb and LREEs in the melts and spherules can be explained by mixing with Archean continental crustal rocks beneath the Deccan basalts. The Sr and Nd isotopic variations are also consistent with this explanation. However, enrichments in Cr, Ni compared to the target basalts are indicative of mixing with the impactor.

Abstract ID: 34939

Final Number: P34A-0250

Title: Identifying "Pristine" Craters on Mars: Defining Criteria and Characteristics

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Published Material: The research and results presented herein are also being presented at the Lunar and Planetary Science Conference in March 2015.

Abstract Body: High-resolution meter-scale images of what are thought to be the youngest and best-preserved impact craters on Mars suggest that even the youngest craters on Mars show signs of modification by active geologic processes. As such, in order to constrain impact processes (e.g., ejecta properties and emplacement) and modification processes (i.e., various erosion and depositional processes), the visible and thermophysical characteristics of the most "pristine" craters on Mars must be constrained as a baseline. Indeed, various preservation/age terms (e.g., fresh, young, pristine, etc.) are used in the literature for Martian craters and often do not account for the fact that crater preservation and age may not be correlated. This is the case on a planet with active geologic processes, such as Mars, that exhibit both temporal and geographic variation in modification rate.

The objective of this study is to identify and characterize a set of physical properties associated with pristine Martian craters that will be utilized as a baseline for further studies. These craters will provide the best means to: 1) place further constraints on various aspects of the impact processes, and 2) examine how the physical properties of craters change as the crater and ejecta are modified over time, and as a function of target material and latitude. Here we define a "pristine" crater as a one that is both young (age) and appears morphologically "fresh" (i.e., the least-modified). In addition, we have begun to devise a crater classification scheme that couples both preservation and age of craters, which will prove useful for continued studies.

In summary, by using a synthesis approach that combines observations from both visible and thermal datasets, we are identifying examples of the youngest and best-preserved craters on Mars (i.e., "pristine"). These craters will provide a critical baseline for understanding the impact process and utilizing craters as a gauge for understanding the evolution of the Martian surface and past climates on Mars.

Table 1. Criteria for finding the best-preserved "pristine" Martian craters

Criterion	Assessment Difficulty	Preferred Data (Secondary)	Range	Limitations
Thermal Secondary Crater Rays	Easy	THEMIS day & night thermal infrared images	Below 60° latitude, range of good thermophysical data	Excludes craters at higher latitude (>±60°), craters well outside of Thermophysical Unit C (moderate TI, albedo and dust cover)
Pitted-Impact Deposits	Easy to Moderate	HiRISE (MOC & CTX)	Between 30-60° latitude,(Fig. 2, Tornabene et al., 2012)	Excludes high latitude (>±60°) craters
Depth-Diameter (d/D) Ratio	Moderate	MOLA PEDR (HiRISE CTX & HRSC stereo image derived DTMs)	MOLA PEDR coverage poorer at equator with respect to the poles	MOLA coverage limitations; craters below ~15 km are often poorly resolved; d/D may be exaggerated by pre-existing topographic effects
Preserved Secondary Crater Field	Moderate to Difficult	CTX (HiRISE, MOC & THEMIS VIS)	N/A	Small secondaries require higher-resolution datasets (e.g. HiRISE), which have less surface coverage
Low Size-Frequency Distribution (SFD) of Overprinting Impacts	Difficult	CTX or HiRISE	N/A	Time consuming to count small overprinting craters to derive a modeled age based on isochrons.

Abstract ID: 34603

Final Number: P34A-0252

Title: Martian Dust and Deposition from Green Valley to Gale Crate

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Published Material: Dust Deposition on the Phoenix Telltale (Moores et al) accepted for publication in Planetary and Space ScienceSurpressed Boundary Layer during the first 360 days of MSL (Moores et al) is in press at IcarusTheir combination to describe dust & deposition over long timescales is new to this abstract.

Abstract Body: The atmosphere and surface of Mars both derive their characteristic colour from the presence of fine micron-sized dust. The two reservoirs are linked with the breakdown of surface materials creating the fine particulates that are lofted and redistributed across the planet. These particulates subsequently accumulate once again where atmospheric conditions permit.

This presentation will examine new data for dust deposition on Mars from recent results of the Phoenix and Mars Science Laboratory (MSL) Missions. First, the effect of surface orientation on accumulation rates is examined by comparing the Phoenix SSI Calibration targets with recent work on the wind telltale mirror, inclined at 50 degrees to the horizontal. Next we will describe estimated dust deposition rates from MSL.

The northern part of Gale Crater, where MSL is currently operating, is known to be a sink for dust. The suppressed boundary layer prevents vigorous atmospheric mixing and dust-devil formation and has been observed to be relatively dust-free (see Moore et al., this conference), consistent with a settling environment. As such, this location is a potential analogue for the kinds of environments that may have been involved in the formation of rhythmites on Mars.

To constrain the formation rates of such deposits, data from Gale for line-of-sight optical depth profiles will be used to estimate the net rate of delivery of dust to the surface. This will be compared to the rate of dust accumulating on the MastCam Calibration Targets and REMS UV sensors, as derived from the change in signal observed on these sensors over the first Martian Year of the Mission.

Abstract ID: 34387

Final Number: P34A-0253

Title: A Full Martian Year of Atmospheric Monitoring Movies From Gale Crater

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Abstract Body: Using images from the Navigation Camera (NavCam) onboard the Mars Science Laboratory (MSL) Rover Curiosity, atmospheric movies were created to discern time-variable features, such as clouds, across a series of images. To detect these features, two different pointings of the NavCam were used: a vertical pointing, used to create Zenith movies, and a more horizontal pointing aimed just above Mt. Sharp, used to create Supra-Horizon movies. The analysis of these movies over long timescales allow large-scale atmospheric patterns to become apparent.

Now, with a full Martian year of atmospheric monitoring movies, seasonal trends in the water cycle and optical depth within Gale Crater have become noticeable. Of the 65 Zenith movies and 74 Supra-Horizon movies collected during the first 334 sols of the mission (LS 150° to 350°), features were apparent in 22 of each, most of these occurring before sol 60. During the second half of the first Martian year (sols 335- 668), 25 of the 46 Zenith movies acquired showed some discernible feature upon mean-frame subtraction. The increase in cloud features can in part be attributed to the cooler temperatures and increased humidity within the crater due to Mars approaching aphelion near sol 475 (LS 60°).

Abstract ID: 34348

Final Number: P34A-0254

Title: Update on Line-of-Sight Extinction Seen within Gale Crater, Mars

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Published Material: Sols 100 - 360 initially reported in: Moores, J.E. et al., 2014. Observational evidence of a suppressed planetary boundary layer in northern Gale Crater, Mars as seen by the Navcam instrument onboard the Mars Science Laboratory rover.
http://dx.doi.org/10.1016/j.icarus.2014.09.020

Abstract Body: The line-of-sight optical depth within Gale Crater has been derived using the Navigation Cameras (Navcam) of the Mars Science Laboratory rover, Curiosity. The images used were initially obtained to observe dust devil frequencies within Gale Crater. All images point due north and contain the local ground, the distant crater rim, and the sky above the crater. The imaging parameters for this observation were standardized on sol 100. The line-of-sight optical depth is compared to column optical depth (using Mastcam) for sols 100 – 360 and is discussed by Moores et al. (2014). As we now have data up to sol 844, this observation has covered more than an entire Martian year. Moores et al. (2014) concluded that values for the line-of-sight extinction were less than the extinction seen in the column optical depth measurements made by Mastcam. After continuing observations we can draw similar conclusions. For the majority of the Martian year, we see a line-of-sight extinction that is less than the column extinction, indicating that the air within the crater is less dusty than the air above the crater. There is a period of 50 sols (sols 600-650; Ls ~ 130°) in the data in which the derived line-of-sight extinction matches the Mastcam column extinction; this suggests a period in which atmospheric mixing between the air inside the crater with the air surrounding the crater may occur.

Abstract ID: 34426

Final Number: P34A-0255

Title: Transmission Spectroscopy of Packed Simulated Mars Regolith

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Abstract Body: An investigation into how to better understand the phase-function of transmitted UV and VIS irradiation through packed Mars regolith stimulants is ongoing. The transmission spectra of Mars analog soils irradiated with a 300 Watt Xe arc lamp were collected using a mini-goniometer and spectrometer (wavelength range: 151.04 – 598.82 nm).

The regolith catalogue includes several sizes of sieved (45 – 850 µm) and un-sieved JSC Mars-1; other analogs that include acidic, alkaline, high salt, Phoenix, and aeolian martian simulants;, and a terrestrial basalt in fine and medium grain varieties. Samples were prepared to a thickness of 0.5, 1.0, and 2.0 mm using aluminum templates. Thicknesses less than 0.5 mm are in preparation to analyze the finer grain regolith simulants that have proven to be completely opaque at 0.5 mm.

Preliminary results showing the UV-VIS transmission as a function of wavelength and 3-diminsional space will be presented. The goals of this project are to both improve modeling of martian analog regoliths in radiative transfer codes and to assess the evaluation of the habitability of such analogs under martian conditions.

Abstract ID: 33784

Final Number: P34A-0256

Title: Raman analyses of thermolabile samples in various Martian conditions: implications for ExoMars

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Abstract Body: The Raman Laser Spectrometer instrument (RLS) onboard the ExoMars rover will fly to Mars in 2018. This rover will provide powdered samples to a suite of instruments inside the analytical laboratory drawer of the rover, including the RLS instrument. RLS will analyze up to 30 randomly selected points along a flat surface of the powdered samples. RLS will work autonomously by self-regulating the Raman acquisition parameters (integration time, number of accumulations) as a function of the sample under analysis. However, not all parameters can be adjusted during the operation phase, namely, the laser power and irradiance level on the sample. So, this parameter has to be fixed by design prior to flight. It is well known that thermolabile samples can be damaged (which means a reduction of the signal to noise ratio of the resulting spectra) if the energy provided by the laser cannot be thermally dissipated by the sample. Furthermore, this effect is worsened in low-pressure conditions, where the convective dissipation of the atmosphere is greatly reduced.

In order to study the performance of the instrument with different laser irradiance levels, we have performed a series of analysis on several thermolabile sulfates and oxides, including hematite, jarosite, coquimbite, and also organic carbon. These tests were performed at different temperatures ranging from -40 to -5ºC, in a 6mbar CO_2 atmosphere, which will be the operational conditions in which the samples will be found inside the ExoMars rover. A customized vacuum chamber was used to allow analyzing the samples under these conditions.

Though the behavior of the samples can be theoretically established, there are many factors that cannot be easily modeled in the theoretical calculations. Thus, this work in mainly aimed at experimentally observing the resilience of the samples with increasing laser irradiance on the sample surface, and the influence of the sample temperature on these results. The analysis is performed by evaluating the SNR values obtained with each different irradiance level. For these tests, 5 different points of each sample at 4 different temperature levels and 8 different irradiance levels were studied. This provided thousands of spectra that have been analyzed to obtain graphs and to assess the behavior of the samples vs the temperature and irradiance applied.

Abstract ID: 36224

Final Number: P34A-0257

Title: Andesite Weathering in a Hyperarid, Periglacial Environment: Implications for Mars

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Abstract Body: Widespread phyllosilicates have been identified in Noachian (4.5-3.7 Ga) terrains on Mars inferring the presence of past liquid water on the surface, and thus a habitable environment. To date, investigations of the potential weathering reactions on Mars have focused on basalt given the ubiquity of mafic minerals on the planet. However, there is increasing evidence of more siliceous deposits on Mars, especially in the Noachis Terra dacitic lava in the Nili Patera region and coarse-grained felsic deposits at the Bradbury landing site in Gale Crater. Therefore, there is a need to understand the weathering patterns and reactions of felsic materials on Mars. Full cycle weathering reactions under a hyperarid, periglacial environment were investigated in a dry, isolated depression in the Sur Lipez region of the Bolivian Altiplano (21º25'53.6" S 67º59'08.5" W). Andesitic Quaternary lavas, high sulfur concentrations, high temperature fluctuations, aridity, low ozone concentrations, and high solar radiance dominate the geology and climate of the region making the Altiplano an environmental analogue to early Mars. Preliminary XRD, SEM, and NIR investigations suggest freeze/thaw reactions dominate within the boulders surrounding the basin producing a series of fractures throughout the rocks. Physical degradation of the boulders results in small, highly weathered pebbles around the basin's edge. Within the pebbles glass is most susceptible to weathering followed by pyroxene > plagioclase laths > plagioclase phenocrysts > Fe-Ti oxides. Evidence of chemical weathering is also present as cavities within the pebbles become lined or filled with alunite from dissolution/ re-precipitation reactions with the aluminosilicates. Visible and near infrared data suggest the < 2 µm fraction collecting in the basin's center is dominated by montmorillonite and hematite. Further results from this study will aid in understanding the weathering processes of siliceous volcanic rocks during early Mars including the chemical trends during alteration and potential clay-forming processes.

Abstract ID: 36866

Final Number: P34A-0258

Title: Spectroscopic Characterization of Green Rust and its Implications for Mars Astrobiology

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Abstract Body: One mineral that may be particularly relevant to prebiotic chemistry on the early Earth, early Mars, and other wet rocky worlds is Green Rust (GR), a double layered Fe(II,III) oxyhydroxide with a hydroxylated brucite structure. Green rust forms readily in natural environments, and would have comprised a large fraction of chimneys precipitated at submarine alkaline hydrothermal vents on the early Earth where it has been proposed that metabolism emerged. As a double layer hydroxide GR has many interesting and useful properties: it can concentrate a variety of organic and phosphorus species in its interlayers, preserving them against degradation, and it is a versatile redox catalyst for reactions that might drive the emergence of life; e.g., the reduction of nitrate to ammonium. It is likely that GR and related minerals are still present on Mars today. If so, they may preserve biosignatures or tell us about the early Martian environment and its potential to give rise to life. To address these science questions and the challenges associated with the analysis of GR, we are simulating its formation in ancient hydrothermal systems and developing methods to detect, analyze, process, and preserve/cache these delicate minerals – particularly using spectroscopic technologies that will fly on upcoming Mars missions. GR was synthesized anaerobically in laboratory systems using chloride or carbonate iron salts, and the resulting precipitate analyzed laser Raman spectroscopy time-series. A total of 20 spectra were recorded at 5-min intervals. By the end of the experiment the initial green rust was completely oxidized into maghemite and ferrihydrite. The laser power at the sample surface was kept below <1mW in order to prevent thermally-induced oxidation. Quantitative analysis of the spectral time-series allowed us to constrain the kinetics of green rust oxidation and determine intermediate oxidation products, including goethite and hematite. Future experiments will study the stabilization of GR by trace components such as phosphates, and its ability to drive other proto-metabolic reactions and sequester organic molecules.

Abstract ID: 36245

Final Number: P34A-0260

Title: Spectral Reflectance Properties of Underdense Asteroid Regoliths Simulated by Pressed Pellets

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Abstract Body: A number of upcoming spacecraft missions are targeting low albedo asteroids, particularly the NASA-CSA OSIRIS-REx and JAXA Hayabusa-2 asteroid sample return missions. The target asteroids of these missions are a few hundred meters in diameter, and as a result their surfaces have microgravity environments. Due to the effects of microgravity and vacuum, the regoliths on the surfaces of these asteroids will likely be very loosely packed (termed underdense regoliths). Prior to sample acquisition, the target asteroids will be subjected to comprehensive mapping campaigns which will include a number of imaging spectrometers. This research aims to examine the spectral properties of dark asteroids by simulating loosely packed regolith in the laboratory, with the goal of aiding in the identification and remote characterization of scientifically interesting targets.

Underdense regolith samples were simulated by mixing potassium bromide (KBr, an optically transparent material) with serpentine. A spectral reflectance study (0.35-2.5 µm) was conducted on various ratios of KBr to serpentine, to simulate varying densities of underdense regolith. We measured the KBr-serpentine concentrations in two forms: pressed pellets (smooth and roughened surface) and loosely packed poured powder. This allows for a comparative analysis of the two forms as well as gaining a better understanding of how and whether properties of the mixtures we produced in the lab differ from properties of underdense regoliths. The spectral data has been analyzed in order to look for patterns in band depth, albedo and slope of the various sample concentrations. Preliminary findings show an increasing blueness of slope with an increase in the KBr:serpentine ratio, and this is qualitatively similar to the blue slope observed in Bennu spectra. Quantitative analysis of band depth in the 1 µm region indicates that a slight deepening occurs with increasing KBr percentage, however band positions do not appear to be affected. This data helps us to determine whether optically robust underdense regoliths can be simulated using pressed pellets and whether spacecraft measurements can be used to identify loosely packed regolith for suitable sampling regions.

Abstract ID: 35423

Final Number: P34A-0261

Title: The Io Volcano Observer (IVO)

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Published Material: Abstract submitted for EGU

Abstract Body: IVO, first proposed as a NASA Discovery mission in 2010, uses advanced lightweight solar arrays and a 1-dimensional pivot to achieve observing flexibility during a series of fast (~18 km/s) flybys of Io. All science objectives from the Io Observer New Frontiers concept recommended in the 2011 Planetary Science Decadal Survey are addressed by IVO's five instruments plus gravity science: Narrow- and wide-angle cameras (NAC and WAC), dual fluxgate magnetometers (DMAG), a thermal mapper (TMAP), and particle environment package for Io (PEPI) consisting of an ion and neutral mass spectrometer (INMS) and a plasma ion analyzer (PIA). A student collaboration hotspot mapper (HOTMAP) is also an option. The NAC and TMAP are on a ±90° pivot for off-nadir targeting during encounters and for distant monitoring. WAC and HOTMAP are mounted on the S/C nadir deck, and observe during ±20 minutes of Io closest approach. PEPI is mounted on the S/C structure with the INMS field of view in the ram direction when the S/C nadir deck points at Io, and the PIA and has a large (hemispheric) field of view to include the upstream direction. The DMAG sensors are on the end and middle of 3.8-m boom and collect data continuously.

IVO launches in 2021, arriving at Jupiter in early 2026. Its highly elliptical orbit with perijove near Io is inclined >40° to Jupiter's orbital plane, which provides opportunities to observe Io's poorly explored high latitudes and also minimizes total ionizing radiation dose compared to other Jupiter orbiters (<10% that of JUICE). Four of the encounters are designed for optimal measurement of induced magnetic signature from mantle melt. Two can be used for gravity science, pointing the high-gain antenna at Earth during the encounters. The final flyby includes a flythrough of Pele's plume, if it is active, for gas composition. Encounter periods last ~1

week, including global monitoring and four Io eclipses, with distant monitoring and data playback near apojove. The apoapse period of each orbit provides extended monitoring of Io and Europa at high phase angles (>120°), best to detect and monitor volcanic plumes as well as high-temperature hot spots on Io. IVO will collect at least 20 Gb of science data per encounter: 100 times the Io data from the 8-year Galileo tour.

Abstract ID: 35442

Final Number: P34A-0262

Title: Some remarks on global tectonics of Enceladus

Presenter/First Author: Leszek Czechowski, University of Warsaw, Warszawa,

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Published Material: Parts of the results are presented in EGU 2014.

Abstract Body: Enceladus, a satellite of Saturn, is the smallest celestial body in the Solar System where volcanic activity is observed. Every second, the mass of ~200 kg is ejected into space from the South Polar Terrain (SPT) – [1] .

The loss of matter from the body’s interior should lead to global compression of the crust. Typical effects of compression are: thrust faults, folding and subduction. However, such forms are not dominant on Enceladus. We propose here special tectonic model that could explain this paradox.

We consider here hypotheses stating that the mass loss from SPT is the main driving force of the following tectonic processes: subsidence of SPT, flow in the mantle and motion of plates. It is an extension of [2] and [3].

The numerical model is developed. It is based on the equations of continuous media. We found that the loss of the volatiles results in a void, an instability, and motion of solid matter into the hot region to fill the void.The motion is presented at the Figure and includes:

(i) Subsidence of the ‘lithosphere’ of SPT.

(ii) Flow of the matter in the mantle.

(iii) Motion of plates adjacent to SPT towards the active region.

If emerging void is being filled by the subsidence of SPT only, then the velocity of subsidence is ~0.05 $mm \cdot yr^{-1}$. However, all three types of motion are probably important, so the subsidence is slower but mantle flow and plates’ motion also play a role in filling the void. The preliminary results of the numerical model indicate that the the subsidence rate of ~0.05 $mm \cdot yr^{-1}$ is possible if we assume Newtonian rheology.

Note that in our model the reduction of the crust area is not a result of compression but of the plate sinking. Therefore the compressional features do not have to be dominant. Experimental model is developed to investigate the surface effects of the subsidence. I

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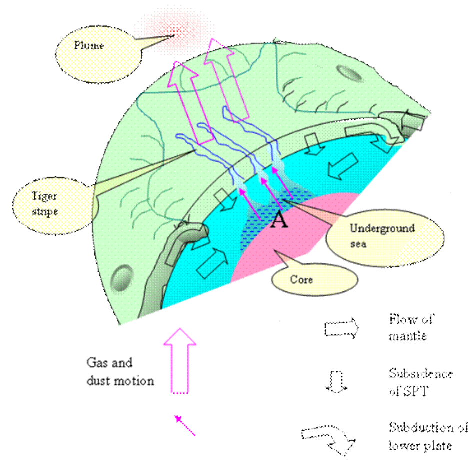

Abstract ID: 35687

Final Number: P34A-0263

Title: Self-tuned tidal resonance and the heating of oceans on icy satellites in the Solar System (and Universe)

Presenter/First Author: Robert Tyler, NASA Goddard Space Flight Center, Greenbelt, MD

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Published Material: Icarus, 2014

Abstract Body: Observations by the Galileo and Cassini spacecrafts have provided a strong indication that our massive water ocean is only one of at least several others in the Solar System. It seems clear that these oceans would have long ago frozen if not for an internal heat source. It also seems clear that in at least some of these cases (e.g. Enceladus), the heat sources previously presumed are insufficient. Recently, it has been shown by the author that if these oceans occupy one of several plausible resonant configurations, then the tidal response and associated dissipative heat can easily maintain liquid oceans on most of the large satellites in close orbits. It has also been shown that these resonant configurations are not just possible but may be inevitable because of a self-tuning effect; as an ocean attempts to freeze, it's eigenmodes are altered and it is pushed into the resonant configurations, with the increase in heat acting to stall further freezing.

More specifically, study of the parameter space of ocean tidal scenarios (where the parameters controlling the tidal response act as coordinates) show that energetic, resonantly forced tidal scenarios are stable configurations, at least until the available tidal energy in the orbit has been expended. Conversely, a satellite with thick ice and no water ocean is possible only if one or more of the following apply: 1) There was never

once a liquid ocean; 2) Available tidal forces were once insignificant, allowing the ocean to freeze; 3) The idealizations used in this study were once invalid for the ocean considered. Because of this expected feedback and self-tuning effect, a forward speculation is therefore that liquid oceans may be very common in the Universe.

Abstract ID: 34462

Final Number: P34A-0264

Title: Constraints on Lower Atmosphere Clouds from Perturbation Images Using the Huygens' Probe Descent Imager and Spectral Radiometer (DISR)

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Abstract Body: The Huygens Probe landed on the surface of Titan in early 2005 after separation from the Cassini spacecraft upon which it resided during its seven-year journey to the Saturn system. During its descent within the Titanian atmosphere, Huygens captured hundreds of still images using its three visual imagers, contained within the DISR instrument.

Following Huygens' landing, DISR continued to take images of the same scene of the surface for approximately an hour. At first glimpse these post-landing visuals may appear to be redundant; but in actuality they provide a rare opportunity to observe subtle changes within Titan's atmosphere when calibrated and compared with each other. Of the three imagers of DISR, only the Side Looking Imager (SLI) offered a view above the horizon once Huygens touched down on Titan. Our analysis will be restricted to data from this instrument.

For each image we isolated the pixels above the horizon, then radiometrically calibrated and co-added the images to increase the signal to noise ratio. Mean frame subtraction was performed on image sets which accentuated the differences between adjacent images following histogram stretching. The resulting image sets were animated in a loop to observe anomalies and patterns of interest for further analysis and to calculate the magnitude of the radiometric variation across the sky.

Abstract ID: 34558

Final Number: P34A-0265

Title: Seasonal Volatile Transport and Plumes on Pluto

Presenter/First Author: Bonnie J Buratti, NASA Jet Propulsion Laboratory, Pasadena, CA

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Abstract Body: The New Horizons spacecraft will reach Pluto for a close flyby in July 2015. To place this singular event within the context of temporal changes on Pluto, ground-based monitoring programs have been gathering observations on this dwarf ice planet for decades. Several lines of evidence support volatile transport on its surface: changes in the rotational light curve of Pluto beyond those expected from viewing geometry alone; changes in albedo patterns mapped by ground-based Hubble Space Telescope Maps (Buie et al., 2010, A. J. 139, 1117); and changes in atmospheric pressure(Young et al. 2013, Ap. J. Lett. 766, L22). Both Mars and Triton, the Neptunian moon that is Pluto's twin, exhibit seasonal volatile frost transport, and both have plumes or plume deposits on their polar caps that are believed to result from the sublimation of the cap. A dark substrate (dust in the case of Mars, and photolyzed methane in the case of Pluto) below nitrogen ice (Triton or Pluto) or carbon dioxide ice (Mars) heats up under solar insolation to create a solid state greenhouse effect. Subsurface volatiles sublimate and catastrophically outgas to form dark plumes. The similarities between Triton and Pluto, including surface temperature, size, obliquity, distance from the sun, and composition, coupled with the good evidence for currently active seasonal volatile transport of Pluto, lead us to predict this dwarf planet will have plumes similar to those on Triton. Given the lack of tidal heating on Pluto, these plumes will be the prime active process on Pluto's surface. During our campaign monitoring the lightcurve of Pluto, we discovered a remarkable opposition effect with the 24-inch telescope at Table Mountain Observatory. As this surge is not visible with the New Horizons spacecraft (it never achieves sufficiently small solar phase angles), its discovery illustrates another example in which ground-based observations are complementary to those of spacecraft.

Funded by NASA

Abstract ID: 34521

Final Number: P34A-0267

Title: Global 3D Radiation-Hydrodynamics Calculations of the Envelopes of Forming Planets Interacting with a Protoplanetary Disk

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Abstract Body: We present 3D radiation-hydrodynamics calculations of envelopes of forming planets, during the phase of sustained solids' accretion. The planets reside in a protoplanetary disk at orbital radii a_p=5 and 10 AU from a sun-like star, and are assumed to have formed according to the Core Nucleated Accretion scenario. The planets have cores ranging from 5 to 15 Earth masses. The protoplanetary disk extends radially from a_p/2 to 2a_p. The planets' envelopes are resolved at the core-radius length scale by using a system of nested grids. The gas is assumed to be a solar mixture of H2, H, He, and their ions. The equation of state includes contributions from non-translational states of H2 and from ionization of atomic species, as well as from radiation energy. The dust opacity assumes a distribution of grains ranging from 5e-6 to 1 mm and multiple grain species. The opacity calculation applies the Mie theory for non-porous particles. We use 1D calculations of planet formation to supply the 3D calculations with solids accretion rates. Results show that temperatures, masses, and gas accretion rates of 1D and 3D envelopes agree within factors of 2. Passive tracers are employed to study the circulation of the gas flow around the cores and identify the spherical region of bound gas, which formally defines the envelope of the planet. We find envelope radii comparable to or smaller than the Bondi radius, and significantly smaller than the Hill radius. We find differential (i.e., depth-dependent) rotation at the envelope equators, and an overall slow bulk rotation of the envelopes compared to that of the solar system outer planets. Yet, specific angular momenta of the planets are comparable to those of the solar system giant planets. The polar flattening is estimated at values <~0.05. We also use passive tracers to study the dynamics of the accretion flow. We find that this flow is not isotropic around the planet and characterize its angular dependence. We find that it preferentially impacts the envelope surface at mid to high latitudes. Support from NASA Outer Planets Research and Origins of Solar Systems Programs is gratefully acknowledged. Computing resources were provided by the NASA High-End Computing Program through the NASA Advanced Supercomputing Division at Ames Research Center.

Abstract ID: 34294

Final Number: P41A-01

Title: Fluvial to Lacustrine Facies Transitions in Gale Crater, Mars

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Published Material: The topographic profile and facies interpretations of the Peace Vallis fan have been published in Science and JGR. 2/3 of the abstract data have not been published.

Abstract Body: NASA's *Curiosity* rover has documented predominantly fluvial sedimentary rocks along its path from the landing site to the toe of the Peace Vallis alluvial fan (0.5 km to the east) and then along its 8 km traverse across Aeolis Palus to the base of Aeolis Mons (Mount Sharp). Lacustrine facies have been identified at the toe of the Peace Vallis fan and in the lowermost geological unit exposed on Aeolis Mons. These two depositional systems provide end members for martian fluvial/alluvial-lacustrine facies models. The Peace Vallis system consisted of an 80 km^2 alluvial fan with decimeter-thick, laterally continuous fluvial sandstones with few sedimentary structures. The thin lacustrine unit associated with the fan is interpreted as deposited in a small lake associated with fan runoff. In contrast, fluvial facies exposed over most of Curiosity's traverse to Aeolis Mons consist of sandstones with common dune-scale cross stratification (including trough cross stratification), interbedded conglomerates, and rare paleochannels. Along the southwest portion of the traverse, sandstone facies include south-dipping meter-scale clinoforms that are interbedded with finer-grained mudstone facies, interpreted as lacustrine. Sedimentary structures in these deposits are consistent with deltaic deposits. Deltaic deposition is also suggested by the scale of fluvial to lacustrine facies transitions, which occur over >100 m laterally and >10 m vertically. The large scale of the transitions and the predicted thickness of lacustrine deposits based on orbital mapping require deposition in a substantial river-lake system over an extended interval of time. Thus, the lowermost, and oldest, sedimentary rocks in Gale Crater suggest the presence of substantial fluvial flow into a long-lived lake. In contrast, the Peace Vallis alluvial fan onlaps these older deposits and overlies a major unconformity. It is one of the youngest deposits in the crater, and requires only short-lived, transient flows.

Abstract ID: 34422

Final Number: P41A-02

Title: Chemistry of sedimentary rocks at Gale crater, Mars: Alpha Particle X-ray Spectrometer (APXS) constraints.

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Abstract Body: Since landing within Gale crater, the MSL Curiosity rover has encountered a variety of sedimentary rocks as it traversed the crater floor, and since arriving at the base of Mount Sharp. Curiosity initially drove towards the Yellowknife Bay (YKB) area before driving towards Mount Sharp. Three waypoint locations: Darwin, Cooperstown, and the Kimberly were selected for more in-depth exploration by the rover along the route to Mount Sharp. Specifically, Curiosity's APXS instrument has acquired 138 rock and soil analyses since landing and embarking along the traverse to Mount Sharp, recording a diversity of rock compositions. A further 37 APXS analyses of the Murray Formation at the base of Mount Sharp have also been obtained. This has enabled the classification of sedimentary rocks into several primary compositional classes:

- The basaltic John Klein class, typified by the mudstones and siltstones encountered in YKB, as well as one sedimentary rock target at the base of Mount Sharp
- The basaltic, high Cr_2O_3 (~0.8 %) Shaler class, typified by cross-stratified sandstones encountered as Curiosity exited YKB, as well as one sedimentary rock target at the base of Mount Sharp
- The K_2O (~3 %), MgO (9-13 %), MnO (~0.5 %), and Zn (1200-4000 ppm) rich, Bathurst class typified by sandstones encountered at a number of different locations along the traverse, including on Bradbury Rise, and at the Cooperstown and Kimberley waypoints
- The moderate SiO_2 (~50 %) and alkali (~4.8%) content Darwin class, typified by coarse grained to pebbly sandstones at the Darwin waypoint and several other conglomeratic outcrops
- The low MgO (~5 %) and CaO (~4.1 %) Pahrump class, typified by mudstones and sandstones encountered within the Murray Formation at the base of Mount Sharp

We will examine how these classes, and comparisons to other, more likely igneous compositional classes, can be used to investigate provenance, as well as the diagenetic and alteration history of Gale crater sedimentary rocks.

Abstract ID: 35930

Final Number: P41A-03

Title: Phyllosilicates in fluvial-lacustrine sediments in Gale Crater as revealed by the Curiosity rover.

Presenter/First Author: Richard J Leveille, McGill University, Montreal, QC

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Published Material: Some of the mission results have been presented in papers by Vaniman et al. (2013), Léveillé et al. (2014) and in LPSC abstracts. This presentation summarizes some of the specific findings on phyllosilicates and adresses new questions related to cements and habitability.

Abstract Body: The Mars Science Laboratory (MSL) rover Curiosity has encountered diverse sedimentary rocks within Gale Crater. These rocks

provide an opportunity to understand weathering and diagenesis on early Mars and to assess past habitable conditions. Determining the chemical and mineralogical composition of rocks involves the coordinated interpretation of data from multiple instruments on Curiosity. CheMin X-ray diffraction results for the Yellowknife Bay mudstone (Cumberland, John Klein) and the Windjana sandstone established the presence of significant amounts of poorly crystalline phyllosilicates. The XRD features are most consistent with ferromagnesian smectites with and without collapsed interlayers. The Windjana sandstone also contains a high abundance of magnetite and K-feldspar. The Confidence Hills target in the Pahrump sandstone contains a lesser amount of a 1.0 nm phyllosilicate (10%), but more iron oxides, dominantly hematite. An amorphous component, present in all rocks analysed by CheMin so far, is likely Fe-rich. In the Yellowknife Bay lacustrine mudstone, fine-scale analyses by ChemCam of sub-cm diagenetic raised-ridges suggests the presence of Fe-Mg-phyllosilicates. As fluids deposited these clays in fractures, they may also have influenced pre-existing neoformed clay minerals in the mudstone. Geochemical modelling, using data from CheMin, ChemCam and APXS suggests that brackish, near-neutral pH fluids existed at moderate temperatures in a shallow near-surface environment. Analyses of elemental composition and mineralogy in Gale Crater are consistent with alteration of basaltic material with Fe and Mg mobility and the possible presence of nanophase Fe-oxide or Fe-Mg phyllosilicate cements. Rocks at Pahrump show evidence for greater chemical alteration; some phyllosilicates may have been removed or altered further by circulating fluids. As Curiosity is now exploring the base of Mt. Sharp, more Fe-Mg-bearing phyllosilicates are expected to be found based on orbital observations.

Abstract ID: 34220

Final Number: P41A-04

Title: The chemistry of sediments at the Lower Aeolis Mons (Mt Sharp) from ChemCam/Curiosity observations

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Abstract Body: The Curiosity rover has encountered a diversity of sedimentary rocks, which overall have displayed significant variations in both texture and composition. Early observations by the Curiosity rover in Gale crater revealed isolated outcrops of cemented pebbles and sand grains with textures typical of fluvial sedimentary conglomerates (Williams et al., Science, 2013). Conglomerates observed by Curiosity contain clasts with a strong diversity in albedo and textures indicating multiple sources on the Gale crater rims. Sandstones and mudstones observed at Yellowknife Bay were interpreted as having been deposited in a fluvio-lacustrine environment (Grotzinger et al., 2014). More stratified sandstones have been observed in the second and third terrestrial years of investigation in the outcrops named Cooperstown, Kimberley, and Pahrump. The latter outcrop corresponds to the lower Mt Sharp/Aeolis Mons based on orbital images and its facies is interpreted as fluvio-lacustrine sediments (Sumner et al., this meeting). The Pahrump sediments have major elements chemistry close to that of the conglomerates, suggesting a genetic relationship through the deposition of fluvial sediments from a similar source, likely the Gale crater rim. Pahrump sediments display subtle variations in major elements connected to variations in facies. There is an enhanced Mg content in resistant layers, which is correlated with a depletion in Fe and enhanced Al/Si ratios as well as enhanced hydrogen emission. These resistant layers have also a higher CIA (Chemical Index of Alteration) compared to the sediments previously encountered. These observations point towards the role of alteration during deposition and/or diagenesis during cementation in these sediments. Diagenesis did leave its imprint to these sediments as seen from the presence of cm-scale dendritic concretions, often enriched in Mg, S and Ni, suggesting fluid circulation during burial. Light-toned veins, observed as being calcium sulfates, postdate layers cementation as well as all other diagenetic features. In summary, Pahrump outcrop exhibits layers with a multiple role of water from the deposition of sediments in a fluvio-lacustrine system to their alteration and diagenetic evolution pointing towards a complex evolution in a climate warmer than the present one.

Abstract ID: 34304

Final Number: P41A-05

Title: Fresh Shallow Valleys in Northern Arabia Terra, Mars: Implications for the Post-Noachian Climate

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Published Material: About 30% of this material was presented as a poster at Fall 2014 AGU and at Mars 8 Conference in July, 2014.

Abstract Body: The working paradigm of the hydrologic evolution of Mars for many years envisioned a sudden decline in fluvial activity around the Noachian-Hesperian boundary, possibly related to the collapse of the early, dense atmosphere. A growing inventory of post-Noachian fluvial features, however, date to the late Hesperian to early Amazonian and may represent the last widespread episode(s) of aqueous activity that occurred during a climate characterized by a relatively thin atmosphere and thick global cryosphere. For example, concentrations of fresh shallow valleys (FSVs) are more widespread than previously reported, occurring in a latitude band from ~30-45° in both hemispheres. FSVs occur in the equatorial regions as well (e.g., possibly Gale crater and vicinity) but are often harder to distinguish from the older, Noachian valleys. FSVs in the northern hemisphere occur along the dichotomy boundary, with the highest concentration in northern Arabia Terra from 35-40°N between 0-20ºE. In this region, FSVs developed both on and away from ejecta of relatively fresh craters, making the direct association between impact processes and formation less likely. Many FSV systems are 150+ km long, and in several cases appear to cross depressions that were likely filled with ice or water during FSV formation. Most FSV systems could have formed from a single episode of erosion but incision of the main channel in some locations may imply episodic formation. Widespread occurrence of FSVs, their similar morphology, and modest state of degradation is consistent with most forming during one or more global intervals of favorable climate, likely through snowmelt from surface or sub-ice flows during the Hesperian. Craters with a single fluvial exit breach (nicknamed “pollywog craters”) imply the involvement of artesian groundwater flow. Crater statistics and cross-cutting relationships indicate the formation of FSVs terminated prior to about 1.4 Ga, suggesting they may be contemporaneous with alluvial fan and delta formation in the equatorial and mid-latitudes.

Abstract ID: 33394

Final Number: P41A-06

Title: Ancient Martian Lakestands and Fluvial Processes in Iani Chaos: Geology of Light-Toned Layered Deposits and their Relationship to Ares Vallis Outflow Channels

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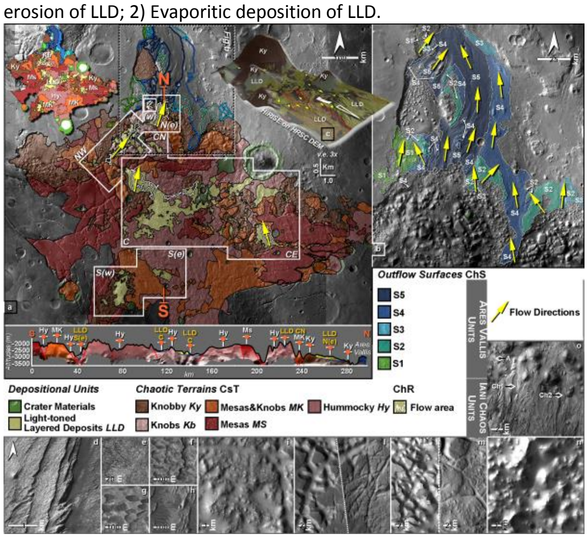
Published Material: LPSC 2012, Italian Geological Society Conference 2014, EGU 2015

Abstract Body: Iani Chaos lies at the head of the Ares Vallis outflow channels. Mapping of Ares Vallis reveals multiple episodes of erosion, probably linked to discharge events from the Iani Chaos aquifer. We present the first detailed geomorphological map of the region. Among five chaos units, distinguished by varying levels of modification (by erosion and fracturing), Light-toned Layered Deposits (LLD) have been mapped and described in Iani Chaos. LLD are characterized by a light-toned albedo, high thermal inertia and a pervasively fractured morphology. The LLD both fill the basins made by the collapsed chaotic terrains and are partially modified by the chaos formation. LLD also overlap chaos mounds or are themselves eroded into mounds after deposition. These stratigraphic relationships suggest that LLD deposition occurred episodically in the Iani region and throughout the history of the development of the chaos. Water seems to have had an active role in LLD deposition and erosion. The composition and morphologies of the LLD are consistent with deposition in an evaporitic environment, entailing stable water on surface. At the same time, we observed potential fluvial features (i.e., channels, streamlined islands, terraces, grooved surfaces) on the surface of the LLD. These landforms mark a fluvial system that can be traced from central Iani northward. Using topographic data, we compared the elevation of the LLD and channel units and find that their altitudes have been controlled by the Ares Vallis outflow events. This demonstrates that 1) a fluvial system within Iani was linked to the Ares Vallis channels system, characterized by five episodes of outflow at least, 2) the LLD are coeval with the Ares Vallis outflow channels. On the basis of our analysis, we propose a formation model of Iani Chaos, given by a cyclic alternation of two stages with time: 1) Fracturing and tectonic subsidence of the bedrock and outflows. Fluvial erosion of LLD; 2) Evaporitic deposition of LLD.



Abstract ID: 34005

Final Number: P41A-07

Title: Formation of Fluvial Gravel Pavements as an Explanation for Persistence of Ancient Cratered Terrain on Titan

Presenter/First Author: Alan D Howard, University of Virginia Main Campus, Charlottesville, VA

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Abstract Body: Portions of the equatorial region of Titan are fluvially eroded into banded (crenulated) terrain, some of which contains numerous circular structures that are likely highly degraded large impact craters. Such cratered terrain probably survives from the late heavy bombardment. A number of explanations for the survival of such terrain to the present epoch include very inefficient fluvial erosion, late acquisition of a dense atmosphere, and intermittent presence of sufficient methane in the atmosphere to support precipitation and runoff. No mechanism has been unambiguously demonstrated to operate on its surface that can chemically of physically break down ice that is likely the most important component of Titan's crust. We quantitatively model a scenario in which fluvial erosion on Titan has largely involved erosion into an impact-generated megaregolith that contains a modest component of gravel-sized debris. As the megaregolith is eroded, coarse gravel gradually accumulates as a lag pavement on channel beds, limiting further erosion and creating a dissected, but largely inactive, or senescent, landscape.

Abstract ID: 33980

Final Number: P42A-01

Title: Some Thoughts on Lithospheric Overturn on Venus

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Published Material: Some of this was shown at the Fall Meeting.

Abstract Body: Impact crater distribution on Venus indicates that the present surface is on average 750 Myr old. There has been considerable debate regarding the nature of the resurfacing, with progressive volcanism or catastrophic overturn endmember models. We present a series of 3D spherical convection simulations with a reasonable yield stress rheology and show that even with an initial degree-1 mantle structure, a lithospheric overturn event is characterized by a number of small downwelling instabilities. We constrain our simulations using the observed geoid, topography, heat flow, and melt production. Very large yield stresses result in a degree-1 type overturn; however the resulting geoid and topography are too large by at least an order of magnitude. We compare the distribution of downwelling instabilities with the global distribution of subduction sites proposed by Schubert and Sandwell (Icarus, 117, 173-196, 1995).

Abstract ID: 35196

Final Number: P42A-02

Title: Lithospheric Flexure, Stress, and Volcanic Edifice Morphology: A Connection for a Subset of Coronae on Venus?

Presenter/First Author: Patrick Joseph McGovern, Lunar and Planetary Institute, Houston, TX

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Abstract Body: The lithosphere responds to emplacement of volcanic materials by flexing. Flexure induces stress in the lithosphere that can influence subsequent ascent of magmas and thereby affect the shapes of the resulting volcanic edifices. Principal stress orientations and considerations of force balance on vertical dikes provide two stress-based criteria for determining where magmas can ascend. A key finding is that lithospheric thickness T_e and edifice shape are linked: thick lithospheres produce low stresses consistent with broad conical edifices, while thinner lithospheres produce higher stress magnitudes and shorter-wavelength flexural responses that can lead to construction of domical edifices and, at the lowest T_e values, annular-shaped topographic ridges. Annular structures are the primary characteristics of the morphometric (not genetic!) class of features known as coronae. Thus, I propose that construction of volcanic edifices upon lithosphere with low T_e can account for the formation of a significant fraction of coronae on Venus.

To constrain this fraction, I consider constraints on T_e from analysis of gravity and topography. Hoogenboom et al. [2004] used spatio-spectral localization of gravity/topography relationships to estimate T_e at 103 coronae on Venus, using top- and bottom-loading models of lithospheric flexure. Here I focus on the 65 coronae determined to be best-fit with a top-loading model, in accordance with the volcanic construction hypothesis. The overall distribution of best-fit T_e is skewed toward low values (mean 12 km, median 6 km), but with a long tail of values stretching up to 48 km. The high T_e values in this tail have been used to argue against the idea that thin lithospheres favor corona formation, but the strong skewing of the distribution toward zero supports this idea. Further, when coronae in the “Fracture Belt” geologic setting are excluded, the best-fit T_e distribution of the remaining 20 coronae has a mean of 6.4 km and median of 4.5 km, with all values less than 20 km (i.e., no tail). The distribution of the 45 coronae in the Fracture Belt setting, therefore, has all the members of the long tail. Further analysis of coronae in the Fracture Belt setting is warranted, to determine if the coronae composing the tail are anomalous in some structural or geographical manner.

Abstract ID: 34242

Final Number: P42A-03

Title: Refining the Stratigraphy of Venus Using the Distribution of Features in Shield fields: A Numerical Modeling and Mapping Study

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Published Material: Preliminary work on this topic was presented in LPSC abstracts in 2013 and 2014 by the two authors. Here we present expanded findings that are soon-to-be submitted to Computers and Geosciences (methods) and JVGR (results).

Abstract Body: Inferring the relative age of geologic units on Venus is challenging due to the paucity of impact craters. Although abundant cross-cutting relationships exist to provide insight into relative ages at the local scale, it is difficult to infer relative timing between distant units that do not have any features or structures in common.

Here we attempt to refine our stratigraphic knowledge of geologic units on Venus by using a suite of statistical tools to infer the relative timing between shield fields (clusters of small volcanoes) and the surrounding structures, particularly fracture sets. Specifically, we have developed MATLAB-based models to search for and characterize potential anisotrophy in the distribution of volcanic edifices in shield fields [1, 2]. Numerical model results are then compared with geologic mapping results to test for potential areas of correspondence [3-5]. The objective is to infer which set(s) of fractures may have been active when the shields were emplaced, thus helping to better place the shields into the local stratigraphic column.

An initial examination of four shield fields (Chernava Colles, Ran Colles, Jurate Colles, Urutonga Colles) yields some results as expected as some surprises. In Chernava Colles, the shield field exhibits a preferred orientation consistent with the dominant NNW-trending fracture set. However, in Ran Colles and Jurate Colles, the preferred orientation of the shields are consistent with the trend of wrinkle ridges rather than fractures, suggesting the reactivation of extensional fractures that may have previously served as conduits of flow material [4].

References:

[1] Thomson B.J. & Lang N.P. (2013) *LPSC*, abstract #2021.

[2] Thomson B.J. & Lang N.P. (2014) *LPSC*, abstract #2347.

[3] Lang N.P. & Thomson B.J. (2013) *LPSC*, abstract #1808.

[4] Lang N.P. et al. (2014) *LPSC*, abstract #2219.

[5] Kelly N.J. et al. (2014) *LPSC*, abstract #2884.

Abstract ID: 33937

Final Number: P42A-04

Title: Giant circumferential graben-fissure systems: A key to the recognition of Venusian corona analogues on Earth

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Abstract Body: Coronae are sub-circular tectono-magmatic structures on Venus, which typically have a raised annulus (up to c. 5 km in relief) and variable interior and exterior topography that allow division into a number of sub-types. The annulus is typically associated with a circumferential graben-fissure system and minor ridges. Graben-fissure systems are potentially linked to underlying dykes. Corona diameters are typically 200-300 km, but diameters up to >1000 km (and in the case of Artemis, 2600 km) are observed.

On Earth, several circumferential dyke swarms which are hundreds of kilometres in diameter have been recognized and are considered to be potential corona analogues (Ernst & Buchan, 1998, LPSC XXIX; Mäkitie et al., 2014, J. Afr. E. Sci.; Ernst et al., 2014, GSA Ann. Mtg.; Klausen et al., 2014, GSA Ann. Mtg.; Buchan & Ernst, this conf.). We summarize the characteristics of Venusian circumferential graben-fissure systems as a predictive guide to the recognition of terrestrial corona analogues: 1) sizes are typically hundreds of kilometres in diameter but can sometimes extend beyond a thousand kilometres ; 2) circumferential systems often only partially circumscribe their related corona; 3) circumferential systems are occasionally associated with radiating graben-fissure systems, and when they are, the foci of the radiating component can be offset from the center of the circumferential component; and 4) circumferential systems can occur as clusters. In addition, it should be noted that if circumferential dyke swarms on Earth are analogues to Venusian coronae then they should have had a primary raised annulus and other related topographic features that have since been eroded, but which may be recognized from the sedimentary record.

Abstract ID: 34898

Final Number: P42A-05

Title: A Giant Circumferential Dyke Swarm Associated with the High Arctic Large Igneous Province (HALIP) – a Possible Analogue for Coronae on Venus

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Co-authors: Richard E Ernst, Ernst Geosciences, Ottawa, ON, Canada

Abstract Body: Giant sub-circular tectono-magmatic features called coronae are common on Venus. They may be associated with mantle plumes or diapirs, are typically hundreds of kilometres in diameter, and usually have a raised annulus with an associated circumferential graben-fissure system that may be underlain by dykes. On Earth, corona analogues appear to be rare, perhaps because erosion has removed the distinctive topographic features. However the dyke swarms should persist. An excellent example of a giant circumferential swarm has been reported recently at Lake Victoria in Africa and there are several other tentative examples. We identify a giant circumferential swarm associated with the 125-80 Ma High Arctic Large Igneous Province (HALIP) and its previously documented giant radiating swarm. The circumferential dykes are roughly perpendicular to the radiating dykes. However, the centre of the circumferential swarm appears to be slightly offset (~200 km) from the focus of the radiating swarm, a feature of some venusian coronae. The circumferential swarm has a diameter of ~1200-1600 km. It is most clearly visible in reconstructions of North Greenland, Svalbard and Franz Josef Land, where segments of the swarm fall along an arc of ~100°. An extension of the swarm into the Canadian Arctic islands is likely, but more speculative, because of uncertainties in undoing deformation associated with the Eurekan orogeny on Ellesmere and Axel Heiberg islands and the presence of dykes of other discordant trends. The age ranges of the circumferential and radiating swarms are uncertain, although many radiating dykes are associated with the early part of the HALIP event and a single dyke associated with the North Greenland portion of the circumferential swarm has previously been dated at 82±1 Ma (Ar-Ar), near the end of the event. Identifying giant circumferential swarms on Earth is important for understanding the evolution of large igneous provinces and interpreting coronae on Venus.

Abstract ID: 36124

Final Number: P42A-06

Title: Emplacement of Volcanic Domes on Venus

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Published Material: A portion of the findings in this abstract were presented at the 2014 Lunar and Planetary Science Conference in The Woodlands, TX, USA. As of the submission date of this abstract, none of the findings are under review and they have not been recently accepted by a scientific journal.

Abstract Body: One key to understanding the resurfacing history of Venus is placing firmer constraints on the emplacement timescales of visible volcanic features. 175 steep-sided domes, with diameters ranging from 19-94 km and estimated thicknesses as great as 4 km, have been identified on Venus. These domes are thought to be volcanic in origin. Among the unanswered questions surrounding their formation are their composition, emplacement duration, and the rheology of the lava that formed them. Rheologically speaking, maintenance of 1-4 km thick flows necessitates higher viscosity lavas, while the domes' smooth upper surfaces imply the presence of lower viscosity lavas. We have investigated the emplacement of volcanic domes on Venus, exploring the effect of boundary conditions on a similarity solution of the Boussinesq equation for pressure driven fluid flow in a cylindrical geometry. The new approach used here addresses time dependent changes in lava viscosity due to cooling and eliminates singularities inherent in previous models for dome relaxation. Two distinct scenarios are explored: one in which a constant volume of fluid (i.e., lava) is rapidly emplaced onto the surface, and another in which the volume of lava on the surface increases over time (i.e., a volumetric flowrate approach). We compare theoretical dome thickness profiles for radially expanding Newtonian fluid to the shape of a typical Venus dome. For the constant volume approach, we find that at the onset of relaxation, bulk lava viscosities lie between 10^{10}-10^{16} Pa-s. Results for the volumetric flowrate scenario suggest a bulk lava viscosity of 10^{12} - 10^{13} Pa-s and emplacement times of approximately 2 - 16 years. Because the chilled lava crust can increase the apparent viscosity of lava flows up to four orders of magnitude greater than the actual viscosity of the fluid lava, our results suggest dome compositions more consistent with terrestrial basaltic andesites than rhyolites.

Abstract ID: 34818

Final Number: P42A-07

Title: Laboratory high-temperature emissivity measurements of Venus analog measurements in the near-infrared atmospheric windows

Presenter/First Author: Jorn Helbert, German Aerospace Center DLR Berlin, Berlin,

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Published Material: First findings have been reported at the AGU fall meeting

Abstract Body: The permanent cloud cover of Venus prohibits observation of the surface with traditional imaging techniques over most of the visible spectral range. Venus' CO_2 atmosphere is transparent exclusively in small

spectral windows near 1 µm. The Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) team on the European Space Agency Venus-Express mission have recently used these windows successfully to map the southern hemisphere from orbit. VIRTIS is showing variations in surface brightness, which can be interpreted as variations in surface emissivity. Deriving surface composition from these variations is a challenging task. Comparison with laboratory analogue spectra are complicated by the fact that Venus has an average surface temperature of 730K. Mineral crystal structures and their resultant spectral signatures are notably affected by temperature, therefore any interpretations based on *room temperature* laboratory spectra database can be misleading.

In order to support the interpretation of near-infrared data from Venus an extensive measurement campaign is underway at the Planetary Emissivity Laboratory (PEL, Institute of Planetary Research of the German Aerospace Center, Berlin). The PEL facility, which is unique in the world, allows emission measurements covering the 1 to 2 µm wavelength range at sample temperatures of up to 770K. Conciliating the expected emissivity variation between felsic and mafic minerals with Venera and VEGA geochemical data we have started with a set of five analog samples. This set includes basalt, gneiss, granodiorite, anorthosite and hematite, thus covering the range of mineralogies. Preliminary results show significant spectral contrast, thus allowing different samples to be distinguished with only 5 spectral points and validating the use of thermal emissivity for investigating composition.

This unique new dataset from PEL not only allow interpretation of the Venus Express VIRTIS data but also provide a baseline for considering new instrument designs for future Venus missions.

Abstract ID: 34269

Final Number: P42A-08

Title: Geologic Analysis of the Near-Infrared Images of the Surface Taken by the Venus Monitoring Camera, Venus Express

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Published Material: Papers in Icarus and PSS in 2012, submission under review in Nature GeoscienceLPSC meetings in 2012 and 2014

Abstract Body: We analyzed night-time near-infrared (NIR) thermal emission images of the Venus surface obtained with the 1-micron channel of the Venus Monitoring Camera onboard Venus Express. There were several directions of our analysis. (1) We studied if tessera terrain has the different NIR emissivity (and thus might have different mineralogic composition) in comparison to the surrounding basaltic plains. Our analysis showed that NIR emissivity of tessera surface material is by 15–35% lower than that of relatively fresh supposedly basaltic lavas of plains. This is consistent with hypothesis that the tessera material is not basaltic andmaybe felsic. (2) We found that the surface materials of plains around Chimon-mana tessera are very variegated in their 1-micron emissivity, probably reflecting differences in degree of their chemical weathering. (3) We also found a possible decrease of NIR emissivity at the top of Tuulikki Mons volcano which may be due to different, possibly more felsic composition of volcanic products on the volcano summit. (4) We have also foundseveral transient bright spots which suggest ongoing extrusions of lava flows causing significant elevation of surface temperatures. These bright spots occur in Ganiki Chasma, an extensive linear rift zone known to represent a stratigraphically youngest tectonic activity. The very strong spatial correlation of the transient bright spots and the Ganiki rift zone boundaries and their similarity to locations of rift-associated volcanism on Earth, provide strong evidence for their volcanic origin

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PRECAMBRIAN GEOLOGY

Abstract ID: 34078

Final Number: PG11A-01

Title: Using U-Pb, Lu-Hf and O Isotopes in Zircons to Unlock the Crust-Mantle Evolution and Relationships to Mineral Systems of the Marmion Terrane (3.02-2.68 Ga), Superior Province, Canada

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Published Material: Only some preliminary U-Pb results by SHRIMP were reported in an article to the OGS Summary of Field Work and Other Activities and within a poster at the Centre for Exploration Targeting Members' Day.Bjorkman, K.E., McCuaig, T.C., Lu, Y.J., Beakhouse, G.P., Hollings, P. and Smyk, M.C. 2014. The Marmion terrane four-dimensional crust–mantle evolution and mineral systems: An update; in Summary of Field Work and Other Activities 2014, Ontario Geological Survey, Open File Report 6300, p.12-1 to 12-13.Bjorkman, K.E., McCuaig, T.C., Lu, Y.J., Hollings, P. Fiorentini, M.L., Kemp, A.I.S (2014) The 4D crust-mantle evolution and mineral system distribution of the 3.0 Ga Marmion Terrane, Western Superior Craton, Canada; in CET Corporate Members'' Day 2014, University of Western Australia, Crawley, 6009, WA, Australia

Abstract Body: The architecture of the lithosphere focuses the transfer of fluid, mass and energy from the Earth's mantle to crust, thereby controlling the location of many major mineral systems. Modeling the crust-mantle evolution through time and space can therefore provide mappable exploration criteria for mineralization. Isotopes of Hf and O provide insight into rates, processes and setting of crust-mantle growth and can serve as "paleogeophysics" to image the 4D lithospheric architecture. We use isotopes of U-Pb, Lu-Hf and O in zircons to identify major lithospheric blocks of the Marmion Terrane (3.02-2.68 Ga), Wabigoon Subprovince, Superior Craton. This provides insight into crustal growth rates and processes across the Meso to Neoarchean transition.

Other multi-isotopic mapping of Archean cratons has typically been craton-wide, and because of the scale have large sample spacing. This study focuses on a geologically complex, yet well-characterized terrane to give detailed context to the results of larger studies. Nine lithotectonic domains

over 300 myr are preserved in crustal and supracrustal events in the south-central Wabigoon Subprovince. U-Pb geochronology by SHRIMP confirms magmatic age domains at 2.99-3.02, 2.93-2.94, 2.89, 2.82-2.83, 2.78-2.80, 2.70-2.73, and 2.67-2.68 Ga. Large portions of postulated terrane boundaries within the study area are obscured by post-tectonic granitoid batholiths and are not observable in geophysics or geology. Au, Ni-S, Cu-Zn and Fe mineralization are localized in Meso-Neoarchean greenstone belts and proximal TTG batholiths of the terrane.

We present multi-isotopic, geochemical and petrographic results of granitoid rocks across the Marmion terrane. The results map the internal and external boundaries of the Marmion Terrane, showing that crustal growth across the Marmion terrane largely occurred by progressive magmatic addition and reworking of older crust.

Abstract ID: 35136

Final Number: PG11A-02

Title: Ca. 2.17 Ga mafic magmatism in the Superior Craton: a case for a rift-related LIP

Presenter/First Author: Dejan Milidragovic, Laval University, Quebec City, QC

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Abstract Body: Significant volumes of mantle-derived magma, evidenced by extensive mafic dyke swarms and thick gabbroic sills, intruded the Superior Craton during the Paleoproterozoic (ca. 1880-2500 Ma). The Otish Gabbro, Biscotasing, and Payne River suites and the coeval mafic volcanics in the Labrador Trough were emplaced along the southern and eastern present-day margins of the Superior craton at ~2.17 Ga. The ~2.17 Ga magmas were variably enriched in FeO, TiO_2, and incompatible elements relative to modern mid-ocean ridge basalts, suggesting contributions from at least three geochemical reservoirs (continental crust, asthenosphere, and metasomatized lithosphere). The relatively unfractionated Ti/Yb_{MORB} ratios (0.9-3.0) suggest that the ~2.17 Ga mafic magmas largely equilibrated at depths ≤100 km, near the spinel-garnet transition.

Estimated potential temperatures during the Paleoproterozoic (≥1550ºC) constrain the pressure of melting of ambient mantle to a minimum depth ~50 km under a thin crustal lid. Due to a sharp increase in dP/dT slopes of mineral stability surfaces at higher temperatures, melting in a significantly hotter Proterozoic mantle (ΔT =+100ºC) will cease at significantly greater depths, well within the garnet stability field. Consequently, the relatively shallow depths of equilibration of ~2.17 Ga mafic magmas of the Superior Craton are inconsistent with derivation from anomalously hot mantle plume(s). Instead, the geochemical character of ~2.17 Ga magmas suggests derivation by decompression melting of metasomatized lithosphere and of upwelling asthenospheric mantle during regional lithospheric thinning. The metasomatism of lithosphere is attributed to prior Paleoproterozoic events, possibly involving ca. 2.5 Ga mantle plume activity. The lithospheric thinning along the eastern and southern margins of the Superior Craton resulted in extensive replacement of the depleted Archean lithospheric root by fertile Proterozoic lithospheric mantle to depths of ≤ 100 km.

Abstract ID: 34512

Final Number: PG11A-03

Title: Visualisation of Plate Reconstructions for the Archaean: an example from the Superior Craton

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Abstract Body: Investigation of deep time plate tectonic reconstructions and of the blocks they represent is possible, using modern software tools and a number of simple approximations for the spatial context of the various blocks. Although not spatially accurate in a true global geographic setting, relative spatial and time constraints can be honoured. This has the advantage that one can investigate various reconstruction settings and scenarios so as to develop a better understanding of the geological evolution. Reconstructions reflect palaeolatitude derived from palaeomagnetic data, where available, together with structural vergence directions as a way to move apart crustal blocks. GPlates or Paleogis software platforms may be used for representation, so permitting one to illustrate changing location of igneous and metamorphic activity (as points for individual geochronology samples and as polylines for dyke swarms); changes in geochemical signature relative to location and time; location of different styles of ore deposit and mineralisation and any other features that can be captured in GIS with time attribute information. In cases where lithostratigraphic attribute information are available from digital geological maps, it is also possible to use these in continuously varying time or as a succession of integrated time-slice maps. Background raster images reflecting regional gravity, aeromagnetics or radiometrics move with the associated domain blocks so facilitating the matching of features across blocks in cases where alternative reconstructions may need to be considered. In the case of the Superior Craton, utilisation of these techniques helps emphasise the unique isotopic character of the Abitibi domain relative to other blocks, requiring a protracted depleted source in its lithosphere for millions of years prior to the development of volcanic-hosted massive sulphide mineralisation at about 2700 Ma, quite unlike the situation in the other terrains of the craton.

Abstract ID: 33501

Final Number: PG11A-04

Title: Age and Evolution of Deep Continental Roots beneath Northern Canada

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Published Material: Part of the data were recently presented in a poster at AGU, 2014. No journal publication yet.

Abstract Body: The age, composition and extent of Archean lithosphere is well documented beneath the Slave Craton. Little is known, however, about the deep continental roots beneath the rest of Canada's vast north, despite the discovery of many new diamond-bearing kimberlites. Here we present age and composition information for kimberlite-borne peridotite xenoliths from the central Rae Craton (two localities: Repulse Bay and Pelly

Bay) and central Victoria Island (CVI - a possible northern extension of the Slave Craton), and the Parry Peninsula (a possible new micro-craton- the Mackenzie craton), to investigate the nature and evolution of the deep lithosphere in these regions.

The peridotites from the central Rae Craton, CVI and Parry Peninsula are generally characterized by high forsterite contents (Fo 92-93) and low whole-rock Al_2O_3 contents (< 2 wt.%, many < 1wt.%), similar to typical cratonic peridotites worldwide. However, these peridotites show a large span in Re-depletion model ages (T_{RD}). For the central Rae Craton, both localities preserve evidence of Archean parentage, with more of the Repulse Bay samples yielding Archean T_{RD} ages (>2.5 Ga) than for Pelly Bay. They also show significant Paleoproterozoic (1.6 to 2.2 Ga) ages that indicate reworking or newly formed lithospheric mantle in this period, contrasting with the little disturbed central Slave lithosphere by other studies. This event was most likely associated with either the Thelon-Taltson orogen in the west or the Trans-Hudson orogen in the southeast.

Despite having highly depleted mineral and bulk compositions, we find no definitive evidence of Archean lithosphere beneath the Mackenzie craton (Parry Peninsula peridotites). Similarly, the CVI peridotites yield no Archean TRD ages but are dominated by Paleoproterozoic ages (1.5 to 2.3 Ga). For both CVI and the Mackenzie craton, the local deep lithosphere is more likely an extension of the Wopmay orogen (ca. 1.9 Ga) rather than the northern or western extension of the Slave Craton.

Deep, refractory, diamond-bearing lithosphere can form in post-Archean times, perhaps in subduction zone settings.

Abstract ID: 35532

Final Number: PG11A-05

Title: Geochemistry of the Wijinnedi-Snare, Courageous-MacKay, and Lac du Rocher/Camsell Lake volcanic belts of the Slave craton

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Published Material: Earlier/preliminary findings were presented at the 2014 Yellowknife Geoscience Forum, NWT.

Abstract Body: Archean volcanic belts throughout the Slave craton host gold deposits, several volcanogenic massive sulphide (VMS) deposits and numerous VMS prospects. This study provides a comprehensive comparison of three bimodal volcanic belts across the southern Slave craton; the ca. 2674 Ma Wijinnedi-Snare volcanic belt; the Courageous-MacKay volcanic belt, with ca. 2810 Ma basement overlain by ca. 2700 Ma Cycle I and ca. 2670 Ma Cycle II volcanic packages; and the ca. 2672 Ma Lac du Rocher/Camsell Lake volcanic belt.

Mafic volcanic rocks are tholeitiic to calc-alkaline and display MORB – BABB signatures, with flat chondrite-normalized patterns. The associated intermediate and felsic volcanic components are calc-alkaline and have two predominant chondrite-normalized patterns; the first group shows enrichment in LREE and a steep HREE slope, while the second has similar LREEs, a negative Eu anomaly, and a distinctly flat HREE pattern. Within the Courageous-MacKay belt, Cycle I volcanic unit hosts the DEB VMS deposit, while the Cycle II sequence hosts the Tundra, Salmita and FAT gold deposits. The lower stratigraphic felsic unit hosting the DEB deposit are FII rhyolites, referred to a Superior craton-type classification scheme. While FIII rhyolites are characteristic of most large VMS deposits in the Superior, FII rhyolites are host to a number of Archean VMS deposits. The depositional settings of all three volcanic belts are consistent with a VMS-bearing environment, with VMS-like occurrences recorded at multiple locations.

Neodymium (Nd) isotope analyses of whole-rock samples were targeted for individual belts, stratigraphic levels, and relationship to basement material. Intermediate to felsic volcanic rocks from Wijinnedi-Snare belt have εNd_i values between +0.9 and +2.1. Lac du Rocher samples have εNd_i between +2.0 and +2.5. The Courageous-MacKay belt has a range between εNd_i of +0.7 and +5.2. The data indicate that volcanic rocks include a dominant mantle component, with some crustal assimilation, regardless of proximity to basement. Results are anticipated to advance the knowledge of the Slave craton stratigraphy, provide further insights into Archean magmatism, and assist in the identification of VMS prospective volcanic belts.

Abstract ID: 36304

Final Number: PG11A-06

Title: The Complex History of the Slave Craton Lithospheric Mantle Root in the Context of Regional Tectonics

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Abstract Body: The Slave craton is one of the smallest recognised cratons worldwide. It is surrounded by Paleoproterozoic orogenic belts, Wopmay/Great Bear on the west and the Taltson-Thelon on the east and south. Several Proterozoic diabase dike swarms cut the Slave, the most intensive of which being the ~1.27 Ga Mackenzie LIP. Using peridotite xenoliths derived from kimberlites we present a N-S transect across the craton with the aim of examining the effects of these post-Archean events on the composition, age and depth of the lithospheric root. We present new Re-Os isotope data for peridotite xenoliths from Gahcho Kue (southeast Slave), Diavik (central Slave), and the Artemisia kimberlite (northern Slave), that are integrated with previously available data. Late Archean minimum Re-depletion ages dominate the lithospheric mantle of the central Slave and the small available dataset for the southern Slave. Archean ages are present at Jericho, in the lower part of the North Slave but there is an increasing proportion of Paleoproterozoic and Mesoproterozoic Re depletion ages. In contrast, Archean depletion ages are absent from Artemisia, where the peridotite suite is dominated by Proterozoic depletion ages. Progressing North from the Central Slave there is a decreasing proportion of Archean model ages in the lithosphere, through Jericho to Artemisa. Approximately 70% of the dataset at Artemisia give Re depletion ages within error of the Mackenzie LIP event, with a secondary component (~ 30%) close to the Wopmay/Taltson orogenic events. This age spectrum in the far North of the Slave Craton, combined new data from regions to the N and NW of the Slave craton indicate the likelihood of major new lithosphere generation in both the Paleoproterozoic and Mesoproterozoic and adds to the growing evidence for the generation of stable "cratonic-like" lithospheric mantle in the

Proterozoic (e.g., the Siberian craton). This observation, if correct, has major implications for post-Archean diamond sources.

Abstract ID: 36250

Final Number: PG11A-07

Title: Age and provenance of Archean basement and Paleoproterozoic supracrustal rocks within Wopmay orogen

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Published Material: A previous version of the this oral presentation was given at the Yellowknife Geoscience Forum, November 2013, Yellowknife, NT

Abstract Body: The Paleoproterozoic Wopmay orogen is bounded in the east by the Slave craton. Bisecting the orogen is the Wopmay fault zone (WFZ) and west of it is the >1.93-1.89 Ga Hottah terrane and 1.875 to 1.85 Ga Great Bear magmatic zone. East of WFZ and west of Slave craton, polydeformed Neoarchean rocks are overlain by Paleoproterozoic strata. In one interpretation, these rocks began as part of the Hottah terrane, were thrust over the Slave craton during Calderian orogeny, and are preserved as a klippe ("Turmoil klippe"). Other interpretations suggest these Archean rocks are reworked from the Slave craton.

The extent and character of Archean rocks in the southern Wopmay orogen (between 63°N and 66°N) has been refined through bedrock mapping, U-Pb geochronology, and Nd isotope geochemistry. Results indicate the Mesoarchean and ca. 2580 Ma plutonic rocks have a Slave craton provenance, including those in the type section to the Turmoil klippe (Bent gneiss). Screens of Archean supracrustal rocks occur within granites and are correlatable to the Duncan Lake Group of the Slave craton. Paleoproterozoic quartzite, marble, and siltstone were deposited directly on deformed Archean basement and exposed as a series of domes and basins, metamorphosed between greenschist and granulite grade. Detrital zircons from the overlying quartzites have 2.7, 2.67, 2.60, 2.58 Ga, and 2.03 Ga ages, supporting a provenance from the Slave craton and the initial rift in Wopmay orogen. One sample contains the Slave spectra, along with ca. 2.33, 1.97, and 1.93 Ga detrital zircons that are similar to the Hottah terrane and Taltson magmatic zone. These strata may best be correlated to the Akaitcho Group, although a high component of Slave detritus has not been previously recognized in these sedimentary rocks.

The Archean rocks in Wopmay orogen began as part of the Slave craton. However, ca.2580 Ma granitic rocks in the Slave craton are not deformed, whereas those in Wopmay orogen underwent ductile deformation prior to and after deposition of the overlying strata. The post-Archean deformation is interpreted to be a result of initial rifting at ca. 2.02 Ga, followed by post-sedimentation folding and thrusting. The area east of WFZ is interpreted as an imbricate structure (duplex?) shoved over the western margin of the Slave craton during ca. 1.88 to 1.85 Ga deformation.

Abstract ID: 36539

Final Number: PG12A-01

Title: Questioning Myths of the Middle Proterozoic Time

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Abstract Body: The middle age of the Earth, the so-called 'Boring Billion', attracted growing interest in the last decade. It is generally accepted that C isotope variations in seawater were muted in the aftermath of the ~2.22-2.1 Ga Lomagundi C isotope excursion until ~1.3 Ga. Seawater Sr composition, a proxy for hydrothermal vs. terrestrial fluxes, seems to be also invariant during that time, while it subsequently sharply rose starting at ~800 Ma. Redox history of the atmosphere and oceans in the Middle Proterozoic seems uneventful; it is generally assumed that deep oceans were anoxic and Fe-rich (ferruginous) and atmospheric oxygen was low until the late Neoproterozoic. The exact timing and trend of the Neoproterozoic oxygenation event are still uncertain, with views ranging from those favoring the Ediacaran to those arguing for pre-Sturtian oxygenation recently advocated. These patterns were broadly related to sluggish tectonics, with possible shutdown or slowdown of plate tectonics limiting nutrient fluxes and biological productivity.

We will present results of our ongoing work challenging some of these interpretations and pointing towards a more dynamic history of seawater redox and its chemical composition in the Middle Proterozoic. Specifically, our data point to a short-lived carbon isotope excursion with a large magnitude at ~2.03 Ga. Deep-oceans were likely in a suboxic state during the 'Boring Billion', e.g., capable to partially oxidize Fe and, possibly, Mn. Atmospheric oxygen started to rise before 1.3-1.4 Ga, reaching the peak before the ~810 Ma Bitter Springs Excursion and was highly variable in its aftermath in association with climatic changes and changes in biogeochemical C cycle. Atmospheric oxygen likely rose high and fell back several times in the Proterozoic before the emergence of Metazoans in the late Neoproterozoic.

Abstract ID: 36802

Final Number: PG12A-02

Title: Proterozoic Atmospheric Oxygen Levels

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Published Material: A portion of this reasearch was publisehd in Science in 2014.

Abstract Body: The oxygenation of Earth's surface fundamentally altered global biogeochemical cycles and ultimately paved the way for the rise of metazoans at the end-Proterozoic. However, current estimates for atmospheric O_2 levels during the billion years leading up to this time vary widely. Based on Cr isotope data from a suite of Proterozoic sediments from China, Australia and North America, interpreted in the context of data from similar depositional environments from Phanerozoic time, we find evidence for inhibited Earth surface Cr oxidation in the mid-Proterozoic (1.8 to 0.8 billion years ago). These data suggest that atmospheric oxygen levels were at most 0.1% of present atmospheric levels. Direct evidence for such low O_2 concentrations in the Proterozoic helps explain the late emergence and diversification of metazoans.

Abstract ID: 34857

Final Number: PG12A-03

Title: Sedimentary and Geochemical Heterogeneity in the Mesoproterozoic: A Natural Consequence of Protracted Oxygenation?

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Abstract Body: Late Mesoproterozoic (1.3 to 1.0 Ga) sedimentary basins have long been considered enigmatic. Despite relative stability in the biological realm, late Mesoproterozoic strata preserve an incredible diversity of stromatolite morphology. Carbonate facies similarly display a broad range of carbonate fabrics, including water-column micrite, sea-floor precipitates, molar-tooth microspar, and herringbone carbonate, each of which had been described previously as time-distinctive Precambrian facies. Late Mesoproterozoic sedimentary basins are also increasingly likely to preserve deposits of bedded marine gypsum, compared to older sedimentary successions, despite geochemical evidence for extremely low marine sulfate concentration. Finally, although early data suggested prolonged geochemical stasis, a growing body of evidence from black shale facies indicates variably oxic, euxinic, and ferruginous marine conditions.

At first glance, the diversity of sedimentary facies and geochemistry preserved in these basins hampers efforts to define long-term changes in the Earth's global biosphere. Do differences between basins reflect local overprinting of a global signal? Do differences between basins reflect secular change at rates unresolvable by our current geochronology? Or do differences between basins reflect an underlying heterogeneity of the late Mesoproterozoic ocean system?

Here we review sedimentary fabrics and geochemistry of the 1.12 Ga Atar Group, Mauritania, West Africa. The Atar Group preserves nearly the full range of sedimentary facies that is observed in other Late Mesoproterozoic, carbonate-dominated basins. The arrangement of these facies, both spatially and stratigraphically, in combination with geochemical evidence, suggests that much of the heterogeneity preserved across late Mesoproterozoic basins can be explained by the dynamic interaction of the marine substrate, sea level, and a chemically stratified water column. We highlight a scenario wherein heterogeneity of both facies and geochemistry is a natural consequence of protracted biospheric oxygenation.

Abstract ID: 35861

Final Number: PG12A-04

Title: Trends in Nutrient Supply, Productivity and Atmosphere Oxygenation through the Boring Billion

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Abstract Body: The redox sensitive and nutrient trace elements in marine sedimentary pyrites in Proterozoic black shales have been used to provide clues to nutrient supply, productivity and atmosphere oxygenation during the boring billion years. Using the nutrient trace elements adsorbed in marine pyrite (Zn, Cd, Cu, Ni, Mo and Se) as a proxy, reveals that following the GOE1, nutrient supply to the oceans dropped to a minimum around 1650 Ma, peaked at 1300 to 1000 Ma dropping again to a second minimum around 850 Ma, before rising gradually and then steeply toward the end of the Proterozoic. Using uranium in the shale matrix as a biological productivity proxy reveals a similar pattern with productivity at a minimum between 1400 and 1600 Ma, with a second minimum at 800 to 1000 Ma. The opposing patterns of Se (oxidation proxy) and Co (reduction proxy), indicates the Se/Co ratio in marine pyrite maybe a useful atmosphere oxygenation proxy. The pattern of this proxy compared with Mo and Se in pyrite suggests atmosphere O_2 was at a relative maximum at the start of the boring billion and declined in several steps to a relative minimum around 1000 Ma, corresponding with the second minimum in nutrient supply and productivity. These patterns may possibly relate to the supercontinent cycles, tectonic activities (plate collision) leading to uplift, erosion and increased nutrient supply to the ocean.

Abstract ID: 34386

Final Number: PG12A-05

Title: Sedimentology and Geochemistry of a 1.4 Ga Continental Playa System, the Lower Sibley Group, Northwestern Ontario: Implications for the Mesoproterozoic Hydrosphere and Atmosphere

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Co-authors: Riku T Metsaranta, Ontario Geological Survey, Sudbury, ON, Canada

Abstract Body: The 900 m thick Sibley Group consists of playa to deltaic to aeolian deposits outcropping north of Lake Superior and east of Thunder Bay. The lowermost 100 m thick succession of highly oxidized siliciclastic rocks and dolostone was deposited in a north-south trending half graben. The sediments can be divided into 15 lithofacies associations representing distinct depositional environments. The lower siliciclastic unit contains: boulder conglomerate-sandstone-dolocrete (proximal ephemeral braided stream), pebble to cobble conglomerate (ephemeral braided stream), trough cross-stratified sandstone (braided stream), green sandstone-siltstone (delta), massive cobble conglomerate (transgressive shoreline lag), planar cross-stratified sandstones (nearshore lacustrine sandwaves), and thinning-upward sandstones (lacustrine storm sand sheets). The overlying mixed siliciclastic-carbonate unit contains: red siltstone (non-saline lake), red siltstone-dolostone or dolomitic sandstone (saline lake), and halite-mudstone (ephemeral salt pans). Next is the upper siliciclastic unit with: sheet sandstones (lake infilling) and stromatolitic dolostone-chert (shoreline). After final desiccation of the lake terra rosa soils, collapse breccias and intraformational conglomerates developed. Paleocurrents, detrital zircon geochronology and sulfur isotopes indicate a change in drainage directions resulting in sand sheets infilling the saline lake. Sr isotopes reflect shallow groundwater circulation and lacustrine dolostone containing significant radiogenic Sr. Carbon and O isotopes are heavier upward in the saline lake deposits, probably due to evaporation and residence time effects. Most interestingly, REE patterns for dolomite in the dolocrete, stromatolitic shoreline deposits and overlying intraformational conglomerates have patterns similar to modern oxygenated groundwater, whereas the saline lake dolomites have hat-shaped patterns resembling modern groundwater draining waterlogged, organic-rich areas.

Abstract ID: 36826

Final Number: PG12A-06

Title: Deep-water Seep-related Carbonate Mounds: Implications for Seawater and Vent Fluid Geochemistry in the Mesoproterozoic Borden Basin, Nunavut

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Published Material: A government summary of activities summarizes geochemical results but very little interpretation. (Canada-Nunavut Geoscience Office Summary of Activities, 2014).Early versions of interpretations and results have been presented at GAC-MAC (2014-Fredericton) and GSA (Vancouver-2014).Most interpretations presented in this paper are new and have not been presented.

Abstract Body: Large deep-water dolostone mounds (Ikpiarjuk Formation) formed by fluid venting through subaqueous faults during black shale deposition in the Mesoproterozoic Borden basin (NU, Canada). Mounds consist of pelagic dolomudstone and clotted benthic dolostone with marine cement: well-preserved, bladed, length-slow dolomite (originally herringbone calcite or primary dolomite), fibrous length-fast dolomite (originally HMC) and blunt-tipped prismatic crystals replaced by blocky dolomite (originally aragonite). This mineralogy is identical to Phanerozoic cements when seawater Mg/Ca is high (>2), usually associated with global tectonic quiescence.

Detritus-corrected REE+Y patterns show binary mixing of marine and seep fluids. The seawater-dominated end-member has a positive slope in shale normalization, indicating a marine heritage, and a +ve Ce anomaly, indicating deposition below a redoxcline. REE+Y patterns show a strong local runoff influence and hence basin restriction. The seep-dominated end-member has flat REE+Y patterns, no Ce anomaly, and a -ve Eu anomaly. Carbon isotope values are typical for Mesoproterozoic seawater (~3.5‰). The absence of a +ve Eu anomaly suggests that seep fluids were <300°C and not influenced by an anomalous heat source (intrusion). The lack of light $\delta^{13}C$ in mound dolostone indicates that methane was not a major component of seep fluid. Seep fluids may have originated as seawater-derived brines that became concentrated evaporatively and sank to interact with basement rocks where their REE pattern was modified, before being vented as high-Mg/Ca, <300°fluids. Although trace elements indicate a marine basin water heritage, the Borden basin was epicratonic, its geochemistry influenced by local weathering, and redox-stratified. Such conditions are common in Mesoproterozoic basins, complicate understanding global seawater conditions, and imply that controls on Phanerozoic carbonate mineralogy may not adequately explain Mesoproterozoic carbonates.

Abstract ID: 35038

Final Number: PG12A-07

Title: Stratigraphy, Architecture and Morphodynamics of an Early Neoproterozoic Alluvial Plain: The Nelson Head Formation of Brock Inlier, NWT, Canada

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Published Material: The research deals with 1 Ga fluvial deposits superbly exposed in the Brock River Canyon, NWT. New data on depositional architecture and moprhodynamics of Precambrian rivers will be presented and discussed.

Abstract Body: The Nelson Head Formation is a *ca* 1.0 Ga sandstone exposed within several western Canadian Arctic inliers, including the Brock Inlier, where it is superbly exposed along extensive canyon cliffs. We present stratigraphic and architecture data consisting of line drawing, logging and paleocurrent analysis of 3D sections. Fluvial deposits record vertical and lateral alternation of coarse-grained, tan-yellow pebbly sandstone (mainly quartz arenite) and, recessive, maroon-red, fine-grained silty sandstone.

Strata are organized in 2 to 8 m thick bedsets that continue for >800 m along strike and >300 m down-dip. Trough-cross bedding is dominant, forming compound sets that reach 4 m in thickness. Subordinate planar-cross bedded deposits form sets up to 50 cm thick, and preferentially occur in the upper parts of bedsets. Soft-sediment deformation structures include common ball-and-pillow, convolute bedding, heavy mineral sags and fluid-escape conduits. Bedsets comprise lower, large inclined sets and upper, cross-cutting lithosomes with planar to concentric fill. Coarser units are somewhat thinner but are laterally more homogeneous up-section. Lower in the section, paleoflow indicators point to northwestern to northeastern transport, with high dispersion in individual units and upward flow rotation in some cases. Up-section, paleoflow is more focussed to the northwest.

Finer-grained units are micaceous (sericitic) and their maroon-red colour reflects an abundance of iron-oxide cement. Bedding units are 10 to 70 cm thick, planar-bedded, and continue for >600 m along strike and >300 m down-dip. Finer units are normally graded, thicker and more laterally continuous lower in the section. Ripple-cross lamination, climbing in places, is common and alternates with minor wavy plane-parallel lamination. Rare trough-cross bedding occurs in dm-thick sets in the lower parts of thicker units. Paleoflow is consistently north-northwest with low dispersion.

Correlative exposures of the Nelson Head Formation in the Minto Inlier of Victoria Island and the Katherine Group of the Mackenzie Mountains comprise remnants of continental-scale fluvial system that drained vast portions of the Canadian Shield. The formation is additionally one of very few Proterozoic sandstones where fluvial sinuosity has been documented.

Abstract ID: 36810

Final Number: PG12A-08

Title: New Meso-Neoproterozoic Paleomagnetic Results from the Congo-Sao Francisco Craton

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Published Material: Approximately 10% of material presented is in press with Geological Society of London Special Publications

Abstract Body: The Congo-Sao Francisco (SF) craton is a keystone of Gondwana and also a possible part of the Precambrian supercontinent Rodinia, but its movement through Meso-Neoproterozoic time still remains mostly unconstrained due to sparsity of reliable paleomagnetic data. Paleomagnetic results from 1.4 to 0.6 Ga igneous rocks, spanning southern Congo-SF from Tanzania to Namibia and eastern Brazil, help define a new apparent polar wander path for the craton. The youngest rocks in our paleogeographic reconstruction, the Sanyika redbeds of Tanzania, are still under geochronological investigation, but detrital zircon analyses demonstrate sedimentation ages of less than ~684 Ma. Five sites within the redbeds yield a shallow ESE-WNW dual-polarity remanence direction held by hematite. Together with published data from the Gagwe lavas, Mbozi Complex, and Luakela volcanics, our new data suggest complicated motions of Congo-SF craton through the Tonian-Cryogenian interval. These results are combined with a key pole from Brazil dated at 920 Ma, which is used to better define continuous motion of the craton relative to Laurentia and Baltica. We also sampled Mesoproterozoic rocks from three different geological units in northern Namibia. The oldest of these is the Kunene Anorthosite Complex, dated at ~1370 Ma. In the southern Kunene area, the anorthosite complex is intruded by Epembe syenites (~1220 Ma) and related dolerite dykes, and in the eastern area near Swartbooisdrif, the anorthosite is intruded by both dolerite and carbonatite dykes (~1130 Ma). Initial results from Namibia appear promising, including a possible positive baked-contact test for a Swartbooisdrif dyke intruding Kunene anorthosite. All of the new results are incorporated into an animation of Congo-SF motion through Mesoproterozoic Nuna breakup to terminal Proterozoic-Cambrian Gondwana assembly.

Abstract ID: 35559

Final Number: PG13A-01

Title: Deformation, Lithogeochemistry and New U-Pb Geochronology of the Aberdeen Lake Area, Central Rae Craton, Nunavut

Presenter/First Author: Rebecca Corrine Hunter, Laurentian University, Saskatoon, SK

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Co-authors: Bruno Lafrance, MERC, The Goodman School of Mines, Laurentian University, Sudbury, ON, Canada; Larry Heaman, University of Alberta, Edmonton, AB, Canada

Abstract Body: A new lithostratigraphy is proposed for the Neoarchean Woodburn Lake group (WLg) in the Aberdeen Lake area of the Rae Domain, western Churchill Province. The WLg has been correlated with the Prince Albert Group in the Melville Peninsula and the Mary River Group in north-central Baffin Island. Thus, knowing how and when the WLg formed is important for understanding the tectonic history of the Rae Domain. The WLg can be subdivided into three lithostructural sequences comprising a lower mafic volcanic package with local komatiite and felsic volcaniclastic interlayers, a middle clastic to intermediate volcaniclastic package with abundant banded iron formation and a distinctive trachydacite unit, and an upper semipelite-dominated sedimentary package with local graphitic, psammitic and banded iron formation interlayers. Based on LA-MC-ICPMS U-Pb zircon dating, the lower sequence was deposited ca. 2.74 Ga, the middle sequence between ca. 2.68 and 2.71 Ga, and the upper sequence is bracketed between ca. 2.68 Ga, the age of the trachydacite unit, and ca. 2.66 Ga, the inferred age of an intrusive monzodiorite gneiss in the study area. The geochemical signature of the WLg suggests that these rocks represent a back-arc to marginal arc environment. The ca. 2.68 Ga felsic volcanism observed in the middle sequence is similar to volcanism observed in the Henik Group of the Hearne Domain, and indicates that these Neoarchean supracrustal belts could have a similar tectonic history. The implications are that comparable geological settings are recorded in the Neoarchean within the two separate domains or alternatively, it records a single igneous event across an amalgamated Rae-Hearne craton at 2.68 Ga.

Abstract ID: 36642

Final Number: PG13A-02

Title: Neoarchean continental arc construction followed by collisional deformation along the eastern Rae domain, western Churchill Province: implications for fingerprinting tectonic processes

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Co-authors: Michael L Williams, University of Massachusetts, Amherst, MA; Kevin H Mahan, University of Colorado at Boulder, Boulder, CO; Greg Dumond, University of Arkansas, Fayetteville, AR; Michael J Jercinovic, University of Massachusetts, Amherst, MA

Published Material: Initial findings were reported during an "arc" session at GSA, 2014.

Abstract Body: The western Churchill Province provides an opportunity to study the growth and evolution of Archean continental lithosphere. It is been divided into the Rae and Hearne domains, but the nature and history of the boundary between them remains enigmatic. The Athabasca granulite terrane (AGT), located on the eastern margin of the Rae domain, was host to a prolonged phase of magmatism and tectonometamorphism during the Neoarchean. Geochemical analysis of ca. 2.61 Ga plutonic rocks paired with structural analysis and in-situ monazite geochronology have yielded insight into the Archean infrastructure of the eastern Rae domain, and show that ca. 2.61 Ga plutonic rocks represent the roots of a continental arc. Plutonic rocks range from 58.01 to 73.71 % SiO_2, and form linear trends on modified alkali-lime index plots, plotting largely in the calc-alkaline field. On Pearce diagrams, all samples plot in the volcanic arc granite field. Samples are LREE enriched, and contain flat and relatively depleted HREE when normalized to chondrites, indicative of a garnet bearing source. The entire Neoarchean plutonic complex, independent of bulk SiO_2 content, contains systematic enrichment in LILE and Pb, and depletions in HFSE and is interpreted to have been derived from a metasomatized lithospheric mantle source. Collectively, these data suggest that ca. 2.61 plutonic rocks represent a large continental arc complex. In-situ U-Th-total Pb monazite geochronology indicates that regional tectonism occurred immediately following the cessation of arc plutonism from ca. 2.59 – 2.53 Ga. This involved crustal thickening, lateral flow of plutonic rocks, and extensive migmatization at conditions exceeding 1.3 GPa and 800°C. The Neoarchean history of the Athabasca granulite terrane, thus, records a phase of arc construction followed by a period of crustal thickening, high pressure granulite facies metamorphism, and migmatization. This sequence of events is interpreted as the transition from a continental arc to a collisional setting during the Neoarchean, and perhaps, the amalgamation of the western Churchill Province. In addition, the AGT is a deep-crustal view of the accretionary process that can provide insight into the deeper parts of other orogenic belts.

Abstract ID: 36677

Final Number: PG13A-03

Title: Assembly of the Paleoproterozoic Core of Laurentia: New Results from the Churchill Province and its Bounding Orogens

Presenter: Edith Martel, Northwest Territories Geoscience Office, Yellowknife,

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Abstract Body: Integration of over sixty new U-Pb isotopic ages from the Churchill Province and its bounding orogens yields new insights and questions about the assembly of Laurentia as part of Earth's first supercontinent Nuna.

A transect across the Thelon Tectonic Zone (TTZ) from the Mesoarchean Queen Maud block finds the latter reworked during Arrowsmith and Thelon orogenesis and the former characterized by a major 2.03-1.99 Ga magmatic and thermal pulse. A widespread 1.91 Ga thermal event is also recognized. The TTZ appears structurally complex, with imbricated slices of Mesoarchean basement and differing Paleoproterozoic crustal levels possibly due to thick-skinned thrusting also involving the adjacent Slave Province. Previous models of an east-facing rift margin on the Slave, now possibly coeval with the start of TTZ subduction, raise questions about subduction polarity, microcontinent formation and the heretofore simple Slave-Rae collisional interface.

Other Churchill studies reveal a Paleoproterozoic lower crustal domain stretching from Athabasca basin to Hudson strait and characterized by 8-12 kbar paleopressures in both Archean basement and Paleoproterozoic supracrustal rocks. A transect of this domain in the NWT reveals a shallowly-dipping crustal stack of 2.7-2.0 Ga ortho- and paragneisses transected by ductile shear zones and blastomylonites. Archean rocks record MacQuoid and Arrowsmith tectonometamorphism at MPHT conditions. U-Pb metamorphic zircon ages (*ca.* 1.88 Ga and 1.83 Ga) in 2.3-2.0 Ga magmatic rocks show that regional 10-12 kbar assemblages (Grt-Cpx; Grt-Hbl) are Paleoproterozoic.

Exhumation of the lower crust was largely complete by ca. 1.82 Ga when ultrapotassic volcano-sedimentary rocks were deposited in transtensional basins. The scale and character of the Churchill-wide lower crustal domain is reminiscent of the Western Gneiss region of Norway and consistent with others formed worldwide during major collision-accretion events.

Abstract ID: 35482

Final Number: PG13A-04

Title: Is there an Archean lithospheric mantle root beneath the Sask Craton, Canada? Constraints from peridotite xenoliths in the Fort à la Corne kimberlite field.

Presenter/First Author: Janina Czas, University of Alberta, Edmonton,

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Co-authors: D. Graham Pearson, University of Alberta, Edmonton, AB, Canada; Thomas Stachel, University of Alberta, Edmonton, AB, Canada; George H Read, Organization Not Listed, Washington, DC; Bruce A. Kjarsgaard, Geological Survey of Canada, Ottawa, ON, Canada

Abstract Body: Peridotite xenoliths from kimberlites at Fort à la Corne (FALC) present a unique opportunity to study the lithospheric mantle beneath the Sask Craton. Archean (2.4 – 3.2 Ga) crustal ages have previously been reported for the craton. Little is known about this craton, yet it hosts a major diamond deposit within the Fort à la Corne kimberlite field. Establishing the age of the lithospheric mantle beneath this newly recognised craton is essential to constrain its origin and evolution. From a diamond perspective it is also important a) to understand whether the cratonic crust is underpinned by an Archean mantle and b) to constrain the possible influence of the Trans-Hudson Orogeny (THO; 1.79 – 1.91 Ga), representing the collision of the Superior and the Hearne-Rae provinces. Re-Os isotope systematics and platinum group element (PGE) concentrations have been obtained for olivine separates of 24 lherzolite xenoliths from two volcanic centres (Orion South and Star) in the FALC kimberlite field. The Os isotopic compositions vary significantly, yielding T_{RD} model ages ranging from 0.3 to 2.4 Ga (mode at 1.8 – 2.0 Ga) that provide minimum estimates for the timing of melt depletion. Mean Fo values ($Fo_{90.3-91.9}$) of olivines from the lherzolites constrain the fraction of melt extracted to be 20 – 25%. Such moderately high levels of melt depletion would almost quantitatively remove Re ($Re/Os_{elemental}$=0.0005 – 0.00001) and hence T_{RD} ages should approximate the actual ages of melt depletion. On this basis, there are no Archean ages recorded in the Os isotope composition of the Sask Craton lithospheric mantle. The mode of Re depletion ages at 1.8 to 2.2 Ga, with the oldest T_{RD} ages at 2.4 Ga, provides a strong indication that the majority of the lithospheric mantle was depleted and stabilised significantly later than the Archean crust. Hence, the evolution of the Sask Craton may have been similar to the Siberian Craton, where the bulk of the lithospheric mantle seems to have been constructed during craton amalgamation in the Paleoproterozoic (1.8 to 2 Ga).

Abstract ID: 36555

Final Number: PG13A-05

Title: Direct U-Pb evidence for Paleoproterozoic subduction-related metasomatism of the sub-Gardar lithospheric mantle, SW Greenland

Presenter/First Author: Michael A. Hamilton, University of Toronto, Toronto, ON

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Co-authors: Brian G.J. Upton, , , ; Michael A.W. Marks, University of Tübingen, Tübingen, Germany; Kathryn M. Goodenough, , ,

Abstract Body: Rift-related alkaline magmas of the Mesoproterozoic Gardar Igneous Province in south Greenland comprise nearly a dozen large central complexes of gabbro-syenite, volcanic rocks and dyke swarms ranging from transitional olivine basalts to hawaiites, emplaced in a continental intraplate setting at ca. 1300-1140 Ma. Subordinate volumes of carbonatite and alkaline ultramafic lamprophyre occur locally. Gardar intrusions stitch the boundary between the Archean North Atlantic (Nain) craton and the largely juvenile Paleoproterozoic Ketilidian orogen to the south. Most Gardar magmas were emplaced into calc-alkaline magmatic arc rocks of the expansive Julianehåb batholith (outcrop area ~30,000 km^2), formed at 1855-1795 Ma as a consequence of oblique, N-directed subduction of oceanic lithosphere beneath a southern Archean plate margin. The region remained unaffected by tectonomagmatic activity until the onset of Gardar magmatism.

Previous geochemical and tracer isotopic studies of Gardar mafic magmas have ruled out a significant role for crustal contamination or involvement of an ancient (Archean) enriched lithospheric keel; enrichments in K, Rb, Ba, P, F and LREE and depletions in Nb-Ta have instead been attributed to metasomatic modification of the sub-Gardar mantle by melts or fluids rising from the subducting Ketilidian oceanic plate. Mantle xenoliths in the Gardar Province are currently only known to occur in a single locality. On Igdlutalik Island, a Gardar mela-aillikite dyke carries abundant rounded,

ultramafic nodules (variably altered peridotites), locally with relic olivine (Fo91.5) and Cr-spinel. Peridotites with cross-cutting veins, and discrete nodules of phlogopite-rich glimmerite attest to volatile-charged, K-rich metasomatism in an assemblage that also comprises subordinate calcite, apatite, zircon and titanite. CA-ID-TIMS U-Pb analyses of single zircon grains from glimmerite yield ages of 1800 Ma, directly implicating Paleoproterozoic subduction with attendant metasomatic enrichment of Ketilidian refractory mantle residual after major arc construction.

Abstract ID: 34544

Final Number: PG13A-06

Title: Petrogenesis and Geodynamic History of the Lynn Lake Greenstone Belt, Manitoba: Implications for Trans-Hudson Orogen Tectonics

Presenter/First Author: Michael W P Glendenning, University of Windsor, London,

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Co-authors: Joel E Gagnon, University of Windsor, Windsor, ON, Canada; Ali Polat, University of Windsor, Windsor, ON, Canada

Published Material: A version of these findings were submitted to Lithos in November of 2014 and is currently under review.

Abstract Body: The circa 1.9 Ga old Paleoproterozoic Lynn Lake greenstone belt in north-western Manitoba has been previously interpreted to be the product of a collage of subaqueous volcanic rocks formed in oceanic volcanic arcs, ocean islands, intra-arc rifts, and mid-ocean ridges, all of which included little to no contribution from continental crust. Despite these interpretations, lithogeochemical data from the southern terrane and isotopic data from the northern terrane suggest the involvement of continental crust during the formation of the metamorphosed volcanic and igneous rocks that comprise the Lynn Lake greenstone belt. The results of new outcrop mapping, core logging, petrographic characterization, and lithogeochemical analyses were integrated with historic lithogeochemical data in order to: 1) quantify the importance of continental crust in the formation of the northern terrane; 2) re-interpret the tectonic evolution of the Lynn Lake greenstone belt; and 3) assess the implications of this re-evaluation for the tectonic evolution of the Trans-Hudson Orogen. Based on high-field strength element abundances and Th-Nb-La systematics, the ultramafic to intermediate metavolcanic rocks comprising the Lynn Lake greenstone belt can be subdivided into two distinct tectonic environments: 1) mantle plume-derived crustally-contaminated oceanic plateau, continental rift, or rifted continental margin; and 2) continental volcanic arc. This study indicates that the Lynn Lake greenstone belt formed during either formation of the Manikewan Ocean via rifting of the Superior Craton to form the Hearne Craton, or during formation and closure of the Snowbird Tectonic Zone via rifting of the Rae Craton to form the Hearne Craton, which resulted in redirection of plume material to the passive Hearne margin. Consequently, re-examination of the mineral deposit potential of the Lynn Lake greenstone belt, in the context of the revised tectonic environment, is warranted.

Abstract ID: 36123

Final Number: PG13A-07

Title: Structural geology of the McLeod Road - Birch Lake sequence, Snow Lake, Manitoba, and implications for the evolution of the southeastern Trans-Hudson Orogen

Presenter/First Author: Kate ELIZABETH Rubingh, MERC, The Goodman School of Mines, Laurentian University, Sudbury, ON

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Co-authors: Bruno Lafrance, MERC, The Goodman School of Mines, Laurentian University, Sudbury, ON, Canada; Harold Lorne Gibson, MERC, Department of Earth Sciences, The Goodman School of Mines, Laurentian University, Sudbury, ON, Canada

Abstract Body: The McLeod Road – Birch Lake (MB) sequence is a fault bounded panel of bimodal volcanics and volcaniclastic rocks in the Paleoproterozoic Flin Flon – Snow Lake greenstone belt of the southeastern Trans-Hudson Orogen (THO). It is bounded to the north by the Birch Lake Fault and to the south by the McLeod Road Thrust (MRT). It hosts the past gold-producing Snow Lake Mine (1.4 M oz) and is immediately north of the major volcanogenic massive sulphide camp of Snow Lake. The MB sequence underwent three major deformational events. Early D1 collision of the Flin Flon – Snow Lake greenstone belt with the Sask craton produced early thrust faults that repeat the stratigraphy of the MB sequence. The latter is folded by the F1 Nor-Acme anticline (NAA), which formed during thrusting and has a strong axial planar NE trending S1 foliation and coaxial NE plunging L1 stretching lineation. D1 is a progressive deformation event and later during D1, the NAA is cut by the MRT, which juxtaposes the (1835 – 1842 Ma) Burntwood turbidites with the (1.89 Ga) MB sequence volcanics. The Birch Lake Fault is parallel to the MRT, but it juxtaposes younger Missi conglomerates (1845 Ma) over the MB sequence volcanic rocks and has normal shear sense indicators. Thus, the MB sequence is bounded by parallel thrust and extensional faults, a geometry analogous to that produced by channel flow in the Himalayas. During D2 collision with the Superior craton, a NNE-striking, regional S2 cleavage formed transecting the NAA and MRT and reactivating the MRT as a sinistral shear zone. Continued shortening and ongoing collision of the Superior craton during D3 forms broad open NE trending map scale F3 folds. The orthogonal collisions of the Sask Craton and then Superior Craton with the Flin Flon – Snow Lake greenstone belt both contributed to the thrusting and folding history of the southeastern THO, resulting in its complex dome-and-basin geometry.

Abstract ID: 35231

Final Number: PG13A-08

Title: Nd Isotope Mapping of Crustal Boundaries within the Makkovik Province, Labrador, Canada.

Presenter/First Author: Rebecca Madelaine Moumblow, Self Employed, Washington, DC

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Published Material: Submitted to Precambrian Research

Abstract Body: Abstract: The Makkovik Province of eastern Labrador represents part of an accretionary orogen active during an early stage in the development of the Paleoproterozoic southern Laurentian continental margin. New Nd isotope data for the eastern Makkovik Province suggest that accreted juvenile Makkovik crust was generated in the Cape Harrison domain during a single crust-forming event around 1.95 Ga.

As previously proposed, an arc accretion event around 1.9 Ga is argued to have triggered subduction-zone reversal and the development of an ensialic arc on the composite margin. After the subduction flip, a temporary release of compressive stress around 1.86 Ga led to the development of a retro-arc foreland basin on the downloaded Archean continental edge, forming the Aillik Group. Unlike previous models, a second arc is not envisaged. Instead, a compressive regime around 1.82 Ga is attributed to continued ensialic arc plutonism on the existing margin.

The tectonic model for the Paleoproterozoic Makkovikian orogeny proposed here is similar to that for the Ketilidian orogeny.

Major and minor trace element analyses suggest that much of the magmatism in the Makkovik orogen results from post-accretionary ensialic arc activity, and that few vestiges remain of the original accreted volcanic arc. This pattern of arc accretion and intense post-accretion reworking is common to many accretionary orogens, and is revealed by a combination of Nd and U-Pb isotopic data.

Abstract ID: 33680

Final Number: PG22A-01

Title: Supercontinent-superplume coupling in Earth history: toward a new tectonic paradigm

Presenter/First Author: Zheng-xiang Li, Curtin University, Perth, WA

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Published Material: The ideas have been published in various papers, particularly the Li and Zhong 2009 paper in PEPI. This talk will be an update in preparation for the new IGCP project.

Abstract Body: The question of what drives plate tectonics remains a major challenge to geoscientists. Major breakthroughs over the past 30 years include (1) the recognition of a likely cyclic nature of supercontinent evolution, including the Pangea (320–170 Ma), Rodinia (900–700 Ma), and Nuna/Columbia (1600?–1300? Ma) cycles; (2) seismic tomographic evidence for subducting slabs reaching the lower mantle; (3) the discovery of the two equatorial, antipodal, large low shear-wave velocity provinces or superplumes in the lower mantle that underlie (and feed?) almost all the know mantle plumes since the Permian; and (4) the increasing recognition of TPW events (True Polar Wander – rotation of the entire mantle and lithosphere relative to the planetary rotation axis) in Earth history that reflect changes in mantle structure and convection patterns. Although many believe that subducting slabs can influence lower mantle structure and dynamics, some believe that the two superplumes are long-lived in Earth history and are thus independent of the plate system. Here I present a self-consistent working hypothesis that features the followings: (1) the Earth's history has been dominated by cycles of supercontinent assembly and breakup coupled by antipodal superplume events; (2) circum-supercontinent subduction leads to the formation of two antipodal superplumes (and individual plumes above them) corresponding to the positions of the supercontinent and the superocean, respectively; (3) the superplumes can bring themselves and the coupled supercontinent to equatorial positions through TPW events, and eventually lead to the breakup of the supercontinent; equatorial antipodal superplumes also allow for inertial interchange true polar wander; and (4) the breakup of the supercontinent gradually changes the Earth from a dominantly circular subduction system to scattered multiple-subduction systems, thus weakening the antipodal superplumes until after the formation of the next supercontinent.

Abstract ID: 34623

Final Number: PG22A-02

Title: PALEOPROTEROZOIC PALEOGEOGRAPHIC RECONSTRUCTIONS: BASED ON PALEOMAGNETIC DATA AND LIPS BARCODE CONSTRAINTS

Presenter/First Author: Sergei A Pisarevsky, University of Western Australia, Crawley, WA

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Co-authors: Richard E Ernst, Ernst Geosciences, Ottawa, ON, Canada

Published Material: 20% of the content has been recently accepted (Pisarevsky et al., 2014, Precambrian Research, http://dx.doi.org/10.1016/j.precamres.2014.05.023). Now these data are integrated with a broader sets of data and new implications are found.

Abstract Body: Using two independent datasets – Large Igneous Provinces (LIPs) database and recently updated 2.5-1.8 Ga paleomagnetic database – we built a series of global paleogeographic reconstructions. The data do not contradict the existence of a supercontinent around 2400 Ma, but its exact configuration and the timing of its assembly and breakup are speculative. However, some plausible models are considered. Both paleomagnetic and LIPs data are unevenly distributed both in time and in space. Consequently paleopositions of some ancient cratons are not always constrained by data. We demonstrate that the Superior, Kola-Karelia, Yilgarn, Zimbabwe, Kaapvaal, Nain (North Atlantic), Dharwar, Wyoming and Rae cratons could be assembled into a supercontinent (or a supercraton, Superia), which could exist between 2500 and 2370 Ma only if moving relatively fast. The paleogeography before 2500 Ma and between 2370 and 1800 Ma is less clear, but we consider several alternative scenarios. In addition to abovementioned cratons we establish permissive positions for the Slave craton and for the ancient fragments of Siberia, Amazonia, Congo and São Francisco cratons, in view of new paleomagnetic data. It is likely that the Slave craton was distal from the Superior craton (and possibly from Superia) around 2200 Ma, as has been suggested in several publications.

Abstract ID: 34470

Final Number: PG22A-03

Title: Targeting Comprehensive Visualisation of Precambrian Geological Evolution of the Earth's Crust and its Mineralisation

Presenter/First Author: Bruce M Eglington, University of Saskatchewan, Saskatoon,

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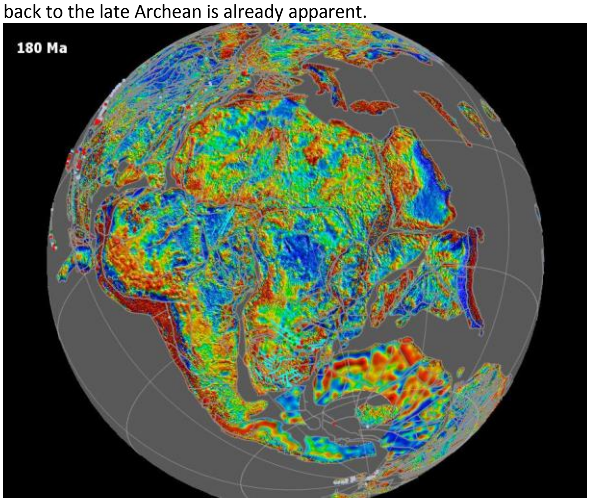
Co-authors: Sally Jane Pehrsson, Geological Survey of Canada Ottawa, Ottawa, Canada; David AD Evans, Yale University, New Haven, CT; David Huston, , , ; Steven Reddy, , ,

Published Material: Some aspects of plate reconstructions are in press but much is new. Some aspects of the database description has been presented but this will focus on new aspects. This presentation has been invited by Evans and Ernst so it will need to incorporate some existing information but will also include new data/fits/interpretations hot off the computer.

Abstract Body: Investigation of the regional geological evolution of the Earth's crust and its mineral deposits is consistently hampered by insufficient information structured to easily compare across time, space and structural domains. IGCP projects 440 (Rodinia supercontinent) and 509 (Nuna supercontinent) provided an effective mechanism to bring together researchers and to compile relevant geological information. IGCP 509 also formally created a number of invaluable datasets, housed in the online DateView and StratDB databases (available from http://sil.usask.ca), including information for geochronology, isotope geochemistry, lithostratigraphy, ore deposits and large igneous provinces. Investigation of information in these databases permits the quantification of global periodicity in Earth evolution since about 3800 Ma, consistent with the formation of several successive supercontinents. At regional scale it is clear that supercontinent amalgamation and disintegration was diachronous. Mineralisation style and location can be shown to be consistent with this behaviour and to fit well with general Phanerozoic settings, so providing additional ways to investigate the spatial distribution of Precambrian crustal blocks. Plate tectonic reconstructions in the

Palaeozoic and Precambrian (pre-seafloor spreading) are just as feasible as Cenozoic to Mesozoic situations but require additional constraints and tests. Modern tools such as GPlates and Paleogis plate reconstruction software which link effectively with GIS-based information, facilitate model development and allow one to test continuously varying time views overlaying multiple datasets. Both younger and older reconstructions are essential to achieving realistic reconstructions. Detailed identification of the domain blocks (plates), including their older subdivisions is a prerequisite for success.
Significant progress in achieving plate reconstructions from the present back to the late Archean is already apparent.



Abstract ID: 36815

Final Number: PG22A-04

Title: Proterozoic Marine Redox Evolution

Presenter/First Author: Noah J Planavsky, Yale University, Riverside, CA

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Co-authors: Christopher Reinhard, Georgia Tech, Atlanta, GA; Timothy Lyons, University of California-Riverside, Riverside, CA

Abstract Body: There has been extensive debate about marine redox structure in the Proterozoic over the past two decades. We will briefly review this debate and present some new paleoredox work. Given that the Animikie Basin has been essential in shaping our view of the Proterozoic oceans, we will highlight a recent multi-proxy paleoredox study in previously unexplored Paleoproterozoic Animikie Basin drill cores from the Stambaugh Formation in the Paint River Group (Iron River-Crystal Falls district of Michigan). Based on previous tectonic reconstructions and analysis of sedimentary regimes, the Iron River-Crystal Falls sections capture the deepest-water facies of the Animikie Basin. In contrast to previous work, we find evidence for highly variable marine redox conditions—including ferruginous, euxinic, and short-lived oxic conditions—and suggest this variability may be representative of the Proterozoic oceans more broadly. We have been searching for a single redox structure for the Proterozoic oceans. However the hallmark of Proterozoic marine settings may be the lack of a single characteristic redox structure. The Proterozoic oceans are likely defined by strong, short-term redox landscape variability.

Abstract ID: 34518

Final Number: PG22A-05

Title: An Appalachian-style Multi-terrane Accretion/Collision Model for the Assembly of South China

Presenter/First Author: Shoufa Lin, University of Waterloo, Waterloo, ON

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Abstract Body: South China is traditionally interpreted to have formed by the collision of two blocks, the Yangtze and the Cathaysia. The proposed timing of collision varies from Proterozoic to Mesozoic, corresponding to that of the various tectonothermal events documented in South China. A better understanding of South China is important not only for the assembly of Asia, but also for the reconstruction of supercontinents (e.g., Rodinia).

In this contribution, we propose, as an alternative interpretation, that the evolution of South China involved accretion/collision of multiple terranes (i.e. more than two blocks) and each of the major tectonothermal events corresponds to an accretional/collisional event. The Cathaysia Block has been divided into two parts, West and East, with contrasting histories. New and available age data indicate that the boundary between West and East Cathaysia is not the Zhenghe-Dapu fault as previously thought, but lies ~20 km to its west. In our model, West Cathaysia is a composite terrane formed by amalgamation of multiple terranes/arcs at ~1.0–0.88 Ga. Arc magmatism in the Shuangxiwu, Wuyi and Yunkai areas, metamorphism in the Tianli schist and emplacement of the Xiwan ophiolite were related to the process. West Cathaysia and the Yangtze Block collided at ~825–815 Ma along the NE Jiangxi fault/suture zone, following westward subduction (current coordinate) that generated a ~860–825 Ma arc–back-arc system preserved in the Jiangnan belt. The resulting Yangtze-West Cathaysia continent collided with a postulated continent to the east at ~460–440 Ma, leading to high-grade metamorphism in part of West Cathaysia (the down-going plate) in this “Caledonian”-aged orogen. East Cathaysia, characterized by a ~1.87–1.86 Ga basement and ~250–230 Ma high-grade metamorphism, possibly originated from an “Indosinian” orogen in the Paleo-Tethyan regime to the south. It accreted to the east of West Cathaysia in the Mesozoic, possibly through large-scale strike-slip movement. Before or during the process, the eastern part of the Caledonian-aged orogen and the postulated continent moved away from South China through rifting and/or strike-slip motion. Such a multi-terrane accretion/collision model is similar to what has been proposed for the Appalachian orogen.

Abstract ID: 36329

Final Number: PG22A-06

Title: Paleomagnetic Insights into the Global Climatic Condition Prior to Sturtian Glaciations: Evidence from the South China

Presenter/First Author: Shihong Zhang, China University of Geosciences Beijing, Beijing,

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Abstract Body: In some influential models of paleocontinental reconstruction (e.g. Li et al., 2013), the south China block (SCB) was placed in low paleolatitudinal region at ~780 Ma. Huang et al. (2014) recently reported some low values of the chemical index of alteration (CIA) observed from ~780 Ma strata in the SCB and combined their data with the speculation of low paleolatitudinal position of the SCB to suggest that the earth had witnessed multiple climate cooling prior to the Sturtian glaciations. I agree that jointly interpreting of the paleolatitudinal data and CIA data would provide useful constraints to global climatic conditions in deep time. However, the paleolatitudinal positions and tectonic settings of

the SCB in Neoproterozoic are still matters of dispute. Accumulating paleomagnetic data demonstrate that the SCB had experienced an equator-ward drifting during the middle and late Neoproterozoic while the supercontinent Rodinia was breaking up. The SCB was located in very high latitudinal region (> 60° N) at ~820 Ma and reached the Equatorial region at a time close to the Cambrian/Precambrian boundary. The newly obtained paleomagnetic and geochronological results suggest that the SCB was still located at middle to high latitudinal regions (between ~35° and ~55° northern hemisphere) at ~780 Ma (Xiao et al., 2015). The high-latitudinal pre-Cryogenian sedimentary rocks up to thousands meters thick are predominately reddish clastic sandstone, siltstone and shales, suggesting a likely greenhouse climatic condition on the Earth before the Cryogenian Period. These sediments formed in high sedimentary rate rift basins and experienced multiple deposition, erosion and redeposition cycles. The low CIA data from the SCB have no straightforward meaning of global cooling.

Abstract ID: 33107

Final Number: PG22A-07

Title: A Relic of the Mozambique Ocean in south-east Tanzania

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Abstract Body: The Neoproterozoic geology of East Africa records the events leading up to the formation of Gondwana and subsequently Pangea, and hence understanding the geodynamic history of this area offers a unique insight into supercontinent development and pre-Gondwanan continental growth.

Here, we present new geochemical and geochronological data from the Ntaka region of the Nachingwea district of south-east Tanzania suggesting this area of the Mozambique Belt constitutes an exotic nappe terrane that was part of the Neomozambique Ocean in the Neoproterozoic.

The lithological sequence in the region consists of a 770-720 Ma ‘basement’ of intermediate-felsic paragneiss possibly after volcanogenic sediments which show typical arc-like geochemical signatures. These are intruded by 700-650 Ma amphibolites (±garnet) after mafic-intermediate intrusives that also have arc-like geochemistry. This sequence is then intruded by a set of ca. 670-650 Ma ultramafic, dominantly pyroxenitic sills collectively termed the Ntaka intrusion, which have a much more mantle-like, non-arc origin. The mafic-intermediate intrusives occur synchronous with, and outlast, the ultramafic magmatism, suggesting this event was transient in the context of the overall tectonic regime. The final magmatic event in the terrane is the intrusion of sill-like 640-620 Ma orogenic granites that are coeval with 640-600 Ma upper amphibolite-granulite facies metamorphism.

The broader geodynamic setting consisted of the Congo-Tanzania-Bengweulu Block/Craton to the west and the Azania-Dhawar blocks/craton to the east of the Neomozambique Ocean, both of which contain Archean-Paleoproterozoic detritus. Subsequently, based on the island-arc like geochemical characteristics of the 700-650 Ma mafic intrusive rocks and the lack of detrital zircons >1000 Ma, we suggest that the Ntaka region represents a Neoproterozoic intra-oceanic island arc which was accreted to either East Africa or Azania shortly before full continental collision (the East African Orogeny) at ca. 640-620 Ma. We hypothesise that the short-lived period of ultramafic magmatism at ca. 660 Ma represents a short (ca. 10 Ma?) period during which the island arc intersected a mantle plume ‘hot spot’, resulting in the emplacement of magmas with primary liquid compositions of ca. 15% MgO.

Abstract ID: 34727

Final Number: PG22A-08

Title: The Large Igneous Provinces Industry Consortium Project: Accomplishments and next steps

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Published Material: 30% has previously been published, but this represents a new synthesis of previously published and new results

Abstract Body: The Large Igneous Provinces (LIPs) Industry Consortium Project has generated c. 220 U-Pb dates from LIP units (mainly dolerite dykes) across the world, which provided the first robust LIP barcodes for crustal blocks such as West Africa, Siberia, Amazonia, and Sarmatia, led to the discovery of more than 10 Proterozoic LIPs of scale comparable to the Siberian Trap LIP, identified critical LIP barcode matches constraining pre-Pangea supercontinent reconstructions, and provided numerous new targets for paleomagnetic testing of these reconstructions. These results directly benefit academic research and also allow sponsoring mining and oil/gas companies to develop improved exploration strategies by: 1) providing reconstructions that allow known major ore deposits (of any type) to be traced into greenfield areas on formerly adjacent blocks, 2) enabling enhanced targeting within LIPs that are prospective hosts of orthomagmatic deposits (*e.g.*, Ni-Cu-PGEs) or indirectly contribute to other deposit types (*e.g.*, hydrothermal deposits), and 3) contributing to the oil industry by helping to identify and correlate sedimentary basins formed during supercontinent breakup events. The potential influence of the LIPs identified during this project on hydrocarbon exploration also includes the generation of source rocks (via ocean anoxia events caused by oceanic LIPs), the maturation/ overmaturation of hydrocarbons (via a LIP thermal pulse), and by the development of hydrocarbon traps (e.g. beneath sills).

The LIPs Industry Consortium Project (www.supercontinent.org) was funded by a consortium of 6 Industry Sponsors (mining and oil) who provided $1.5 million over 5 years for research into LIPs around the world, focusing on dolerite dyke and sill swarms from LIP events extending back through Proterozoic time. This industry funding was supplemented by a matching NSERC-CRD grant and other funds, enabling a robust complementary program of graduate student research (in geochronology, geochemistry and geophysics) on LIPs.

Abstract ID: 35166

Final Number: PG23A-01

Title: U-Pb TIMS and in-situ SIMS dating of baddeleyite and zircon from sub-volcanic sills of the Ongeluk Formation (Transvaal Supergroup) in the

Griqualand West sub-basin, Kaapvaal Craton, with implications for Snowball Earth and the Great Oxygenation Event

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Published Material: Some of the ID TIMS ages and paleomagnetism of the Westerberg Sill Suite were presented at the 2014 October GSA Meeting in Vancouver, Canada. These results are currently under review. The in situ dating is new material

Abstract Body: The Great Oxygenation Event (GOE) in the Paleoproterozoic coincides with a complex series of glacial episodes preserved in supracrustal successions on the world's cratons. These Paleoproterozoic glacial rocks are bracketed in age between 2.46 and 2.22 Ga, based on the glacial record in the Huronian Supergroup on the Superior Craton in Canada). In southern Africa, the cover successions of the western Kaapvaal Craton preserve possible glacial correlatives of the Huronian Supergroup in the Griqualand West sub-basin of the Transvaal Supergroup. This potential correlative is the glacial diamictites of the Makganyene Formation. The Makganyene Formation is in turn conformably overlain by the Ongeluk Formation, a series of subaqueous mafic volcanic rocks with a putative age of ca. 2.22 Ga. However, both local and global correlations using glacial units of the Transvaal and Huronian supergroups are hampered by a lack of robust well-placed geochronological data. The timing of the Ongeluk Formation itself has been challenged. Here, the sub-volcanic sills of the Ongeluk volcanic rocks have been dated using U-Pb in-situ SIMS analysis on baddeleyite to ca. 2.43 Ga. This has been coupled with ID TIMS dating and paleomagnetism studies on the coeval Westerberg Sill Suite. This suggests that the Ongeluk Formation volcanic rocks, and the immediately underlying Makganyene Formation glacial deposits, are approximately 200 Myr older than generally assumed. These new ages lend support to three glacial epochs around the GOE, of which the first was low-latitude in the Makganyene Formation. The Makganyene diamictites could correlate to diamictites from the Duitsland Formation in the more eastern Transvaal sub-basin of the Transvaal Supergroup, with a significant revision of regional stratigraphic correlations, that is in itself not without challenges. In such a scenario, the Ongeluk volcanic rocks could be correlated with the Bushy Bend volcanics, and not the ≤ 2.25 Ga Hekpoort Formation volcanics. This new magmatic event may be linked with the evolution of the Vaalbara continent, the Kenorland supercontinent, and global environmental changes related to magmatism and weathering in the Paleoproterozoic Era.

Abstract ID: 33657

Final Number: PG23A-02

Title: Zircon U-Pb Constraints on the Age of the Paleoproterozoic Volcano-Sedimentary Succession in the Alta-Kautokeino Greenstone Belt, Alta, Northern Norway

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Abstract Body: A succession of Palaeoproterozoic mafic volcanic and interlayered carbonate and siliciclastic sedimentary rocks, the Raipas Group of the Alta-Kautokeino Greenstone Belt (Bergh & Torske 1988), is exposed in the Alta-Kvænangen tectonic window beneath the Caledonian nappes in northern Norway. The Raipas Group unconformably overlies the Archean basement and connects with supracrustal sequences of the Karelian Province. The lower part of the Raipas Group is dominated by basaltic lava flows, in part with coarse massive and pillow lavas. Rhytmic tuffaceous units are common at higher levels and silty layers and dolomite, locally stromatolitic, dominate the middle part. Carbonates in the lower volcanic sequence record the Lomagundi positive C-isotope excursion (>+8‰). The upper part of the Raipas Group consists of clastic sedimentary packages, the Skoadduvarri and Luovusvarri sandstones and dolomites (Gautier et al. 1979). The search for zircon in several tuffaceous layers and lava flows was not successful, except for a basal coarse-grained (gabbroic) lava which yielded typical prismatic to skeletal zircon crystals and fragments. Chemically- and air-abraded zircons yielded near concordant results defining an ID-TIMS U-Pb age of 2150 ± 2 Ma. Detrital zircon from the overlying Luovusvarri sandstones, dated by ICP-MS, yield two dominant groups of ages at 3.1 to 2.7 Ga and 2.1 to 1.8 Ga and sparse ages between 2.5 and 2.1 Ga. In two samples the average ages of the youngest grains are 1925 ±7 Ma and 1922 ±7 Ma. The 2.15 Ga age indicates that the Raipas Group lavas formed during rifting of the Fennoscandian Shield (opening the Kola Ocean) while the overlying sandstones (~1.9 Ga in age) might be foreland basin deposits related to the Lapland-Kola Orogeny (Torske & Bergh 2004; Daly et al. 2006).

Bergh SG & Torske T 1988. Precam Res 39.

Daly JS et al. 2006. JGSL 32.

Gautier AM et al. 1979. NGT 59.

Torske T & Bergh SG 2004. NGU Bull 442.

Zwaan KB & Gauthier AM 1980. NGU Skrifter 357.

Abstract ID: 35545

Final Number: PG23A-03

Title: A Late Mesoproterozoic Exterior Laurentia–Baltica Margin; Implications for Rodinia Reconstructions

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Abstract Body: The existence of a Precambrian supercontinent - Rodinia - was proposed in the 1970s, when several geologists noted the existence of orogenic belts of similar age (ca. 1.0 Ga) that today are located on different continents. Along with paleomagnetic data, correlating these belts has been the main tool for reconstructing Rodinia. The amalgmation of Laurentia, Baltica and Amazonia, represented by the Grenville, Svecornorwegian and Sunsas orogenies, respectively, is integral in most Rodinia reconstructions. However, this interpretation is not uniquely supported by the paleomagnetic data.

A number of authors have proposed very similar orogenic evolutions in the Grenville and Sveconorwegian Provinces. Although this is broadly correct with respect to timing, recent models for the Sveconorwegian and Grenville Provinces, based on extensive mapping, geochronology and petrology, suggest that rather than forming an eastward continuation of the collisional Grenville Province, the Sveconorwegian remained an active margin throughout the Grenville-Sveconorwegian orogeny. Furthermore, the Sveconorwegian province does not preserve evidence requiring collision with a major landmass. This new interpretation is compatible with the an exterior Laurentia–Baltica margin, imposing an important constraint on Rodinia reconstructions. Correlating orogenic belts based mainly on age data, with only scant knowledge of the tectonic nature of the belt, is inherently risky. This is easilly understood when appreciating the complexity of modern contintental margins, such as the southwest margin of Asia, with tectonic environments ranging from major continent-continent collision zones, zones of major strike-slip movement and extensive and long-lived magmatic arcs. We propose that the Late Mesoproterozoic Laurentia–Baltica margin displayed a similar complexity.

Abstract ID: 34533

Final Number: PG23A-04

Title: Laurentia – Siberia Connection: An Update with Evidence From Provenance and Magmatic Evolution Studies

Presenter: Robert Rainbird, Geological Survey of Canada, Ottawa, ON

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Abstract Body: Continental reconstructions that display a connection between Siberia and Laurentia since the amalgamation of Nuna ca. 1.9-1.8 Ga are well supported. Their separation is considered to be mainly between ca. 780 and 720 Ma.

Paleomagnetic data support a north Laurentia – south Siberia connection, but allow for several options, which can be tested by comparing their magmatic events and provenance evolution.

The youngest orogenic belts in the Siberian Craton are ca. 1.9-1.8 Ga. In contrast, eastern Laurentia is defined by the 1.8-1.6 Ga Yavapai and Mazatzal provinces and adjacent ca. 1.45-1.0 Ga Grenville Province. The pre-780 Ma clastic units of northwestern Canada contain distinctive Grenvillian detrital zircons supporting a paleogeographic model whereby extensive river systems transported detritus across Laurentia to its northern margin. However, in Siberia broad distribution of Grenvillian detrital zircons is known only in upper Mesoproterozoic – lower Neoproterozoic successions on the SE margin of the Siberian Craton, and, partly, on the SW margin of Siberia. Such provenance is not recorded in comparable successions located on the northern margin of Siberia.

Proterozoic inliers of the Wernecke and Ogilvie mountains along with Great Bear Lake area host evidence for mafic magmatism at ca. 1.74, 1.67, 1.59, 1.38, 1.27, 0.78 and 0.72 Ga. Mafic magmatic events at 1.75-1.7, 1.67, 1.34 and 0.78-0.72 are recognized in the southern Siberia. In northern Siberia, mafic magmatic events at ca. 1.75, 1.5 and 1.38 Ga are documented, but there is no evidence for younger events.

Provenance and magmatic events studies as well as paleomagnetic data show that north Laurentia – south Siberia connection remains the most viable option. Of concern is the location of Pearya terrane in the early Neoproterozoic. If it was a part of Laurentia, it has no counterpart on the south Siberian margin and a separate landmass between Siberia and Laurentia is required.

Abstract ID: 34970

Final Number: PG23A-05

Title: Microbial Community Behavior Recorded in Cuspate Microbialites from the Mesoproterozoic Dismal Lakes Group

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Co-authors: Linda C Kah, University of Tennessee, Knoxville, TN; Tracy D Frank, Univ Nebraska, Lincoln, NE

Published Material: The model for microbialite formation was published in the January 2015 issue of *Geobiology* and presented at the 2013 GSA Annual meeting. The speculation about 2-community behaviors is developed more fully in this submission.

Abstract Body: Offshore facies of the Mesoproterozoic Dismal Lakes Group, arctic Canada, preserve microbialites composed of ridge-like vertical supports draped by concave-upward, sub-horizontal elements, resulting in cuspate microbialites with substantial primary void space. These microbialites constitute the lower platform facies of the September Lake reef complex and likely formed in water depths greater than several tens of meters. Morphological and petrographic analyses suggest that structures formed as neutrally buoyant organic mats. Carbonate precipitation within mats was concurrent with growth of the microbial structures and either stabilized or facilitated collapse of otherwise neutrally buoyant forms. Structures were then further stabilized by precipitation of marine herringbone cement.

The two distinct components of these microbialites, vertical supports and horizontal draping laminae, suggest the presence of two distinct microbial communities with different mat-forming behaviors. Similar vertical elements are observed in a variety of modern natural and experimental settings and are associated with motile, filamentous organisms; upward movement typically occurs in response to light or nutrient pressures. In contrast, sub-horizontal laminae more closely resemble mats dominated by non-motile forms.

We suggest that these unusual microbialites are a product of interaction between communities dominated by motile and non-motile microbial members under nutrient-limiting conditions. Mats likely contained a combination of photosynthetic and chemosynthetic communities that either (1) grew across an oxic–anoxic interface, with vertical elements influenced by oxic waters, and draping elements influenced by anoxic conditions; or (2) grew under low-oxygen conditions across a chemical interface, where sulfidic conditions prevailed in the higher vertical elements and ferruginous conditions dominated the lower, horizontal elements. The abundance of coniform stromatolite forms in the Proterozoic—across a variety of depositional environments—may thus reflect a combination of distinct community behavior, combined with elevated carbonate saturation state, together permitting growth and preservation of a diversity of coniform microbialite structures.

Abstract ID: 33171

Final Number: PG23A-06

Title: Petrology, Structure and Chemostratigraphic Correlation of Chehmit inlier, Tigrai, Northern Ethiopia. Tadele Tesema[1], Mulugeta Alene[1], Nicholas L. Swanson-Hysell[2], Adam C. Maloof[3]

Presenter/First Author: Tadele Tesema Hundessa, Addis Ababa University, Addis Ababa,

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Published Material: This work was partly presented at 24th colloquium of African geology that was held in Addis Ababa, Ethiopia from january 8-14, 2013. The study is still undergoing for better understanding of paleo geography and the then earth history from the stratigraphic sequences of Tambien Group.

Abstract Body: Abstract

The Chehmit area is one of the six exposed Neoproterozoic inliers in northern Ethiopia, which consists of both Tsaliet and Tambien Group rocks. The metavolcanics, metavolcanoclastics and phyllite rocks exposed in the area represent the Tsaliet Group whereas the mixed clastic-carbonate metasedimentary rocks constitute the Tambien Group. The ash within the Werii Slate that has been dated at 815 Ma constrain the maximum depositional age of the Tambien Group. An integrated structural, petrological and carbon and oxygen isotope study has been carried out to understand the deformation, metamorphic and Neoproterozoic history of the area. Field structural data demonstrate that there are at least three phases of deformations. Earliest deformation produced minor, steep tight folds and N-S trending, pervasive regional foliation; followed by the formation of major upright folds, and latest brittle structures. Petrographic study of rock samples from the area shows predominantly lower green schist facies metamorphism coeval with the earliest phase of deformation. Stable C and O isotope analysis was carried out on limestones in a stratigraphic section through the Assem Formation in the area. The limestone unit contains an anomalous C-isotope signature that enables local and global correlations with other Neoproterozoic formations. The $\delta^{13}C$ values of limestone in a stratigraphic section through the Assem Formation in the Chehmit area range from -5.8‰ to -2.0‰ with an average value of -3.8‰ while the values of $\delta^{18}O$ range from -7.1‰ to -14.2‰ with an average value of -11.3‰. Although negative carbon isotope excursions in the Neoproterozoic era are often in close stratigraphic relationship with glacial deposits, no glaciation features or erosion surfaces are observed in this unit. Instead, the negative C-isotope excursion is correlated with the Bitter Springs Stage anomaly (found in Australia, NW Canada and Svalbard) which is hypothesized to be the result of inertial interchange true polar wandering. The extended interval of low $\delta^{13}C$ values obtained from the studied limestone indicates a correlation with the Bitter Springs anomaly. Radiometric dating and paleomagnetic studies of the rocks of the Chehmit area can be used to test this correlation.

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Abstract ID: 33094

Final Number: PG23A-07

Title: Petrogenesis of the Cryogenian (850-750 Ma) Imorona-Itsindro Suite, Central Madagascar: Insights into pre-Gondwana Arc Formation Using Zircon Isotopic Proxies

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Abstract Body: Madagascar occupies an important location within the East African Orogen, which involves a collection of Neoproterozoic microcontinents and arc terranes lodged between older cratonic units during the final assembly of the supercontinent Gondwana. The Imorona-Itsindro suite of central Madagascar represents voluminous Cryogenian (850-750 Ma) magmatism with different geochemical characteristics interpreted to signify contemporaneous emplacement in varied tectonic settings. While the age of the magmatic suite is widely accepted, the origin and geochemical nature of magmatism is poorly understood. Arc magma generation is suspected to coincide with oceanic plate subduction during closure of the Mozambique Ocean along the Betsimisaraka Suture in eastern Madagascar. Recently, others have questioned the existence of a Neoproterozoic suture in Madagascar and suggest extension related emplacement into the middle and upper crust through a system of pre-existing fractures. In this comprehensive geochemical study of the Imorona-Itsindro suite, we present new whole rock geochemical data, coupled with microbeam U-Pb, Hf and O zircon isotopic analysis that demonstrates that the suite had several sources from contaminated mantle melts to crustal melts. The spatial variation of these sources is discussed that yields new insights into the origin of this diverse magmatic suite and shed its significance for the closure of the Mozambique Ocean during the amalgamation of Gondwana.

Abstract ID: 36357

Final Number: PG23A-08

Title: Ediacaran paleomagnetism and paleogeography of Tarim craton

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Co-authors: Yongxiang Li, Nanjing University, Nanjing, China

Abstract Body: Tarim craton, western China, is one of the building blocks of Rodinia supercontinent, variously reconstructed on the northern or eastern margins of Australia. If the latter position is correct, then Tarim would form part of the “missing link” between Australia and Laurentia in standard Rodinia models. Precambrian rocks are exposed around the edges of Tarim craton, including our field area in the NW (Aksu-Wushi) region. There, Cryogenian metasedimentary rocks are cut by undated mafic dykes and then unconformably overlain by a sporadically exposed diamictite (Yuermeinak Fm) and cap carbonate, which are then conformably overlain by redbeds and overlying Sugetbrakredbeds and basalts. In northeastern exposures of our study area, these strata appear to have been extensively remagnetized in mid-late Paleozoic time; such remanence directions are similar to those reported previously from the SugetbrakFmin the same area (Zhan et al., 2007Precamb Res 154, 143-158). In southwestern exposures, a two-polarity, N-up/S-down characteristic component is identified from 36 sites. This direction is distinct from all published Phanerozoic results derived from Tarim craton, and it passes a regional fold test (implying a pre-Permian age of remanence) and an inverse baked-contact test on a mafic dyke that may be Carboniferous-Permian in age, based on its remanence direction and prevalence of magmatism of that age in the region. A reversal test using site-level statistics yields a positive C-class rating. Our result is also

substantially different from the recently published Cryogenian pole from the same area (Wen et al., 2013Precamb Res 226, 75-90), implying significant APW / continental motion for Tarim during Cryogenian-early Ediacaran time. Relative to quasi-static Australia, Tarim rotated substantially through that interval, probably related to Rodinia breakup.

Abstract ID: 33408

Final Number: PG33A-01

Title: Depositional Setting of Algoma-type Banded Iron Formation from the Meadowbank, Meliadine and Musselwhite gold deposits

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Published Material: 40% of the material is submitted for an GSC Open File on the TGI-4 researches

Abstract Body: Algoma-type Banded Iron Formations (BIFs) are chemical sedimentary rocks comprised of alternating layers of iron-rich minerals and chert interstratified with bimodal submarine volcanic rocks in Archean greenstone belts. However, the geologic setting for Algoma-type BIF deposition remains equivocal due to the overprinting effects of post-depositional deformation and metamorphism and the absence of modern analogues for comparative studies. Recent studies suggest the abundance of REE+Y in chert bands may reflect the primary BIF geochemical signature and therefore may constrain geological settings favourable for BIF deposition.

In this study, the results of LA ICP-MS on chert at three BIF-hosted gold deposits are presented to assess whether epigenetic gold mineralization is preferentially developed within a particular geochemical type of BIF. The three deposits studied were: (1) Meadowbank deposit (Churchill Province); (2) Meliadine gold district (Churchill Province); and, (3) Musselwhite deposit (Superior Province). The results of this study, which explore rare earth elements (REE) and yttrium as tracers of depositional processes for Algoma-type BIF, suggest that chert bands record: (1) interaction of seawater with Fe-oxyhydroxides, as suggested by heavy rare earth element enrichment coupled with La and Y enrichment; (2) high-temperature (>250 ºC) hydrothermal fluids, as suggested by positive Eu excursions; and (3) hydrogeneous contamination, which is suggested by relatively consistent REE concentrations and a chondritic Y/Ho ratio. Moreover, the pH conditions of the water column at the time of BIF deposition are evaluated using Ce/Ce* as a pH proxy, which suggest acidic seawater conditions associated with positive Ce/Ce* anomalies. This data set does not suggest there is a preferred chemical type of BIF for epigenetic gold mineralization.

Abstract ID: 34043

Final Number: PG33A-02

Title: Lateral Geochemical Gradients and Physical Processes Associated with the Genesis of Iron Formations: Examples from the Paleoproterozoic to Mesoarchean of Superior Province

Presenter/First Author: Philip William Fralick, Lakehead University, Thunder Bay,

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Published Material: The three examples I use have all been published by me in the literature. Such is the nature of reviews to show under appreciated processes.

Abstract Body:

Abstract ID: 35572

Final Number: PG33A-03

Title: IF, GIF, and two BIF in northwest Canada: time-space relationships and depositional environments

Presenter/First Author: Luke Ootes, Northwest Territories Geoscience Office, ,

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Co-authors: Kurt Konhauser, University of Alberta, Edmonton, AB, Canada; Rasmus Haugaard, University of Alberta, Edmonton, AB, Canada; Andrey Bekker, University of California Riverside, Riverside, CA; Ernesto Pecoits, University of Alberta, Edmonton, AB, Canada; Natalie Aubet, , ,

Abstract Body: Bedrock exposures in northwest Canada preserve many relevant features critical to understanding Precambrian Earth history. One of these is iron formation (IF), whose physical and chemical attributes uniquely provide details regarding the composition of Precambrian seawater and environmental change. Two distinct types of banded IFs are preserved in the Slave craton. The older was deposited at ca. 2.85 Ga and precipitated on top of fuchsitic quartzite, unconformably overlying basement gneisses. The BIFs are up to 10 m thick and consist of micro- and meso-bands of chert and magnetite. They are generally overlain by massive to pillowed basalt flows or, locally, by pebble conglomerates. The younger BIF type occurs as 5 to 10 m thick beds of interlaminated chert-magnetite-carbonate, with local grunerite and sandstone beds, within ca. 2.62 Ga turbidite packages. These BIFs are preserved across the craton in a southwest to northeast fashion and represent a significant hiatus in turbidite deposition to allow for the chemical precipitation and preservation. The deep-water nature of these Neoarchean BIFs is in stark contrast to the more shallow nature of the Mesoarchean BIFs.

In the East Arm basin, south of the Slave craton, up to 9 m of ca. 1.88 Ga granular IF is preserved within green, grey, and red shales of the Gibraltar Formation in the Great Slave Supergroup. This GIF contains hematite-jasper, and its granular nature, along with ripple marks and local stromatolites, attest to the shallow-water deposition of this iron formation on a marine shelf. The age is similar to that of the Gunflint Iron Formation in the Superior craton, which is also granular and was deposited in a shelf environment. In the northern Mackenzie Mountains, up to 120 m of ca. 700 Ma IF is preserved in the Rapitan Group. It consists of hematite with chert-carbonate nodules and less common individual jasper and hematite beds up to 10 cm thick. The upper exposure of the IF contains granular hematite, perhaps indicating an upward-shallowing depositional environment. Unlike the older IFs, the Rapitan Iron Formation was deposited under glacial conditions of the Sturtian Snowball Earth and represents a return to IF deposition after a 1.15 Ga hiatus.

Abstract ID: 35544

Final Number: PG33A-04

Title: Detailed Geochemistry and Nd isotopes of a 2.85 Ga old BIF from the Slave Craton: Unraveling the Seawater Sources and Precipitation of Iron and Silica in BIF Formation

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Co-authors: Luke Ootes, Northwest Territories Geoscience Office, , Canada; Robert A Creaser, University of Alberta, Edmonton, AB, Canada; Kurt Konhauser, University of Alberta, Edmonton, AB, Canada

Abstract Body: Banded iron formations (BIFs) are metamorphosed chemical sediments that initially precipitated from Precambrian ocean water. The alternating bands of silica and iron contain important information about the composition of seawater at the time of BIF formation, as well as the relative contributions of hydrothermal discharge and continental weathering. In this work we use the combination of geochemistry and Sm-Nd isotopes on a layer-by-layer basis of the ~2.85 Ga old BIF from the Central Slave Cover Group (CSCG). The bulk of the CSCG is composed of oxide BIF underlain by fuchsitic quartzite that unconformably rests on basement gneisses. Seven silica bands and seven iron bands were separated from the BIF. Geochemical analyses show that in all the bands Al_2O_3 is < 1 wt.%, with less in the silica bands (average 0.12 wt.%) relative to the iron bands (average 0.41 wt.%). Highly insoluble elements, such as Ti, Zr, Nb and Th, are elevated in the iron bands relative to the silica bands. Both the total REE concentrations and the shale-normalized REE patterns reveal a systematic difference, with higher REE content and a more elevated LREE patterns for the iron bands. This, together with the higher abundances of insoluble elements, points towards a larger terrigenous input during precipitation of the iron. However, a well-developed Eu anomaly occurs in all the bands suggesting some mixing of high-T hydrothermal fluids with the upper seawater. The iron bands have consistently depleted $e_{Nd}(t)$ values between +1.0 to +2.8 (average of +1.7) reflecting that the dissolved REEs in the source water during ferric iron precipitation may have contained a mixture of submarine hydrothermal fluids and bulk upper seawater dominated by more evolved continental sources. The silica bands, on the other hand, show a higher spread in their $e_{Nd}(t)$ values. Four of the bands have enriched $e_{Nd}(t)$ values of -2.2, -1.2, -0.6 and -0.4 (average of -1.1) and three of the bands have depleted $e_{Nd}(t)$ values of +1.7, +2.4 and +3.4 (average of +2.5). This trend suggests that both evolved and more depleted continental landmasses contributed to the dissolved REE budget of the ambient surface seawaters during silica precipitation.

Abstract ID: 35310

Final Number: PG33A-05

Title: The Mobility Of Biologically Critical Transition Metals Following Simulated Iron Formation Diagenesis: Zinc and Nickel

Presenter/First Author: Leslie James Robbins, University of Alberta, Edmonton, AB

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Co-authors: Stefan Lalonde, European Institute for Marine Studies, Plouzane, France; Elizabeth Swanner, University of Tübingen, Tübingen, Germany; Merle Eickhoff, , , ; Christopher T Reinhard, California Institute of Technology, Pasadena, CA; Caroline Peacock, University of Leeds, Leeds, United Kingdom; Andreas Kappler, University of Tübingen, Tübingen, Germany; Kurt Konhauser, University of Alberta, Edmonton, AB, Canada

Published Material: These findings have been submitted to, and reviewed by the journal of Chemical Geology. A revised manuscript was recently resubmitted, and is currently being considered for publication.

Abstract Body: Banded Iron Formations (BIF) are iron- and silica-rich chemical precipitates deposited during the Precambrian. They have proven to be a key paleoenvironmental proxy, particularly with regards to the availability of biologically critical elements, such as zinc (Zn) and nickel (Ni), which play key roles in eukaryotic and prokaryotic metalloenzymes, respectively. Recent investigations into the BIF record indicate a stable paleomarine reservoir for Zn, while for Ni a dramatic decline is indicated immediately prior to the great oxidation event. However, what remains cryptic regarding the BIF record is the possible influences of post-depositional effects. Here, we examine the mobility of Zn and Ni from ferric oxyhydroxides, in the absence and presence of organic matter, during simulated pressure-temperature diagenesis (1.2 kbar and 170ºC). Following a two-week diagenetic treatment, that captures the critical mineral transformation from ferrihydrite to hematite, both metals were strongly retained, regardless of the presence of organic matter. Indeed, more than 90% of both metals were retained following diagenesis; hematite was the predominant iron mineral in the non-organic matter experiments, while siderite, magnetite and hematite formed in the carbon-bearing experiments. These results further support the use of BIF for examining the paleomarine trace elements concentrations, and that the authigenic records of Zn and Ni are faithfully recorded in well preserved BIF despite post-depositional alteration.

Abstract ID: 36611

Final Number: PG33A-06

Title: Did Archean mantle plume events stimulate or limit marine productivity?

Presenter/First Author: Andrey Bekker, University of California Riverside, Riverside, CA

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Abstract Body: Iron Formations are a hallmark of Archean chemical sedimentation, yet the impact of associated mantle plume events on biological productivity in the oceans is poorly understood. Iron Formations typically have low organic carbon content, but are commonly stratigraphically associated with organic matter-rich shales. Low organic carbon contents in iron formations have been explained by oxidative remineralization of organic matter in presence of co-precipitated iron oxyhydroxides. To understand the impact of mantle plume events on biological productivity in the Archean oceans, it is critical to know what in general controlled organic productivity and burial in the Archean oceans and how high they were.

We approach this question from the perspective of biogeochemical carbon cycle under largely anoxic surface conditions typical for the Archean. Since organic carbon from older sediments would not be oxidized during continental weathering, carbon isotope mass balance requires that carbonate carbon released from older sedimentary successions during continental weathering would also not be utilized for biomass production. As a result, Archean organic productivity and burial were limited and processed only juvenile, mantle-derived carbon. The limitation was likely imposed by a smaller flux of nutrients delivered from the continents under anoxic surface conditions. Mantle plume events that led to deposition of iron formations could have also resulted in a higher flux of nutrients to seawater via submarine hydrothermal processes and acidic weathering conditions, induced by a higher volcanic flux of CO_2 and SO_2 to the atmosphere. We thus suggest that on a geological timescale mantle plume events could have led to enhanced marine productivity, which might explain associated, short-lived oxidation events before the GOE.

Abstract ID: 35119

Final Number: PG33A-07

Title: Precambrian Secular Evolution of Oceanic Nickel Concentrations

Presenter/First Author: Kurt Konhauser, University of Alberta, Edmonton, AB

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Abstract Body: Iron formations (IF) preserve a history of Precambrian oceanic elemental abundance that can be exploited to address nutrient limitations on early biological productivity. In 2009 we reported that secular trends in IF Ni/Fe ratios record a reduced flux of Ni to the oceans ca. 2.7 billion years ago, which we attribute to decreased eruption of Ni-rich ultramafic rocks[1]. We determined that dissolved Ni concentrations may have reached ~400 nM throughout much of the Archean, but dropped below ~200 nM by 2.5 Ga and to modern day values (~9 nM) by ~550 Ma. As Ni is a key metal cofactor in several enzymes of methanogens, its decline would have stifled their activity in the ancient oceans and disrupted the supply of biogenic methane. Here we provide an updated compilation of Ni concentrations and Ni/Fe ratios in Precambrian iron formations based on a greatly expanded (>3 fold) dataset. We frame our rock record compilation in the context of new experiments examining the partitioning and mobility of Ni during simulated diagenesis of Ni-doped iron formation mineral precursors, as well as a fresh look at Ni-Fe scaling relationships in IF vs. modern Fe-rich chemical sediments. While its potential effects on atmospheric oxygenation remains to be fully resolved[2], our new results reaffirm the Paleoproterozoic Ni famine, whereby the enzymatic reliance of methanogens on a diminishing supply of volcanic Ni links mantle cooling to the trajectory of Earth surface biogeochemical evolution.

1. Konhauser KO, et al. (2009) Oceanic nickel depletion and a methanogen famine before the Great Oxidation Event. Nature 458: 750–753.
2. Kasting JE (2013) What caused the rise of atmospheric O_2? Chemical Geology 362: 13-25.

Abstract ID: 35139

Final Number: PG33A-08

Title: Exploring Relationships Between the Chemical Evolution of the Atmosphere-Ocean System and the Secular Variation in BIF-hosted Gold Deposits

Presenter/First Author: Camille A Partin, University of Saskatchewan, Saskatoon, SK

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Abstract Body: As one of the most readily recognized and intriguing chemical sedimentary rock types, banded iron formations (BIFs) also serve as a useful and elegant archive of ocean chemistry. Their apparent secular distribution throughout geologic time has influenced models of evolving ocean chemistry for decades—that more or less stand today, with some important modifications. Recent intensive research concerning chemical changes in BIFs throughout geologic time has greatly expanded our knowledge of changing redox conditions as well as understanding controls on biological evolution. In particular, this work suggests that a dramatic change developed in the Orosirian period (2.05 to 1.8 Ga) resulting in a lower redox state of the atmosphere-ocean system. In contrast to the preceding Siderian and Rhyacian periods (2.5 to 2.05 Ga) that experienced high (modern-like?) oxygen levels, the Orosirian period records a deoxygenation event. There is a notable decrease in the abundance of some trace elements in BIFs, including U, Co, Zn, and Cr, after the end of the Lomagundi Excursion (ca. 2.06 Ga). The same trend is observed in organic matter-rich shales that show a shift in isotopic values and significantly lower trace element abundances. This time interval also coincides with a major peak in orogenic gold deposit occurrences (ca. 2.1 to 1.85 Ga) typically associated with BIFs. While this new model of evolving redox-state of the atmosphere-ocean system has been developing over the last few years, the implications of dynamic oxygen levels in the Proterozoic has not been fully explored. This talk will explore recent advances in our knowledge of the evolving redox state of the Precambrian atmosphere-ocean system, especially in the Orosirian period, and use this to consider ideas regarding controls on secular variations in mineral deposit occurrences.

Abstract ID: 35710

Final Number: PG34A-0268

Title: Petrology and geochemistry of pillow lava bearing volcanic rocks form the Nuvvuagittuq greenstone belt: implications for early crust formation settings

Presenter/First Author: Meghan Moher, University of Ottawa, Ottawa,

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Co-authors: Jonathan O'Neil, University of Ottawa, Ottawa, ON, Canada

Abstract Body: Rare remnants of ≥3.6 Ga supracrustal rocks are the only samples available to study the formation of the primitive crust and the early environments in which it formed. With a possible age of ~4.3 Ga, the Nuvvagittuq Greenstone Belt (NGB) located on the east coast of the Hudson Bay in the Northeastern Superior Province, provides a glance at what these primitive settings may have looked like. The proposed Hadean age of the NGB comes from the irregular ^{142}Nd isotopic compositions of garnet-cummingtonite-biotite layered rocks called the Ujaraaluk unit. Deviation in ^{142}Nd from modern terrestrial mantle can only be produced before 4.0 Ga, while the parent isotope (^{146}Sm) was still actively decaying. The $^{142}Nd/^{144}Nd$ vs. Sm/Nd correlation observed in the Ujaraaluk unit is thus consistent with a pre-4.0 Ga formation age. The Ujaraaluk unit is generally basaltic in composition and divided into three distinct geochemical groups following a stratigraphy reminiscent of volcanic successions found in modern convergent margins. The layered texture of the Ujaraaluk unit however, could be suggestive of a sedimentary origin. Disagreements about the exact formation age of the NGB arise in part from the vague origin of the Ujaraaluk rocks. This research will investigate the petrology and geochemistry of pillow-bearing rocks to the SW and SE of the NGB in order asses their potential genetic link with the Ujaraaluk unit. Preliminary results suggest that these volcanic rocks follow the same chemostratigraphy as the Ujaraaluk unit with samples exhibiting ^{142}Nd deficits falling on the same $^{142}Nd/^{144}Nd$ vs. Sm/Nd Ujarraluk correlation. This will help to better constrain the nature of the protolith of the NGB lithologies, crucial to interpret geochronological results, and provide a better picture of early supracrustal environments.

Abstract ID: 36347

Final Number: PG34A-0269

Title: Petrological and Geochemical Study of Cordierite-Orthoamphibole Rocks from the Nuvvuagittuq Greenstone Belt: Evidence for Seawater Hydrothermal Alteration of Oceanic Crust in the Hadean?

Presenter/First Author: Evelyn Y Abramovitch, University of Ottawa, Ottawa,

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Co-authors: Jonathan O'Neil, University of Ottawa, Ottawa, ON, Canada

Abstract Body: With a possible age of ~4.3 Ga, the Nuvvuagittuq Greenstone Belt (NGB) may represent the only remnant of Hadean crust available to study Earth's earliest environments. The NGB is dominated by mafic rocks called the Ujaraaluk unit. The Ujaraaluk preserves a chemostratiraphy ranging from pillow-bearing basaltic rocks at the base of the sequence displaying tholeiitic affinities, to rocks sharing geochemical signatures with modern-day boninites, and basaltic andesites of calc-alkaline affinities at the top. Chemical sediments (banded iron formation) are found at the transition between the tholeiitic and the boninitic basalts. The geochemical stratigraphy in the NGB closely matches what is observed in the modern-day Izu-Bonin-Mariana forearc, suggesting similar petrological processes were involved in its formation. If the igneous age of the NGB is indeed Hadean as suggested by the $^{142}Nd/^{144}Nd$ vs. Sm/Nd correlation observed in the Ujaraaluk unit, it offers the unique opportunity to study the primitive oceanic crust and better understand the Hadean environments in which it formed. This study focusses on the petrology and geochemistry of a specific rock type within the Ujaraaluk unit composed of cordierite-orthoamphibole observed in all three distinct geochemical Ujaraaluk groups. They display high magnesium and low calcium contents consistent with seawater alteration of basaltic crust. Preliminary data show that they exhibit ^{18}O depletion (close to mantle values) with respect to other Ujaraaluk samples [1]. These signatures suggest that the cordierite-orthoamphibole rocks could have been formed in a VMS-type (Volcanogenic Massive Sulfide) hydrothermal system and represent Hadean seawater-altered oceanic crust. This would suggest that VMS-type hydrothermal environments were already present nearly 200 million years after the Earth's formation and can help to further expand our understanding of early crust formation.

[1] E. Thomassot et al., *in prep*.

Abstract ID: 34986

Final Number: PG34A-0270

Title: Lithogeochemistry and distribution of 4.0–3.4 Ga units of the Acasta Gneiss Complex, NWT, Canada

Presenter/First Author: Jesse Ray Reimink, University of Alberta, Edmonton, AB

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Co-authors: Tom Chacko, University of Alberta, Edmonton, AB, Canada; Richard A Stern, University of Alberta, Edmonton, AB, Canada; Larry Heaman, University of Alberta, Edmonton, AB, Canada

Published Material: A preliminary version of this information was presented in talk form at the Northwest Territories Geoscience Forum, November 2014.

Abstract Body: The Acasta Gneiss Complex (AGC) has long been known to contain rock units with crystallization ages close to 4.0 Ga (Bowring and Williams, 1999; Stern and Bleeker, 1997) making them the oldest known evolved rock units in the world. However, the AGC has experienced a long and complex history with multiple periods of igneous intrusion, deformation and metamorphism. Indeed, previous workers have demonstrated that orthogneisses within the AGC have igneous ages ranging from ~4.03 to ~3.4 Ga (Iizuka *et al*., 2007). This large range in crystallization ages gives us the opportunity to investigate the evolution of Earth's earliest known continental crust through a period of greater than 600 million years.

The geochemical signatures present in some of the oldest rock units are distinct from the TTG suite of granitoids (Reimink *et al.,* 2014), a suite of rocks commonly thought to represent the major contributor to growth of continental crust in the Archean (Moyen and Martin, 2012). Archean TTGs are formed by deep-seated melting of a hydrated basaltic precursor in the presence of significant garnet, potentially in a subduction-like environment while the some of the oldest components of the AGC have geochemical signatures indicating high degrees of fractional crystallization and shallow-level fractionation of plagioclase.

Here we present an updated geologic map of key areas within the Acasta Gneiss Complex in which we delineate units based upon age as well as composition. Recently acquired whole-rock geochemistry, LA-ICPMS zircon U-Pb geochronology and SIMS O-isotope analyses of zircons from a large suite of key samples indicate a significant change in mode of crust formation by 3.6 Ga. These data document a gradual change from a shallow crustal processes generating basaltic to andesitic compositions between 4.0-3.75 Ga, to deep-seated partial melting of hydrated basalt, represented by voluminous Archean TTG intrusion at 3.6 Ga.

Bowring & Williams, (1999) *Cont. Min. Petro.* **134**, 3-16.

Stern & Bleeker, (1999) *Geosci Can* **25**, 28-31.

Iizuka et al., (2007) *Precambrian Research* **153**, 179-208.

Reimink *et al.* (2014) *Nature Geoscience* **7**, 529-533

Moyen & Martin, (2012) *Lithos* **148**, 312-336.

Abstract ID: 35737

Final Number: PG34A-0271

Title: The Zircon Hf Isotopic Record of the Acasta Gneiss Complex

Presenter/First Author: Ann Bauer, Massachusetts Institute of Technology, Cambridge, MA

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Co-authors: Samuel A Bowring, Massachusetts Institute of Technology, Cambridge, MA; Jeffrey D. Vervoort, Washington State University, Pullman, WA; Christopher M Fisher, Washington State University, Pullman, WA

Published Material: Goldschmidt (2014) talkAGU (2014) posterThere will be new whole rock Hf and Nd data, new whole rock geochemical data, and new zircon Hf data (about 30% of the zircon Hf data will be new).

Abstract Body: The Acasta Gneiss Complex (AGC) of the Slave Craton in the Northwest Territories, Canada, comprises compositionally and isotopically diverse gneisses with crystallization ages of 3.3 to >4.0 Ga. Whole rock geochemical data and inherited zircons up to 4.2 Ga indicate the involvement of even older crust in their generation[1,2]. The rocks of the AGC have undergone a complex history of metamorphism and deformation[1,3] and, as a consequence, the zircons retain this complex history including inheritance, magmatic and metamorphic overgrowths, recrystallization, and multi-stage Pb loss.

We obtained coupled U-Pb and Lu-Hf in zircon data as well as whole rock compositional and isotopic (Sm-Nd and Lu-Hf) data. The complicated nature of the rocks and minerals has necessitated design of an experimental approach that allows us to obtain accurate and representative isotope compositions. For some samples, our solution and laser analytical approaches yield coherent initial ε_{Hf}, however, some more complicated samples demonstrate variable Hf within individual zircon grains and within gneiss samples and require isotopically distinct components.

Our data are generally consistent with published Hf data from the Acasta Gneiss Complex[4-7] and demonstrate involvement of 4.0 Ga or older crust in younger generations of crust. There are no rocks with zircon Hf isotopic signatures consistent with derivation from a LREE-depleted source; instead, the measured compositions may reflect mixing between a compositionally evolved and relatively unradiogenic reservoir with a reservoir bearing a more radiogenic signature. The simplest interpretation is that these rocks formed in an environment that allowed crustal melting, assimilation and rapid recycling.

[1]Bowring and Williams (1999). *CoMP*, 134(1), 3-16. [2]Iizuka, T. et al. (2006) *Geology*, *34*(4), 245-248.[3]Iizuka et al (2007). *Precambrian Res*, 153(3), 179-208. [4]Amelin et al (2000). *GCA*, 644, 205-4225. [5]Guitreau, M., et al. (2012). *EPSL*, 337, 211-223 [6]Iizuka, T. et al. (2009). *Chemical Geology*, *259*(3), 230-239. [7]Guitreau, M., et al. (2014). *GCA* 135, 251-269. [8]Pietranik et al (2008). *Geology* 36(11), 875-878.

Abstract ID: 34524

Final Number: PG34A-0272

Title: Petrological and geochemical investigation of the Eoarchean crust from the Saglek-Hebron Complex, Northern Labrador

Presenter/First Author: Benjamin Wasilewski, University of Ottawa, Gatineau,

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Co-authors: Jonathan O'Neil, University of Ottawa, Ottawa, ON, Canada; Hanika Rizo, Carnegie Institution for Science, Washington, DC

Abstract Body: The Saglek-Hebron Complex is located in Northern Labrador and is part of the Nain Province. The Eoarchean rocks include two suites of supracrustal assemblages, both composed of metavolcanic and metasedimentary lithologies. The oldest suite consists of the Nulliak assemblage which is estimated to be ~3.8 Ga, with Sm-Nd systematics suggesting an older age of ~4.0 Ga [1] for the mantle-derived rocks. Therefore, the Nulliak assemblage represents one of the oldest suites of mantle-derived rocks at the surface of the Earth and could shed light on the formation of the primitive crust and early mantle evolution. The Nulliak unit is intruded by the ~ 3.6 Ga Uivak gneisses, which could be derived from an older mafic component. Supracrustal rocks from the Upernavik assemblage are consistent with a younger emplacement age of ~3.5 Ga. In order to constrain the formation and evolution of the early crust, here we present a preliminary petrological and geochemical study of well-preserved supracrustal rocks from the Nulliak assemblage (Pangertok and Aupaluttok areas) as well as rocks from the younger Upernavik assemblage. These mafic metavolcanic rocks are mainly composed of hornblende + plagioclase ± garnet of variable grain size. Identification of deformed pillow lavas in both supracrustal assemblages and alternation of the mafic metavolcanic rocks with quartz-biotite-garnet schists is consistent with volcano-sedimentary environments of deposition. Preliminary trace and major element data will also help constraining the composition and formation setting of these ancient volcanic rocks. It has been suggested that the Saglek-Hebron Complex may have been related to the well-studied Eoarchean Itsaq Gneiss Complex in Southwest Greenland [2].

[1] Collerson et al. (1991), *Nature.* [2] Bridgwater and Schiotte (1991), *DGF*.

Abstract ID: 36213

Final Number: PG34A-0273

Title: A Provenance and Metamorphic History of the Sedimentary Rocks in the Eastern Part of the North Caribou Greenstone Belt, Host of the Musselwhite Gold Deposit

Presenter/First Author: Octavia E Bath, University of Ottawa, Ottawa,

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Co-authors: Keiko Hattori, University of Ottawa, Ottawa, ON, Canada; John Biczok, Goldcorp, Thunder Bay, ON, Canada

Published Material: Some data was presented in at GAC-MAC 2014Bath, O., Hattori, K., Biczok, J., 2014. Young un-metamorphosed sedimentary rock in the North Caribou greenstone belt. *Joint Annual meeting of the Geological Association of Canada and Mineralogical Association of Canada, Fredericton, NB. Abstract*

Abstract Body: This study characterizes the sedimentary rocks in the eastern portion of the North Caribou Greenstone Belt, which hosts the Musselwhite Au deposit. The center of the belt is comprised of siliciclastic rocks of the Eyapamikama Lake Assemblage (ELS) and Zeemal Heaton Lake Assemblage (ZHL). The ZHL is close to the terrane boundary with the Island Lake Domain and the Totogon shear zone. Quartz-rich wackes of the ZHL contain detrital zircon grains of igneous origin (Th/U ~ 0.6) with fine oscillatory zoning. They show a wide range of morphologies and yielded three age populations; 2698-2750, 2844-2903 and 2970-2985 Ma. These rocks show elevated MgO (>1%), Ni (>104 ppm), Cr (>180 ppm) and low REE (>88 ppm) and a relatively undifferentiated signature (Th/Sc: 0.67-0.83, $[Ce]_N/[Yb]_N$: 8.1-19, Cr/Zr: 1.3-2.1). They display εNd(2.7 Ga) of -0.97 to +0.50 and DM model ages of ~2.88 Ga. The data indicates a provenance of surrounding batholiths as well as mafic and 2.7 Ga igneous rocks. These sediments contain X_{sp} (0.246-0.414), X_{alm}(0.378-0.548) garnet and ferro-tschermakite, indicating the peak metamorphism under lower amphibolite facies conditions followed by greenschist retrogression chlorite, epidote and actinolite. Quartz-rich wackes of the ZHL show a gradual decrease in metamorphic grade to the east where garnet composition (X_{sp} ~0.381) indicates peak greenschist facies conditions. The arkosic sediments in the central portion of the belt show one population of detrital zircon ages between 2800-2850 Ma. Zircons display similar morphology and lower Th/U (~0.44). Bulk rocks contain low Mg (<1%), Ni (<24 ppm), and Cr (<50 ppm), relatively high REE (104-166 ppm) and an evolved signature (Th/Sc: 0.8-2.1, $[Ce]_N/[Yb]_N$: 14-21, Cr/Zr: 0.07-0.27). εNd(2.85Ga) of -0.14 to +0.77 and DM model ages of 2.92-2.95 Ga, suggesting a provenance primarily derived from the surrounding batholiths (~2.85Ga). They garnet (X_{grs}0.136-0.196, X_{alm}0.606-0.678, X_{pyr}0.038-0.053). These amphibolite facies sediments show varied compositional zoning of garnet, suggesting protracted history of metamorphism.

Abstract ID: 35807

Final Number: PG34A-0274

Title: Characterizing the Archean rocks of eastern Hall Peninsula, Baffin Island, Nunavut, Canada: An integrated approach using U-Pb and Lu-Hf isotopes

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Published Material: The U-Pb SHRIMP geochronology was presented at the Geological Society of America's 2014 annual conference in Vancouver. The format was an oral presentation. The Hf data was briefly mentioned at the end of the presentation but not fully presented.

Abstract Body: Archean rocks of eastern Hall Peninsula, Baffin Island were involved in a period of accretionary tectonism from ca. 1.88 to 1.80 Ga in the Northern Labrador – Baffin Island – West Greenland segment of the Trans-Hudson orogen. Eastern Hall Peninsula lies in the middle of this multiple-stage, three-way collision between the Rae craton, the North Atlantic craton and the Meta Incognita microcontinent with the possible involvement of other microcontinent fragments (e.g. the Aasiaat domain of West Greenland). Consequently, several different interpretations of crustal suture locations are possible and paleo-plate reconstructions of this region have been hindered by the fact that the rocks of eastern Hall Peninsula remain poorly understood. The geologic history of these Archean rocks on eastern Hall Peninsula may hold the key to establishing regional crustal correlations and is also important for the exploration industry with the known presence of diamondiferous kimberlites.

Detailed mapping in a well-exposed study area on east-central Hall Peninsula has highlighted the heterogeneity of this Archean block that was previously thought to be a relatively homogeneous suite of tonalitic to monzogranitic gneiss. Zircon from seven samples from the study area have been analyzed for both U-Pb (Sensitive High Resolution Ion MicroProbe) and Lu-Hf (Laser Ablation Inductively Coupled Plasma Mass Spectroscopy) isotopes in the same spots. The new U-Pb age data bracket the duration of Archean magmatism to ca. 2.99 to 2.72 Ga and document previously unrecognized Archean metamorphism from ca. 2.72 to 2.69 Ga. These Archean magmatic zircons, for the most part, have positive εHf values (+13 to -5) that are typical of magmas that have been derived from the mantle. Hf model ages (T_{DM}) indicate magma derivation from the mantle at ca. 3.00 Ga. One sample with significantly more negative εHf values (-8 to -31) and older T_{DM} ages of ca. 3.50 Ga indicate that it was a melt derived from a re-worked, older crustal source. Additional samples using U-Pb, Lu-Hf and Sm-Nd isotopes will further characterize these Archean rocks and allow comparisons of data from adjacent Archean blocks.

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Abstract ID: 35537

Final Number: PG34A-0275

Title: ID-TIMS Geochronology on Precambrian zircons from northern Quebec: treatment, complications and results

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Abstract Body: During an ongoing mapping project founded by the ministry of energy and natural resources of Quebec, several plutonic and volcanic samples from areas around Lebel-sur-Quevillon and Chibougamau were selected for ID-TIMS geochronology.

Determination of the Precambrian crystallisation age of these samples has proven difficult due to the metamict nature of the zircons. Nearly all grains show radiation damage. During preliminary analyses it became evident that chemical abrasion leads to better results than zircons treated with air abrasion. The problem was the correct measure of chemical abrasion on such metamict zircons. No systematic study was found on time relations and effects on zircons during the partial dissolution process. One cause might be the variable response of grains from the same sample to the leaching acid. This may be due to microstructures in the zircons, which are invisible during picking. The widely used overnight partial dissolution in HF has proven to be too aggressive for the zircons used in this study. Most of them dissolved, the few remaining ones were very fragile and disintegrated on touch. After experimenting with different dissolution times, six hours was determined as the ideal time, where most of the grains remained largely intact but where the partial dissolution was strong enough to improve concordance. Preliminary analyses of three samples reveal formation ages of 2727 ± 7 Ma for a tonalite in the Holmes Pluton, 2686 ± 5 Ma for the Tonnancourt granite and 2774 ± 26 Ma for a migmatite in the Opatica Subprovince. Special attention was given to the migmatite sample since it shows the oldest age gained from that sampling area so far. Initial data point towards two discordia lines with upper intercepts close to each other, one at 2774 ± 26 Ma formed by grains that appear to be magmatic, the other at 2723 ± 1 Ma formed by strongly rounded, metamorphic looking grains. The interpretation of these two lines is not straight forward. In the easiest explanation it would reveal an intrusive age of 2774 Ma and metamorphism at 2723 Ma, however, discordance due to later events obscures the data. Different stages of magmatic evolution and a much later metamorphic overprint remain possible and will be investigated by further research involving CL images and laser ablation.

Abstract ID: 34216

Final Number: PG34A-0276

Title: Structural geology, geochemistry and geochronology of transpressive deformation zones in the North Caribou greenstone belt, NW Superior

Presenter/First Author: Emilie Gagnon, University of Ottawa, Gatineau, QC

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Published Material: GSA Vancouver 2014: October 19-22, 2014. Session: Deformation Localization throughout the Crust. Title: Relationships between regional metamorphism and transpression in shear zones of the Archean North Caribou greenstone belt, NW Superior Province

Abstract Body: The Archean North Caribou greenstone belt (NCGB), host to the Musselwhite gold deposit, possesses abundant transpressive deformation zones on its northern margins, which appear to have formed under amphibolite facies conditions. Protracted deformation and regional metamorphism are coeval with widespread magmatism and accretion events of the Superior Province, and are responsible for folding the ore-hosting BIF and channeling fluids. The importance of these shear zones in the tectonic evolution of the NCGB and their relationship with metamorphism is equivocal, yet structural analyses support a transpressive system that produced steeply-dipping planar and shallow-plunging linear fabrics that trend broadly parallel to the doubly arcuate shape of the belt. This strongly implicates horizontal tectonism, which is partly in contrast with some currently proposed models for Archean greenstone belts that suggest the formation of shear zones at granite-greenstone contacts is during synchronous vertical and horizontal movement. Moreover, geochemical and microstructural analyses from shear zones in the central part of the belt indicate deformation occurring above 500°C under dry conditions (e.g. Dinnick Lake shear zone), whereas monazite recrystallization seems to record fluid-facilitated deformation in the southern arm (e.g. Markop Lake deformation zone). In situ total-Pb geochronology of small (<100 µm) monazites from high strain zones and K-Ar ages of fabric forming micas were obtained in an attempt to resolve the timing of deformation recorded in shear zones. The ages are consistent with protracted metamorphism and deformation corresponding to the amalgamation of the Superior craton from ca. 2.75 to 2.4 Ga. A strong 2.5-2.4 Ga signature is recorded in many deformation zones and may be a consequence of the regional large igneous provinces throughout the Superior during this period. The heterogeneous nature of deformation during the 400 m.y. tectonothermal evolution of the belt and the high metamorphic grade of the host rock may obscure tectonic signatures, however some structural and geochemical characteristics are consistent with other greenstone belts (e.g. Hemlo, Yilgarn) where vertical and horizontal tectonism may be responsible for channeling fluids.

Abstract ID: 36407

Final Number: PG34A-0277

Title: Tectono-metamorphic evolution of the contact between the Opinaca and La Grande Subprovinces, Superior Province, Quebec: implications for Archean tectonics and regional metallogeny

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Published Material: The project was presented at Québec Mines 2014 (Nov 17-20), in Québec city, in the form of a poster.

Abstract Body: The contact between the Opinaca and La Grande Archean Subprovinces in the Superior Province is host to many of the region's gold showings and deposits. However, the processes leading to their assembly are still poorly understood. The La Grande Subprovince (3.45 - 2.57 Ga) is an assemblage of volcano-sedimentary sequences, tonalitic basement and various instrusions of medium metamorphic grade. It is mainly in tectonic contact to the south with the metasediments of the Opinaca Subprovince, where anatexy is widespread. The individual tectono-metamorphic evolution of both subprovinces is still weakly constrained, with very few quantified metamorphic conditions and ages having been reported. Accordingly, the general tectonic setting for their assembly remains unclear. The present contribution aims at characterizing peak and retrograde metamorphism along two transects intercepting the Opinaca-La Grande contact with the use of thermobarometry, pseudosections and Lu-Hf, Sm-Nd and U-Pb geochronology. The resulting information will be synthetized in the form of pressure-temperature-time (P-T-t) paths, from which information on the geodynamic context can be drawn and confronted to existing models. The two main models proposed for the Opinaca-La Grande assembly (metamorphic core complex versus accretion complex) have important implications for exploration models, but also for tectonic processes that may or may not have been active at such scale during the Archean. Furthermore, the similarity of the Opinaca-La Grande architecture with other metasedimentary-volcanoplutonic successions in the Superior may help draw conclusions for the formation of the Superior and Archean tectonics in general. A better understanding of the tectono-metamorphic evolution of these medium to high-grade metamorphic terranes will likely provide new insights in the metallogeny of gold deposits in such environments.

Abstract ID: 35075

Final Number: PG34A-0278

Title: Structural and Metamorphic Study of the Attic Complex in the Lebel-sur-Quévillon Area, Archean Superior Province, Québec.

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Abstract Body: Archean cratons mainly consist of TTG-type plutonic terranes and greenstone belts. In the Superior Province of Quebec, the geology of these units is usually well understood and documented, but their tectonic and metamorphic relationships remain debated. For instance, the contact between the Abitibi Greenstone Belt (AGB) and the Opatica plutonic belt (OPB) has been interpreted as a north-dipping Archean subduction zone. Ongoing studies rather suggest that the OPB represents a deeper domain of an AGB-OPB composite crust. Concurrently, several structural domains within the AGB, such as the Attic Complex of the Lebel-sur-Quévillon area, represent larges areas (more than 600 km^2 for the Attic Complex) of TTG intrusions in the core of antiforrnal domes surrounded by more-or-less linear greenstone belts. In the summer of 2014, the northwestern part of the Attic Complex has been studied in detail during a regional mapping program of the Quebec-MRN. In this segment of the Attic Complex, the tonalite of the Holmes Pluton intrudes the mafic volcanic-plutonic rocks of the ca. 2718 Ma Quevillon Group. Both, the Holmes pluton and hosting volcanic rocks show an E-W trending, north-dipping regional schistosity axial-planar to syn-kinematic folds. To the north, the Holmes pluton is bounded by a NW-SE trending subvertical shear zone. The kinematics of this shear zone remains to be clearly determined but a south-directed variation from greenschist- to amphibolite metamorphic grade on both sides of the structure suggests down-faulting of the Quevillon Group relative to the Holmes Pluton. Our preliminary interpretation is that the Holmes Pluton represents a synmetamorphic and syntectonic intrusion. The geological characteristics of the study area are similar to those of the contact zone between the AGB and the OPB. If such a comparison is correct, the structural and metamorphic study of the Attic Complex should permit to better understand the architecture of the Abitibi Archean crust and to investigate the nature of the basement of the AGB.

Abstract ID: 35877

Final Number: PG34A-0279

Title: Insights into Archean greenstone belt evolution: Evidence from compilation of high precision U-Pb zircon data in the southern Abitibi subprovince, Canada

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Abstract Body: The geodynamic significance of the chronostratigraphic record in the southern Abitibi subprovince (SAS), which forms part of the Superior Province, was investigated through the compilation of existing high precision U-Pb geochronology data. These data, compiled from the Canadian Geochronology Knowledgebase and other pertinent publications, represent the newest and most complete compilation to date. They reveal that early construction of the SAS was episodic and dominated by ~2750-2695 Ma volcanic and intrusive processes. Composite submarine volcanic packages are heterogeneously distributed throughout the SAS, and were synchronous with construction of spatially restricted composite tonalite-trondhjemite-granodiorite batholiths. Five chronologically distinct volcanic episodes are identified that lasted ~10-15 Myrs each. The episodic volcanism was followed by the deposition of the sedimentary rocks of the ~2695-2680 Ma Porcupine/Pontiac and the ~2680-2670 Ma Timiskaming episodes. The appearance of the sedimentary episodes is synchronous

with granitoid intrusive activity, which may be the result of accretionary tectonic processes.

Compilations of detrital U-Pb zircon grain ages indicate that sedimentary rocks in the SAS were largely derived from local volcanic rocks. However, they also display patterns of provenance that are distinct from one another and contain older (>2750 Ma) secondary detrital age populations that do not occur in SAS supracrustal rocks. These populations are best correlated to ages identified in the adjacent Wabigoon and Opatica subprovinces, or to inheritance from underlying felsic SAS protocrust. However, similarly old zircon ages are identified in the North Caribou, Hudson Bay, or Rivière Arnaud terranes to the north. Overall, the chronostratigraphic progression identified in the SAS is representative of greenstone belts worldwide and reflects large-scale geodynamic processes, which may include subduction-related accretionary tectonic processes.

Abstract ID: 36656

Final Number: PG34A-0280

Title: Evidences of linkage of the Cadillac Larder Lake Fault Zone inherited from preexisting structures, Abitibi Subprovince, Quebec

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Abstract Body: The Cadillac Larder Lake Fault Zone (CLLFZ) constitutes a major deformation zone in the southern Abitibi Subprovince ranging from Ontario to Quebec. Numerous deformation events comprising thrusting, extension and strike-slip movements are recorded. In the Quebec portion of the fault, the CLLFZ display different geometries, fabrics and shear sense indicators which lead to subdivide the fault into four segments which are from west to east: 1) Rouyn, 2) Joanna, 3) Malartic and 4) Val-d'Or segments. The fault in these segments is generally E-trending except for the Malartic segment where it is SE-trending. The first event correspond to a N-S shortening and thrusting event displayed by a subvertical E-trending schistosity and dip-parallel stretching lineations present in all 4 segments. An exhumation event displayed by normal shear-sense indicators along with a subhorizontal cleavage is observed in the Timiskaming Group in the Rouyn segment and locally expressed in the Joanna segment. In the Rouyn and Joanna segments where the fault is moderately dipping to the north, a NW-trending cleavage is related to a third event. All segments display the final late dextral strike-slip movement with common shear-sense indicators and subhorizontal stretching lineations but this event is more prominent in the Malartic segment. In this segment, the E-trending main foliation display an anticlockwise angular relationship with bedding planes suggesting an initial architecture already SE-trending. Recording of each deformation event varies through space, as some segments do not express specific deformation event. While dip-parallel stretching lineations are observed in all segments, the Malartic segment and some specific corridors within other fault segment display strike-parallel stretching lineations. The CLLFZ is interpreted to be inherited from the linkage of several early independent discontinuities of different nature during the late strike-slip event.

Abstract ID: 35984

Final Number: PG34A-0281

Title: Progress in Characterizing Regional Metamorphism in the Pontiac Subprovince, Abitibi, Quebec

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Abstract Body: The volcano-sedimentary Pontiac Archean Subprovince is located in the Eastern part of the Superior Province, South of the Cadillac-Larder Lake Fault Zone and the Abitibi Subprovince. Its strong metamorphic gradient has been qualitatively described by many workers, but recent advances in thermodynamic databases now allow a systematic quantification of its geodynamic evolution to be established. The recognition of the the Canadian Malartic world-class gold deposit located in the lower-grade section of the Pontiac also calls for a better understanding of the timing, nature and extent of regional metamorphism in the area, particularly of the timing relationships between deformation and metamorphic recrystallization. This contribution presents preliminary results derived from field and petrographic observations across the biotite-in, garnet-in, staurolite-in and kyanite-in isograds in Pontiac metasediments.

During the summer of 2014, fieldwork has been carried out in collaboration with the MERN South of Val-d'Or and Malartic. Following field observations, the description of metamorphic assemblages in thin sections helped to document mineral textures, infer reactions and assess their relationship with deformation. In the study area, the main stable mineral assemblages, listed from North to South, are biotite-chlorite-muscovite, garnet-biotite-chlorite-muscovite, staurolite-garnet-biotite-muscovite and staurolite-garnet-biotite-muscovite-kyanite. According to available phase diagrams for metapelites, the observed metamorphic gradient would be of the order of 25°C/km with maximum peak conditions in the order of 550°C and 6 kbar (qtz-pl-bt-ms-grt-st-ky). Upcoming multi-equilibria thermobarometry, P-T pseudosections and Lu-Hf Sm-Nd dating of garnet will help further constrain the Pontiac metamorphic evolution. Results will be integrated as precise P-T-t-D paths that will help quantify the Pontiac metamorphic gradient and will suggest an appropriate type of tectonic setting corresponding to its accretion to the Abitibi Subprovince.

Abstract ID: 35072

Final Number: PG34A-0282

Title: Structural Analysis of the Ridout Deformation Zone in the Swayze Greenstone Belt, Ontario

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Published Material: 2014 Canadian Tectonic Group MeetingWu, Q. and Lin, S. 2014. Structural and tectonic study of the Ridout shear zone; in Summary of Field Work and Other Activities 2014, Ontario Geological Survey, Open File Report 6300, p.8-1 to 8-5.

Abstract Body: The Swayze Greenstone Belt is the western extension of the mineral-rich Abitibi Greenstone Belt. Despite being separated by the Kenogamissi Batholith, they share similar lithological assemblages and chronological framework. The Ridout Deformation Zone is a crustal-scale structure that transects the Swayze Greenstone Belt. Its structural

evolution and relationship with the gold-prolific Larder Lake-Cadillac Deformation Zone are unclear, but important for both tectonic interpretation and mineral exploartion. Our field and microscopic structural analysis demonstrates that the Ridout Deformation Zone has experienced at least four generations (G_1 to G_4) of deformation. Evidence for G_1 deformation is scarce and it is characterized by local preservation of a penetrative cleavage. G_2 deformation is characterized by S-asymmetry drag folds and crenulation cleavage oriented clockwise to earlier fabrics, and is interpreted to be an oblique shearing with sinistral and N-side-up components. G_3 is characterized by Z-asymmetry drag folds and δ- and σ-type asymmetrical porphyroclasts and quartz boudins, and is interpreted to be a dextral shearing with dominant strike-slip movement. G_4 is characterized by N-S-oriented brittle fractures, interpreted to be associated with regional NNW-SSE-trending faults. Our results are consistent with those of earlier structural studies in the Swayze Greenstone Belt and support that the Ridout Deformation Zone is indeed a regional-scale structure that has experienced multiple phases of reactivation. Contrary to an earlier interpretation, our results show that the Ridout Deformation Zone is similar to the Larder Lake-Cadillac Deformation Zone in terms of kinematic evolution.

Abstract ID: 35399

Final Number: PG34A-0283

Title: ^{187}Re - ^{187}Os Nuclear Geochronometry: ^{187}Os/^{188}Os$_i$ Isotopic Anomalies in Light of the Great Oxidation Transition

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Abstract Body:

Abstract ID: 35441

Final Number: PG34A-0284

Title: Provenance Analysis by Coupled U-Pb, Hf, and O Isotopic Analysis of Detrital Zircon from the Paleoproterozoic Murmac Bay Group, Northern Saskatchewan, Canada

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Abstract Body: The Murmac Bay Group (MBG) is a Paleoproterozoic-aged sedimentary succession deposited on the southern margin of the Rae craton in northwestern SK. There is currently an open question regarding the depositional setting of the upper MBG, whether it may have transitioned from a rift basin (lower MBG) to a passive margin, or an intracratonic or foreland basin setting. The depositional period has recently been constrained through U-Pb dating of detrital zircon grains at <2.33 to <2.17 Ga (160 million years), while constraints from metamorphism suggest a basin lifespan of up to 400 million years. The latter is anomalously long if the Murmac Bay basin is a typical passive margin like today's Atlantic Ocean. The poorly known basin tectonic setting and provenance coupled with the few existing detrital zircon samples from the MBG warrant further study with detrital zircon geochronology. In the first phase of this study, U-Pb detrital zircon and basement geochronological data from previous studies in the region were compiled, and several possible source locations in the surrounding Rae, Hearne, and Slave cratons were identified using the DateView database by comparing peak ages in the detrital zircon data with dated igneous rocks. The proximity and position of the Rae, Slave, and Hearne cratons is debated widely in the literature, but can be addressed using MBG detrital zircon provenance. Coupled U-Pb, Hf and O isotopic provenance analysis is an essential second step, in order to distinguish between possible igneous sediment sources. No previous detrital zircon Hf isotope studies have been conducted on the MBG, but there are existing Hf isotope studies of regional Archean and Proterozoic plutonic rocks, allowing for rigorous testing of specific zircon sources, including the ~2.3 Ga source that is present in nearly all MBG samples and is assumed to be locally sourced from the surrounding Beaverlodge Domain. A source for the youngest (~2.17 Ga) zircon grains found in the MBG remains enigmatic, however candidate sources exist on the Slave craton that can be further resolved using Hf isotopes. New coupled U-Pb, Hf, and O isotopic data will elucidate a possible tectonic setting by distinguishing between local vs. continental derived sources, providing insight into the positions of these cratons during MBG deposition.

Abstract ID: 33783

Final Number: PG34A-0285

Title: Stromatolites from the Lomagundi-Jatuli Isotopic Event Interval

Presenter/First Author: Pavel Medvedev, Russian Academy of Sciences, Petrozavodsk,

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Published Material: Medvedev P.V., Chazhengina S.Y., Svetov S.A. Application of Raman spectroscopy and high-precision geochemistry for study of stromatolites. Biogenic-abiogenic interactions in natural and anthropogenic sistem. V International Symposium. Saint Petersburg: VVM Publishing Ltd., 2014, p. 108-110.

Abstract Body: The main biotic event during the 2.2-2.1 Ga carbon isotope excursion is an expansion of cyanobacterial communities that is reflected in geological record by abundance of stromatolites, especially cm-sized buildups (ministromatolites) in the carbonate successions. The Paleoproterozoic ministromatolite assemblages are described on the Fennoscandian shield, in China, India, Northern America and Australia. Stromatolites are mineralized microbial buildups, which vary in morphology, have carbonate composition and characteristic fine lamination. Morphology of the buildups is defined by microbial comunity as well as environmental conditions. Stromatolite formation is a result of complex biogenic and abiogenic processes. Asuming that stromatolites are microbial buildups, it is necessary to prove their biogenic origin. For the purpose there are a number of criteria, one of them is presence of synsedimentary carbonaceous matter within individual laminae. Paleoproterozoic (2.0-2.2 Ga) stromatolites from drill cores of the ICDP Project FAR DEEP were studied by Raman spectroscopy (RS) and ICP mass spectroscopy (LA-ICP MS) methods. Carbonaceous matter (CM) was identified by Raman spectroscopy within individual stromatolites laminae. The Raman spectra for CM in stromatolite samples are consistent with poorly ordered CM. According to Raman data the metamorphic alteration temperatures of CM from studied stromatolites are ca. 400 – 450 °C (greenschist facies). Thus, we can assume that the CM of these stromatolites has the syngenetic origin. Profiling geochemical microsampling of the stromatolites has revealed considerable variations in the concentrations of trace elements induced by the internal heterogenecity of the structures. Many elements display multi-order cycles, which are indicated by variation in the step length between the peaks on the variation curves. Morphological features of the studied Paleoproterozoic stromatolites together with identification of synsedimentary carbonaceous matter by Raman spectroscopy are strong argument for biogenic origin of these carbonate buildups. Precision geochemical analysis of the stromatolite laminae composition links to sedimentary settings and environmental conditions of the microbialite formation.

Abstract ID: 36604

Final Number: PG34A-0287

Title: Is the Williston Basin the site of a Proterozoic accretionary triple junction?

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Co-authors: Paul A Mueller, Univ Florida-Geology Dept, Gainesville, FL; David A Foster, University of Florida, Gainesville, FL

Published Material: I cite data which was published in 1991 by Sims, et al. I also presented a few of my initial geochron ages at the annual GSA meeting in Vancouver, CA in October 2014.

Abstract Body: The Great Falls Tectonic Zone (GFTZ) strikes NE to SW through Montana, and is one of a series of collisional belts, including the north-striking Trans-Hudson Orogen (THO) to the east, that formed during the amalgamation of Laurentia (suturing of the Wyoming, Medicine Hat, and Hearne Provinces). Testing the numerous models for these accretionary belts depends on high quality geochronology in critical areas. One such area is the basement to the Williston Basin (WB), near the presumed juncture of the GFTZ and THO. Poorly constrained Rb-Sr whole-rock model ages, Rb-Sr whole-rock isochrons, and K-Feldspar isochrons using samples from several Deep Test Wells (DTW) that penetrated the WB basement suggested ages from 0.65 Ga to 2.9 Ga. Existing U-Pb geochronology includes only 7 discordant analyses yielding upper intercept ages ranging from 1.7-2.9Ga.

New elemental and isotopic data improve the estimates for protolith ages, thermal history, and petrogenesis of the basement at this critical juncture. Initial geochronology from cores in northeast Wyoming and west-central Montana yield ages of ~2.9 and ~3.0 Ga, while a third sample in northeast Wyoming yielded an age of ~2.6 Ga. These ages overlap with previously reported ages from the Wyoming province and help refine the location of the northern margin of the Wyoming Province and its relation to the THO and GFTZ, respectively. DTW AMJ-6 is located at the presumed intersection of the GFTZ and THO in NW Montana, and a basement sample yielded an age of ~1.8 Ga. DTW MT-3, located in NE Montana, also yielded an U-Pb age of ~1.8 Ga, revealing further influence from the Paleoproterozoic orogenies. These ages overlap with ages reported from both the GFTZ and the THO, confirming the geodynamic problem implied by the high angle intersection of the THO and GFTZ at the location of the WB.

Abstract ID: 36788

Final Number: PG34A-0288

Title: Reassessment of the intersection of the Great Falls Tectonic Zone and the Trans-Hudson Orogen through petrologic and geochronological analysis of Deep Test Well derived sample

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Published Material: References geochronological measurments taken previously, which are cited. Petrographic and geochronological analysis pertaining to sample AMJ-6 are original.

Abstract Body: The Great Falls Tectonic Zone (GFTZ) is a Paleoproterozoic collisional belt, marked by high angle, northeast-southwest striking structures cutting across central to northeastern Montana. The GFTZ joins with the similarly aged, north-south striking collisional belt of the Trans-Hudson Orogen (THO) in the subsurface of the Williston Basin. The GFTZ and THO represent important accretionary events in the ~1.7-1.9 Ga amalgamation of Laurentia; however, our understanding of their role in this event is hampered by limited age control and knowledge of tectonic setting.

Deep Test Wells (DTW) within the Williston Basin basement, near the triple-junction of the GFTZ and THO, provide samples for petrographic and isotopic analysis. Previously published data for this region is restricted to Rb-Sr whole-rock model ages, Rb-Sr whole-rock isochrons, and K-Feldspar isochrons, ranging in age from ~0.65-2.9 Ga. Existing U-Pb geochronology, includes 7 discordant analyses, yielding ages ranging from ~1.7-2.9 Ga. This study intends to refine the current understanding of Williston basement age and magmatism through new U-Pb dating of zircons from DTW AMJ-6 and thorough petrographic analysis.

DTW AMJ-6 comprises amphibolitic migmatite (quartzofeldspathic leucosome) and is near the intersection of the GFTZ and THO in northwestern Montana, where a single basement sample yielded a (U-Pb) age of ~1.8 Ga. Thin-section petrography and zircon U-Pb geochronology of samples from the GFTZ further constrain the protolith ages, thermal history, and petrogenesis of the basement at this cratonic intersection. The age is complimentary to ages in both the GFTZ and the THO, validating affinity of the basement in this region. Further work on samples of DTW MAD-1 and AMJ-6 will provide an opportunity to further refine the composition as well as origin of the basement from the collisional regions of both the GFTZ and THO.

Abstract ID: 36644

Final Number: PG34A-0289

Title: Regional Bedrock Mapping and a Comprehensive Geological History of Hall Peninsula, Baffin Island, Nunavut

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Co-authors: Richard Eric From, University of Manitoba, Winnipeg, MB, Canada; Diane Skipton, University of Ottawa, Ottawa, ON, Canada; Cameron MacKay, University of Saskatchewan, Saskatoon, SK, Canada; C. Gabriel Creason, , ,

Abstract Body: The Hall Peninsula Integrated Geoscience Program began in 2012 and is led by the Canada-Nunavut Geoscience Office in collaboration with the Geological Survey of Canada and seven Canadian universities. Regional bedrock mapping and several thematic studies have been conducted over three field seasons to provide new geological knowledge for this otherwise poorly understood area to help develop more accurate tectonic reconstructions and evaluate economic potential. A comprehensive geological history of Hall Peninsula is summarized based on field observations, geochronology, geochemistry and other analytical results.

Eastern Hall Peninsula is underlain by Archean tonalite to quartz-diorite orthogneiss units ranging in age from 2976 Ma to 2701 Ma with evidence of Archean metamorphism at ca. 2730-2690 Ma. Paleoproterozoic supracrustal and intrusive rocks are exposed on western Hall Peninsula. The supracrustal rocks are dominated by pelitic, psammitic, amphibolite and calc-silicate units containing mostly 2.3-1.9 Ga detritus, and are interpreted as correlative with the Lake Harbour Group of southwestern

Baffin Island. These rocks are thought to have been deposited in a proximal shallow-marine to more distal slope-rise to continental-shelf setting with input of mafic material from a nearby volcanic arc or continental rift. Emplacement of granulite-grade monzogranite to diorite intrusions took place around 1892-1852 Ma. Hall Peninsula records three phases of deformation associated with the Trans-Hudson Orogen that have produced thick-skinned, east-verging fold and thrust structures. Related metamorphism took place at ca. 1850-1830 Ma, at medium pressures (~5-7.5 kbar) and peak temperatures increasing from amphibolite facies in the east (~740 C) to granulite facies in the west (>850 C). Ar/Ar cooling ages and thermal modeling of (U-Th-Sm)/He data indicate an extremely slow, protracted cooling history for Hall Peninsula since the late Paleoproterozoic.

Abstract ID: 34285

Final Number: PG34A-0290

Title: Are the amphibolites the source of contamination of iron-formation at Mount-Wright, Canada?

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Abstract Body: The iron deposit of Mount-Wright, Fermont, Canada has been exploited since 1970 for high-quality low-grade iron around 30% Fe. The deposit is located in the Gagnon terrain - in the parautochtone of the Grenville. Mount Wright deposit stratigraphy used is the same as the Labrador Through because River (1983) demonstrated the continuity of the units. The iron formation units in contact with amphibolites show higher contamination in Al, Ti and P. Could the amphibolites be the vector to explain this contamination?

Handheld XRF results show a decreasing Al concentration in iron ore from amphibolite contact (measurement in progress). A microXRF map at the contact of amphibolite and iron formation in thin-section show increasing concentration (over 1 mm towards the contact) in Al, K, Mn, P, Ti while Ca, Fe are decreasing. Trace elements in magnetite in iron formation determined by LA-ICP-MS also show a decrease in Cu, Mg, Al toward the contact with the amphibolite while Zn, Ti and Mn increase. Detailed petrography show Ti exsolution lamella of ilmenite in hematite near the contact of the two units and the presence of rutile in the iron formation while hematite farther from the contact show now ilmenite exsolution. Apatite grain size increases from the iron formation nearing the contact and its proportion increases from 0,5 mm from the contact with amphibolite to 1 mm and more at the contact. The P contamination is explained by the presence of apatite, but at this moment, no direct relationship was established with amphibolite. These observations strongly suggest a contamination from the amphibolites to the iron formation. The igneous or sedimentary nature of the amphibolites is being determined. A magmatic origin of the amphibolite dykes would imply a hydrothermal event associated with their injection. Alternatively, a sedimentary origin would imply that metamorphism has favoured transfer of some elements from the amphibolite to the iron formation.

Abstract ID: 33971

Final Number: PG34A-0291

Title: Characterization of Upper Crustal Electrical Anisotropy in the Precambrian Basement of Northern Alberta, Canada From Magnetotelluric data: Implications for Geothermal Development

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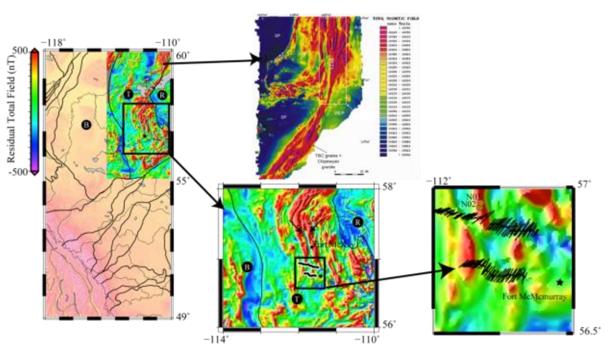
Co-authors: Martyn Jonathan Unsworth, University of Alberta, Edmonton, AB, Canada

Published Material: Similar results were presented at the AGU 2013 fall meeting, and at the EMIW 2014 conference in Weimar, Germany.

Abstract Body: The development of engineered geothermal systems (EGS) in the oilsands region near Fort McMurray (FMC) Alberta, requires the characterization of the Precambrian basement rocks. We present the results from magnetotelluric (MT) measurements made in the FMC region that were gathered for this purpose. Large phase tensor skew values (> 10°), as well as out-of-quadrant phases, in MT data are commonly interpreted to indicate an underlying 3-D resistivity structure. Here it is shown that this type of data can also be explained with a 2-D anisotropic model. Initial inversions of the MT data on three profiles showed that a 2-D isotropic analysis was not able to explain the measured MT data. Forward modeling showed that a reasonable fit could be achieved with a resistivity model that included widespread basement anisotropy beginning at a depth of 4 - 5 km with a resistivity ratio of 2000/5 Ωm. Aeromagnetic and core sample data allowed a correlation of the basement rocks in the FMC region with the exposed rocks of the Charles Lake shear zone (CLsz) that outcrops on the Canadian Shield 150 km north. The conducting phase of the anisotropy is most likely to be interconnected graphite films deposited during metamorphism on the igneous basement rocks. Fluid-filled fractures or accumulations of sulphide minerals would have a strong seismic interface to match the resistivity interface, this is not observed. These films are interpreted to be due to interconnected graphite films oriented ~S27°E within the metamorphic basement rocks. This direction is reasonably close to the current minimum stress direction of ~S40°E, which could help guide investigations of fracture propagation needed for EGS development.



Abstract ID: 34482

Final Number: PG34A-0292

Title: Digital litho- and chrono-stratigraphic representation of the Proterozoic geology of Australia

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Abstract Body: A combination of regional time-space correlation charts, geochronology, lithostratigraphic information and palaeogeographic reconstructions provide easy visualization and improved understanding of the geodynamic evolution of any geological region. The Palaeoproterozoic geology of North America and Greenland and of southern Africa has previously been synthesized at domain level for IGCP 509 project "Palaeoproterozoic Supercontinents and Global Evolution" (Eglington et al., 2009, 2013). Similar digital data are not available for Australia, making it difficult to produce relevant direct comparisons of the regions. Neumann & Fraser (2007) summarized available lithostratigraphic and geochronological information from Australia for the period 1900 Ma to 1400 Ma as a basis for regional geodynamic models and to facilitate exploration of the abundance of mineral wealth associated with this time interval. Their time-space correlation diagrams are raster images produced in graphics packages which cannot be queried.

Here, we report on progress to create a digital database of tectonic domains, geological events and lithostratigraphic unit details linked to available GIS maps for the region so as to generate time-space charts and time-slice palaeogeographic reconstructions for comparison with other information in the StratDB and DateView databases (available from http://sil.usask.ca). Our ultimate objective is to achieve a global coverage of quantitative regional geological compilations which assist in achieving a better understanding of Precambrian geological evolution and facilitate investigation of the association of various mineralization styles with the timing of regional metamorphism, igneous activity and orogenic events. The digital charts and maps created are consistent with the most current information added to the master database, are readily updated and all information captured will remain available in a digital format for future researchers.

Abstract ID: 35033

Final Number: PG34A-0293

Title: Newly Discovered Sveconorwegian Batholiths in SW Norway

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Co-authors: Trond Slagstad, Geological Survey of Norway, Trondheim, Norway; Mogens Marker, , , ; Torkil Røhr, , , ; Nick M W Roberts, NERC Isotope Geosciences Laboratory, Keyworth, NG12, United Kingdom

Published Material: A paper about the first batholith we refer to in the abstract, the Sirdal Magmatic Belt, is currently under review.

Abstract Body: Recent mapping in the Rogaland–Vest-Agder region, SW Norway, revealed the existence of two large granitic batholiths emplaced during the Sveconorwegian orogeny. The first one, the Sirdal Magmatic Belt (SMB) was emplaced between 1070 and 1020 Ma, followed by the Hornblende Biotite Granites (HBG suite) emplaced between 980 and 920 Ma, changing the whole perspective on the regional geology. Previously mapped as high-grade gneisses, the SMB is mainly composed of variably porphyritic biotite granite that cuts granulite-facies rocks, indicating that high-grade metamorphism occurred at a regional scale before the emplacement of the belt. The SW tip of the SMB was metamorphosed later on during the emplacement of the Rogaland Igneous Complex, composed mainly of anorthosite. The later event was accompanied by extensive granitic magmatism and the emplacement of the second batholith (HBG suite). The HBG suite has been mapped as individual plutons, but airborne geophysical data suggest that they are connected in the subsurface and compose one or several batholiths formed around 950 Ma. These new findings do not support the continent-continent collision setting for the Sveconorwegian orogeny, but instead seem to require a long-lived active margin.

Abstract ID: 33823

Final Number: PG34A-0295

Title: Sequence Stratigraphic Correlation and the Age of Diagenesis in the Pandurra Formation, South Australia

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Abstract Body: The Mesoproterozoic Pandurra Formation is an unmetamorphosed, relatively flat-lying unit of siliciclastic redbeds up to 1500 metres thick that was deposited on the northeastern Gawler Craton (GC), South Australia. The Pandurra Formation is a key geological unit of the GC, as it records the first major interval of basin formation following GC assembly and is spatially associated with the Olympic Dam IOCG+U deposit, but remains under-studied to-date. We integrate sequence stratigraphy, petrography, stable isotope geochemistry and geochronology in this study to clarify the paleoenvironments of deposition, stratigraphic architecture, and fluid history of the Pandurra Formation.

Detailed cm-scale logging of ten drill core intersections of the Pandurra Formation revealed six lithofacies comprising pebble conglomerate, coarser-grained lithic to quartz arenites and lithic wackes, finer-grained lithic arenites, and siltstone to mudstone that were deposited in braided fluvial and lacustrine paleoenvironments. Facies stacking patterns and the recognition of widespread, sharp, erosive surfaces helped define three unconformity-bounded sedimentary sequences within the Pandurra Formation. The sequences are products of dynamic tectonism and possibly climate changes that influenced facies distribution.

Burial of the Pandurra Formation resulted in quartz cements and hematite followed by white mica and dickite. Stable isotopic ratios of O and H in white mica and dickite suggest that the fluids responsible for diagenetic alteration had components of both seawater and evolved meteoric water at temperatures between 150 and 200°C. White mica give a spectrum of $^{40}Ar/^{39}Ar$ apparent ages ranging from 1536 ±7 Ma to 1249 ±3 Ma, marking diagenesis and reflecting temporal changes in the fluid-conducting capabilities within the basin. The former date is close to 100 m.y. older than a previously-published whole-rock Rb/Sr isochron age of 1424 ± 51 Ma in Pandurra mudstone, thus extending the maximum age of the Pandurra Formation.

Abstract ID: 33095

Final Number: PG34A-0296

Title: Towards Unravelling the Mozambique Ocean Conundrum using a Triumvirate of Zircon Isotopic Proxies on the Ambatolampy Group, Central Madagascar

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Published Material: Initial findings were presented as a poster at the Gondwana15 Meeting in Madrid, July 2014. The poster was presented by my advisor because I was not able to attend the conference. Since the meeting, our understanding of the data has improved and we have a better understanding of how these rocks relate to similar aged rocks in Madagascar, India and East Africa. The paper is currently under review in the journal "Tectonophysics".

Abstract Body: Madagascar occupies an important location within the East African Orogen, which involves a collection of Neoproterozoic microcontinents and arc terranes lodged between older cratonic units during the final assembly of the supercontinent Gondwana. The detrital zircon record of Proterozoic metasedimentary rock packages within the Antananarivo Domain (the Ambatolampy, Manampotsy, Vondrozo, Itremo and Ikalamavony Groups) are used to identify pre-orogenic tectonic affiliations of the region—affiliations that control interpretations of the evolution of the Mozambique Ocean and the formation of this part of central Gondwana. Here we focus on the Ambatolampy Group, a previously poorly known group of high-grade siliciclastic metasedimentary rocks, and compare these to data from the other sedimentary packages in central Madagascar (the Vondrozo, Sofia, Manampotsy, Itremo, Molo, Ikalamavony, Androyen, Ambodiriana, Iakora and Maha Groups). New U-Pb Sensitive High Resolution Ion Microprobe (SHRIMP) zircon data for the Ambatolampy Group yields detrital age maxima of ~3000 Ma, ~2800-2700 Ma, ~2500 Ma, ~2200- 2100 Ma and ~1800 Ma. The youngest near-concordant detrital zircon age is 1836 ± 25 Ma, which we suggest represents the maximum depositional age of the Ambatolampy Group, in contrast to younger ages reported elsewhere. The detrital spectra are very similar to those from the Itremo Group and we suggest that they correlate with each other. Metamorphic zircons and zircon rims constrain the minimum depositional age to be ~540 Ma; the interpreted age of metamorphism. New d^{18}O data and hafnium isotopic data complement the U-Pb data and provide new constraints on the age, geochemistry and provenance of the metasedimentary rocks. We suggest that central Madagascar contained a Mesoproterozoic (to possibly Tonian) siliciclastic sedimentary basin, within which the Ambatolampy Group, and the Itremo and Maha (and possibly part of the Iakora Groups) were deposited.

Keywords: Madagascar, Gondwana, detrital zircon, geochronology, tectonics, oxygen isotopes, hafnium isotopes

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Abstract ID: 34343

Final Number: PG34A-0297

Title: A New Model for the Quebecia Terrane of the Central Grenville Province as a Composite Arc Belt

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Co-authors: Alan P Dickin, McMaster University, Hamilton, ON, Canada

Abstract Body: After the breakup of Nuna, Laurentia was an active continental margin for a billion years before the assembly of Rodinia. This period of Proterozoic crustal evolution is poorly understood, but much of its geologic history is recorded in crustal terranes of the Grenville Province. The Quebecia Terrane is a 100,000 km^2 Mesoproterozoic arc terrane in the central Grenville Province with T_{DM} model ages ~1.5 Ga, but was shown to contain a few isolated neodymium signatures of Paleoproterozoic crust. A more detailed Nd isotope analysis of orthogneissic samples in the Baie Comeau area of central Quebec has shown the extent and connection between these fragments, showing that they represent one large Paleoproterozoic crustal panel extending longitudinally through the Quebecia terrane. This panel is sandwiched between two large segments of the Quebecia terrane, implying that these segments actually represent two separate arc fragment of the same age that were accreted to the Laurentian margin at the end of the Pinwarian orogeny. It is proposed that through strike-slip tectonics, the Paleoproterozoic panel was detached from the older Makkovikian/Labradorian margin of Laurentia and re-accreted between the northerly and southerly blocks of the Quebecia terrane, forming a 'composite arc belt.' A modern analogue to this process could be the accretion of the western Sumatra block between the east Sumatra and Woyla terrane in Southeast Asia.

Abstract ID: 34296

Final Number: PG34A-0298

Title: Pb Isotope Analysis of Grenville Gneisses: Assessing the Crustal Burial and Exhumation of the Archean Parautochthon in Ontario and Western Quebec

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Abstract Body: The Grenville Province is a 1 Byr-old orogenic belt in the Canadian Shield that reworked older crustal terranes of Archean to Mesoproterozoic age. As a result, the Grenville Province contains an exhumed section of the Archean Superior Province basement, which allows for a detailed study of its crustal structure. To investigate the burial-uplift history of the crust, whole rock Pb isotope data were determined for several Archean gneisses from across the NW Grenville Province in Ontario and Western Quebec. The high mobility of uranium during regional metamorphism of the continental crust generates stratification in the U/Pb ratio, as uranium is preferentially transported from lower crustal levels into the upper crust. Over geologic time, this process leads to variations in the $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios of the crust, and hence, Pb isotope mapping acts as a useful tool for determining the exhumation of highly metamorphosed Archean crust. In Ontario, results collected for Archean gneisses shows a strong correlation between the Pb isotope ratio of the crust and the distance SE across the Grenville Front Tectonic Zone. A trend to less radiogenic signatures of the crust across the GFTZ compliments a similar pattern to the Leveck gneiss data from Sudbury that shows a trend to less radiogenic signatures of the crust away from the Sudbury Igneous Complex. The similarity between the unradiogenic signatures of the Grenville gneiss with the Leveck gneiss provides evidence of a progressive exhumation of the Archean basement across the GFTZ with a major ramp exhumed from a crustal depth of >20km. In contrast, the more radiogenic Pb signatures of Grenville gneiss in western Quebec suggest the preservation of Archean upper crust. Large areas of quartzite gneiss in the vicinity support a model for a Paleoproterozoic sedimentary basin that was buried under the Grenvillian allochthon and later exhumed back to the surface, exposing an unconformity over the shallow Archean upper crust.

Abstract ID: 33839

Final Number: PG34A-0299

Title: Tracking the evolution of the Grenville Foreland Basin: detrital mineral dates from the Sleat and Torridon groups, Scotland

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Co-authors: Helen Bonsor, , , ; Matthew SA Horstwood, British Geological Survey Keyworth, Nottinghamshire, United Kingdom

Abstract Body: The Grenville Orogen, instrumental in the assembly of Rodinia, lacks a clear foreland basin in its type area in eastern Canada. However, Early Neoproterozoic siliciclastic rocks in Northern Scotland are now interpreted as remnants of a proximal Grenville Foreland Basin. Analysis of sedimentology and detrital minerals from the Torridon and underlying Sleat group (previously regarded as different in source and setting), constrain the evolution of this basin.

The Sleat Group, ~3500 m of shallow marine deposits, is overlain via a low-angle unconformity by the Torridon/Morar groups, which comprise > 8000 m of braided river to shallow marine deposits in a basin of large but unknown size.

Youngest U-Pb zircon dates in all samples from both groups all show similar late Grenvillian ages. Key older age components, however, vary in proportion throughout the sequence. The lower Sleat Group deposits show a dominant cluster of ~ 1750 Ma (?Rhinnian source), whereas in the Torridon group ~1650 Ma ages (?Trans Labradorian) become increasingly significant, as are age clusters between 1500 – 1100 Ma (Pinwarre – Elzevirian to early Grenvillian). These changes likely reflect uplift and erosion of different basement complexes within the Grenville Orogen. There is no difference in source across the Sleat/Torridon unconformity. Detrital rutile in the Torridon Group show similar pattern, except for an enigmatic 1900 Ma cluster.

The detrital mineral data and sedimentology tentatively suggest: i) early deposition in a narrow marine basin (lower Sleat Group), sourced from the Irish-Scottish sector of the Grenville Orogen, with orogen-normal fill; ii) within the Sleat Group a gradual switch to more distal sources from the Canadian Grenville orogen, via axial transport ; iii) across the Sleat-Torridon boundary a sudden switch from underfilled to overfilled deposition, but with no change in provenance. This latter deposition represents a major denudation event of the Grenville Orogen.

Abstract ID: 34256

Final Number: PG42A-01

Title: Archaean unstable stagnant lid tectonics

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Co-authors: Tim E Johnson, Curtin University, Perth, WA, Australia; Craig O'Neill, Macquarie University, Sydney, Australia; Lyal Harris, INRS-ETE, Québec, QC, Canada

Published Material: Two figs were previously published by C O'Neill & T Johnson, the rest is mostly new.

Abstract Body: It has been proposed that the early Archaean Earth was in an unstable stagnant lid mode, with non-cratonic areas dominated by oceanic ‘plateau’ type crust. Numerical models of convection under a thick conductive mafic to ultramafic crustal layer imply frequent basal delamination of garnetiferous rocks; with rapid recycling of subaqueously erupted lava into the mantle. The unstable sub-crustal convection pattern would prevent development of a sub-oceanic lithospheric mantle layer (SOLM); in contrast with the modern Earth where a SOLM forms gradually as oceanic lithosphere drifts away from the ridge axis thermal anomaly. The absence of a thick, cold, stiff, dense SOLM beneath Archaean oceanic crust removes the principal driving force for subduction. Archaean continental drift as a result of mantle traction on the sub-continental lithospheric mantle root would produce broad, ‘soft’ mafic accretionary orogens. Partial subcretion and anatexis of oceanic crust beneath the continental leading edge would produce voluminous syn-tectonic TTGs. Bédard & Harris 2014 (Geology) proposed that the S.Superior craton was disaggregated by a Neoarchaean mantle overturn; followed by reassembly of detached ribbon-continents and intervening oceanic tracts when the N.Superior block drifted south. Numerical modelling of global mantle convection on an unstable stagnant lid planet implies frequent early whole-mantle overturn events so as to evacuate mantle heat buildups. Modeling results imply that overturns would cease due to the progressive decay of radiogenic heat, and would then have been replaced by a mobile lid plate tectonic mode. Global mantle overturn events can explain synchronous tectono-magmatic pulses on different cratons. Areas of high vertical flux during overturns would create unusually thick crust and would be favored sites of craton genesis or reworking. Vigorous mantle flow would drive faster continental drift and could also correspond to phases of enhanced tectonism.

Abstract ID: 35640

Final Number: PG42A-02

Title: Implications from geophysical data for the structural and tectonic evolution of the Superior and Yilgarn cratons

Presenter/First Author: Lyal B. Harris, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec, QC

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Co-authors: Jean H J Bedard, Geological Survey of Canada, Quebec, QC, Canada

Published Material: Whilst all information for the Yilgarn is new and unpublished, and not presented elsewhere, some images for the Superior craton to be used for introduction only were included in recent articles: Bédard, J.H. & Harris, L.B. (2014) Neoarchean disaggregation and reassembly of the Superior Craton. Geology, doi: 10.1130/G35770.1 & Harris, L.B., Bédard, J.H. (2014a) Crustal evolution and deformation in a non-plate tectonic Archaean Earth: Comparisons with Venus. In: Dilek Y, Furnes H (Eds), Evolution of Archean Crust and Early Life, Modern Approaches in Solid Earth Sciences 7, Springer, Chapter 9, 215-288.

Abstract Body: Gravity, aeromagnetic and seismic tomographic data for the Superior and Yilgarn cratons suggest that: (i) Some terrane boundaries defined from geological, geochemical and geochronological data and aeromagnetic interpretation of upper crustal features of the Superior craton do not correspond to margins of disparate, lithospheric-scale blocks. Early terrane boundaries preserved in the deep crust and upper mantle at high angles to mapped terrane boundaries and to greenstone belts in the upper crust are identified. Many “terranes” represent reassembled fragments previously derived from disaggregation of older (proto)cratons. (ii) Long wavelength aeromagnetic, bouguer gravity and pseudogravity data portray regional domes at deep crustal levels in both cratons, even in areas dominated by linear greenstone belts and transcurrent shear zones in the upper crust. Differences in shear zone geometries in the Superior craton indicate decoupling between the upper and mid- to lower crust, although shear zones at all crustal levels are compatible with the same inferred bulk shortening. (iii) Most large mineral deposits occur on margins of paleo-rifts preserved in the upper mantle and above deep crustal structures and/or on rims of deep domes at a high angle to greenstone belts for which there is little upper crustal expression. (iv) Broad regional ductile shear zones develop prior to formation of the mapped discrete ductile to brittle-ductile shear and faults. On deep

reflection seismic profiles (i) dipping reflectors cutting the upper mantle and lower crust are interpreted to represent mantle and lower crustal imbricates formed during bulk shortening and not fossil subduction zones, and (ii) both cratons preserve an early extensional and not a thrust/accretionary architecture. Some adjacent blocks differing in age and metamorphism in both cratons (eg. Abitibi-Opatica, Narryer-Youanmi) display basement-cover relationships and are not tectonically juxtaposed exotic terranes. Many observations are incompatible with previous, actualistic, subduction/arc accretion models, and shortening associated with regional folding and shearing in both the Superior and Yilgarn cratons is interpreted as the result of cratonic mobilism. Outcomes provide a new framework and approach for mineral exploration.

Abstract ID: 33105

Final Number: PG42A-03

Title: Komatiite Volcanism: Lithospheric Controls on the Earth's Hottest Melts and Links to Crustal Growth in the Archean

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Co-authors: Marco Fiorentini, University of Western Australia, Crawley, WA, Australia; Nicolas Thebaud, University of Western Australa, Perth, WA, Australia; Campbell McCuaig, University of Western Australia, Crawley, WA, Australia; Kevin F Cassidy, , , ; Chris L Kirkland, Geological Survey of Western Australia, Perth, Australia; Sandra Romano, , , ; Michael Doublier, , , ; Elena A. Belousova, Macquarie University, Sydney, Australia; Stephen J Barnes, CSIRO, Perth, Australia

Published Material: These findings were reported in the Proceedings of the National Academy of Sciences in July 2014, issue 111 (28), pages 10083-10088.

Abstract Body: Major periods of komatiite activity, possibly on the scale of Phanerozoic large igneous provinces (LIPs), occurred in the Archean Yilgarn Craton of Western Australia in two regions during two distinct periods. The oldest known deposits (3.0-2.8 Ga) occur in the south of the Southern Cross Domain (SCD). The youngest (~2.7 Ga) are predominantly found in the Kalgoorlie Terrane (KT). This study aimed to investigate whether variations in lithospheric architecture could explain the location and timing of komatiite magmatism. An integrated program of U-Pb and Lu-Hf analyses were performed on granitoids and felsic volcanics from the south-central Yilgarn Craton, Western Australia. These data have been plotted as time-resolved Lu-Hf maps which record the changing architecture of the craton in space and time.

The 3.1-2.8 Ga Lu-Hf time-slice shows that the south-central Yilgarn lithosphere (encompassing the Forrestania, Lake Johnston and Ravensthorpe greenstone belts) was relatively juvenile (εHf>0) at this time. The region to the north (central SCD), encompassing the Marda greenstone belt, shows an evolved signature (εHf<0). The greenstone belts formed over juvenile crust contain thick komatiite sequences which comprise high Mg lavas, thick cumulate zones and channelized flows, indicative of rapid, voluminous emplacement of extremely primitive magma (Barnes 2006a, 2006b). In contrast, the Marda greenstones are dominated by a thick, mafic succession, with minimal komatiite.

The younger, 2.8-2.6 Ga time-slice indicates that the west Yilgarn has cratonised into a more homogenous, evolved terrane (Youanmi Terrane; YT), whereas the KT has a juvenile signature. This contrast forms an isotopic discontinuity (paleo-craton margin?) between the two terranes, and results in a ~700 km, N-S trending belt of komatiites on the juvenile (KT) side of the isotopic boundary. These komatiites represent some of the hottest magmas ever erupted on Earth (Fo_{ol}92-94). In contrast, there is no known coeval mafic-ultramafic volcanism in the YT.

These results not only explain the timing and location of major komatiite eruptions but also why some regions do not have significant komatiite sequences at all. They also indicate that the evolution of the lithosphere and its subsequent architecture form a major control on komatiite volcanism.

Abstract ID: 34185

Final Number: PG42A-04

Title: Crustal shortening, pop-down tectonics, fluid channelling and ore transfers within hot lithospheres – implications for Precambrian Cratons

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Co-authors: Justine Jaguin, CREGU, Université de Nancy, Nancy, France; Philippe Boulvais, Géosciences Rennes, université de Rennes 1, Rennes, France; Florence Cagnard, , ,

Published Material: Part of the abstract was presented in private conferences, and also at the GSA meeting in Denver in 2013. The presentation will include new data acquired since this time

Abstract Body: Field and experimental works dedicated to deformation modes of hot lithospheres in compressive regimes show major differences compared to modern orogenic belts (Gapais et al., 2014, Tectonophysics 618, 102–106). These works led to a new tectonic model marked by compression-induced downward motions of pop-downs of upper-crustals that pile up along vertical deformation zones. Downward motion of upper-crustals does not require any gravity-induced processes as potentially attached to sagduction of heavy greenstones. The first-order requirement is just a hot and weak lithosphere with a ductile lithospheric mantle (fig. 1). In such a context, pop-downs of upper crust pile up along vertical deformation zones potentially connected with the underlying ductile mantle. These zones are marked by high strains, steeply dipping foliations and steeply plunging stretching lineations. These zones are particularly favourable for circulations of fluids of various origins from surface to mantle and for long-lived fluid-rock interactions (Fig. 1).

We present field examples showing structural features arguing that pop-down tectonics may be a key for various ore concentrations in various crustal levels within ancient hot deformation belts of various ages, from Archaean to Palaeoproterozoic.

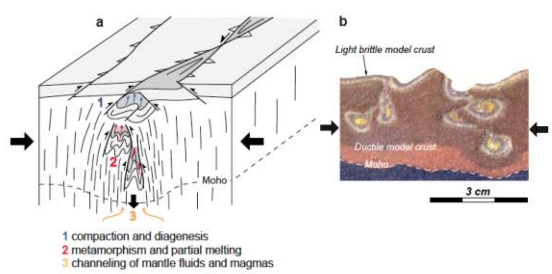

Fig.1. (a) Model of compression of a hot lithosphere where piling-up of upper crustal pop-downs may favour interactions between crustal deformation, fluid transfers, and potential ore deposits. (b) Analogue model of shortened weak continental lithosphere showing piling-up of upper-crustal pop-downs within underlying weak crust (Gapais et al., 2014, Tectonophysics 618, 102–106).

Abstract ID: 34282

Final Number: PG43A-01

Title: Zircon U-Pb ages and Lu-Hf isotopes of Archean Basement in eastern China: Implications for Crustal Evolution of the Eastern Block, North China Craton

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Published Material: *1.* Wu, M.L. et al., 2014. Zircon U-Pb geochronology and Hf isotopes of major lithologies from the Jiaodong Terrane: Implications for the crustal evolution of the Eastern Block, North China Craton. *Lithos 190-191, 71-84.*2. Wu, M.L. et al., 2013. Zircon U-Pb geochronology and Hf isotopes of major lithologies from the Yishui Terrane: Implications for the crustal evolution of the Eastern Block, North China Craton. *Lithos 170–171, 164-178.*

Abstract Body: The Archean basement rocks are widely exposed as several metamorphic complexes in the Eastern Block of the North China Craton, consisting predominantly of granitoid gneisses with minor mafic and felsic supracrustal rocks and charnockites. The timing of crustal growth and tectonic setting of the Eastern Block have been hotly debated. This study presents new zircon U-Pb and Lu-Hf data from major Archean basement complexes in eastern China to better understand the Archean crustal evolution of the Eastern Block of the North China Craton. Magmatic zircon U-Pb data have revealed an intensive magmatism at 2.6-2.5 Ga immediately followed by a large-scale tectonothermal event at ~2.5 Ga over the Eastern Block. In some complexes, multi-stage magmatism of ~2.9 Ga, ~2.7 Ga and 2.6-2.5 Ga have been reported, followed by the ~2.50 Ga widespread metamorphism and local metamorphism at ~1.9-1.8 Ga. Zircon Lu-Hf isotopic data have revealed that the Neoarchean magmatic zircons have positive $\varepsilon_{Hf}(t)$ values with depleted mantle model ages peak at 2.8-2.7 Ga. These suggest the Eastern Block underwent a major juvenile crustal growth at 2.8-2.7 Ga and then experienced a strong crustal reworking event at 2.6-2.5 Ga. Integrated with previous petrological, metamorphic and structural data, it is concluded that the Neoarchean is an important crustal growth period in the Eastern Block and the end-Neoarchean widespread tectonothermal event is possibly related to the intrusion and underplating of magmas originated from a mantle plume.

Abstract ID: 33652

Final Number: PG43A-02

Title: Tectonic and metamorphic setting of orogenic gold deposits in an Archean greenstone belt: implication of $^{40}Ar/^{39}Ar$ dating in the SE Superior province

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Abstract Body: Our metamorphic ages data are consistent with those of adjacent areas of the Superior province, suggesting that the peak and duration of metamorphism might have been coeval over a large region as expected for vertical tectonic models. Available geochronological data for orogenic gold occurrences in the AGB further suggest that most of the auriferous quartz-tourmaline veins and hosting shear zones were formed late during the regional structural evolution.

Abstract ID: 35842

Final Number: PG43A-04

Title: Structural Analysis of the Archean France River Shear Zone and Related Gold Mineralization, Chibougamau, Superior Province, Québec.

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Abstract Body: The Chibougamau mining camp (CMC), located in the northeastern part of the Archean Abitibi greenstone belt, has been the second largest mining district in Quebec from 1955 to 2008 (60,09 Mt of ore which produced 994 802 t Cu, 160 t Au and 102 t Ag). Known for its Cu-Au vein deposits, the CMC hosts shear zones related, gold-bearing veins in volcanic and sedimentary rocks metamorphosed to greenschist-facies. Existing regional studies have demonstrated the spatial relationships between such type of Au deposits and regional E-W-trending shear zones without, however, providing precise chronological relationships. This study evaluates the relative timing of regional deformations and gold-bearing quartz veins emplacement through a detailed structural analysis of a typical shear zone of the CMC, the France River shear zone, which hosts gold-rich veins in the Monexco property, located 30 km northeast of Chibougamau. The France River shear-zone, approximately 450 metres-wide, shows an anastomosing pattern of deformation corridors and it is characterized by folds, a penetrative schistosity S2, and a nearly down-dip mineral and stretching lineation L2. Subsequently, the shear zone was affected by a strike-slip D3 deformation characterized by a more localized crenulation clivage and a sub-horizontal stretching lineation L3. Shear bands and rotation of extension veins suggesting dextral motions are the main kinematic indicators associated with the D3 deformation.

The structural and metallogenic evolution of the France River shear zone can be interpreted in a continuous deformation model. The D2 deformation is associated with north-south directed compressive stress that generated regional folds and faults. The localization of D2 deformation resulted in the development of discrete shear zones, that facilitated the emplacement of dykes and sills of quartz-feldspar porphyry and gabbro. These intrusions predated a dextral strike-slip D3 deformation that is restrained to the France River deformation corridor. «Late» quartz veins cut across all lithologies and are variably affected by D2 and D3, suggesting that the bulk of the gold mineralization is late- D2/syn-D3.

Abstract ID: 35660

Final Number: PG43A-05

Title: Revised geology, U-Pb dating and new interpretations of the relationships between the Malartic - Louvicourt - Piché - Cadillac Groups and the Larder Lake-Cadillac Fault Zone, Abitibi Subprovince, Quebec

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Abstract Body: The Larder Lake - Cadillac Fault Zone (LLCFZ) is one of the most important structures with respect to gold mineralization in the Abitibi Subprovince (AS). It typically juxtaposes rocks of various compositions and ages. In the Rouyn-Noranda area for example, the fault juxtaposes Timiskaming-aged rocks (the Granada Formation, a fluviatil sequence, formed between 2680 and 2670 Ma) and Cadillac Group rocks (CG - a turbiditic sequence composed of wacke, siltstone and shale, formed between 2690 and 2680 Ma). In the Malartic area, U-Pb dating of two samples from a conglomeratic unit of the CG yielded Timiskaming ages (<2678 and < 2676 Ma). These new results reveal that Timiskaming-aged rocks extend further to the east than previously recognized and that this younger sedimentary facies can be contained within the older CG package. The new ages illustrate the complexity of these basins, exhumation of nearby lithologies and the localized, episodic nature of the sedimentation.

The LLCFZ has been historically correlated and associated with a talc-chlorite-serpentine schist corridor, which varies in thickness from less than 100 m to more than 1500 m, and has been named the Piché Group (PG). Although discontinuous along its length the PG, which is composed of variably deformed and carbonatized ultramafic/mafic volcanic rocks, can be observed from east of Louvicourt to Rouyn-Noranda (> 150 km). The origin of the PG is still debatable. It could represent (1) a single homogenous stratigraphic volcanic unit, (2) a composite assemblage, or (3) a tectonically emplaced sliver. However, a new U-Pb age from a tonalitic dyke crosscutting the ultramafic rocks at the Buckshot pit near Malartic yielded an age of 2710 Ma and is proposed to be correlative with the base of the Malartic Group (MG), supporting the sliver hypothesis.

A newly recognized sudsidiary structure to the LLCFZ is the Rivière Héva Fault. This large scale fault (> 80 km) duplicates the lower part of MG and could explain the presence of younger Héva Fm volcanic rocks (2700 Ma) juxtaposed to the Dubuisson Fm (2708 Ma).

With respect to metallogenic and geodynamic models, the LLCFZ and its various subsidiary segments are of tremendous importance. They have affected the various styles and timing of gold mineralization as well as the global architecture of the southern part of the AS.

Abstract ID: 36445

Final Number: PG43A-06

Title: Review of Stratigraphy and Metallogenic Context of the Bartlett, Halliday and Shaw Domes, Western Abitibi Greenstone Belt, Ontario, Canada

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Co-authors: Michel Houlé, Geological Survey of Canada, Québec, QC, Canada

Published Material: Part of the finding have been written up as a Summary of Field work, an Ontario Geological Survey publication.

Abstract Body: The Timmins area, located in the western Abitibi greenstone belt (WAGB), is known for its Au and Ni endowment. The Porcupine-Destor deformation zone (PDDZ), an Au-bearing structure, cuts the Timmins geology into the Timmins gold camp and the Shaw Dome, located north and south of the PDDZ respectively. The Shaw Dome consists of 2 volcanic episodes: 1) 2734–2724 Ma (Deloro) and Ni-rich 2710–2704 Ma (Tisdale).

The Bartlett and the Halliday domes, located southwest of Shaw Dome, were previously thought to be the stratigraphic continuation of Shaw Dome. However, recent geological mapping and geochronology has improved our knowledge of the stratigraphy and metallogenic context of the area. The geology in the Bartlett Dome correlates to the Shaw Dome, based on similar lithologies, geochemical affinities and geochronology. In contrast, new geochronology in the Halliday dome has revealed 2720-2710 Ma (Kidd-Munro) volcanic rocks and younger volcanic and sedimentary rocks (ca. 2689 Ma- Porcupine) thus making the Halliday Dome distinct from the Shaw and the Bartlett domes. In addition, komatiitic rocks displaying pepperitic contacts occur in the younger Porcupine sedimentary rocks. These new findings are significant since they are the first clear recognition in the WAGB of: 1) Kidd Munro episode rocks south of the PDDZ and 2) komatiitic magmatism coeval with Porcupine sedimentary rocks.

Recognition of Kidd-Munro age rocks in the Halliday dome increases its VMS mineralization potential as similar age rocks host the giant Kidd-Creek Cu-Zn Mine. Also, the presence of komatiites of Porcupine age creates a previously unrecognized target for Ni-mineralization in the WAGB. Furthermore, Au potential should not be neglected in this area. The Larder Lake-Cadillac deformation zone is an important Au structure in the WAGB and its potential extension west of Matachewan is poorly constrained. However, recent mapping suggests a possible westward extension of the deformation zone passing between the Halliday and the Bartlett domes where strong deformation corridors and several Au occurrences are present. These new results highlight knowledge gaps in our understanding of the architecture and evolution of the WAGB, thus further investigations are still warranted.

PALEOCEANOGRAPHY AND PALEOCLIMATOLOGY

Abstract ID: 34274

Final Number: PP14A-0318

Title: Geochemical Fingerprints of Maximum Flooding Surfaces in the ca. 850 Ma Upper Fifteenmile Group, Yukon Reflect the Iron Shuttle

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Co-authors: Marcus Kunzmann, McGill University, Montreal, QC, Canada; Galen P Halverson, McGill University, Montreal, QC, Canada

Abstract Body: We have performed a multi-proxy geochemical study ($\delta^{13}C$, $\delta^{56}Fe$, major and trace elements) spanning three maximum flooding surfaces within the ca. 850 Ma, mixed carbonate-shale Reefal Assemblage in Yukon, northwestern Canada, in order to evaluate the role of relative sea level fluctuations on redox sensitive geochemical proxies. The maximum flooding (MF) intervals are characterized by very fine-grained and finely laminated mudstones with relative high %TOC and low Fe_T/Al. The transition above the MF intervals, which reflects shoaling at the beginning of the highstand systems tract (HST), shows a sharp decline in %TOC, rise in Fe_T/Al, and spikes in redox sensitive trace metal concentrations, most notably U. Iron isotope compositions are inversely correlated with Fe_T/Al across this transition, with a sharp decline in $\delta^{56}Fe$

corresponding to an increase in Fe_T/Al. We interpret these patterns to record the influence of the benthic iron shuttle, whereby ^{56}Fe-depleted iron is removed from mudstones (rendering them ^{56}Fe-enriched) during sea level maxima, when high relative sea level, low sedimentation rates, and high organic carbon flux result in anoxic conditions at the sediment-water interface. As these conditions retreat and dissipate during the HST, a return to oxic bottom waters results in an accumulation of ^{56}Fe-depleted iron and trace metals released from anoxic sediments immediately downslope. These results and our interpretation have multiple implications for the redox state of early Neoproterozoic seawater and the application of redox proxies in ancient organic-rich sediments. First, it is evident that at least during period of high sea level, anoxic conditions prevailed below the surface mixed layer on continental shelves. Second, fluctuations in relative sea level under these conditions generates large variations in redox proxies which do not directly reflect changes in the redox state of the global ocean. Finally, the iron shuttle, driven by dissimilatory iron reduction, was vigorous in the early Neoproterozoic, and while it may have resulted primarily in downslope transport of iron, this mobilized iron would have also diffused upslope, where it was removed under oxic conditions of the surface ocean.

Abstract ID: 36002

Final Number: PP14A-0320

Title: A δ^{26}Mg Record of the Paleozoic Oceans

Presenter/First Author: Sarina Cotroneo, University of Ottawa, Ottawa, ON

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Co-authors: Ian Douglas Clark, University of Ottawa, Ottawa, ON, Canada

Published Material: Background information on the site from which the cores were taken has been published, however the focus of the presentation will be on new (unpublished) δ^{26}Mg data.

Abstract Body: The prospect of storing nuclear waste in the deep geosphere (ie. 600-800 m below ground surface (mbgs)) has generated considerable interest in the provenance and movement of deep crustal fluids in the Michigan Basin, where the construction of a deep geologic repository (DGR) for radioactive waste has been proposed. This waste management strategy seeks to isolate radioactive waste from the biosphere on geologic timescales, which demands a detailed understanding of the pore waters in low-permeability environments. A halite-mineralized Ordovician carbonate aquiclude is the proposed host of the DGR. The associated pore waters are a post-dolomitic brine of evaporated Silurian seawater, which has resided in the aquiclude for more than 260 m.y.[1]. Cores reaching depths of 861 mbgs, and spanning Cambrian to Devonian strata taken from a Bruce Power nuclear site near Kincardine, Ontario, have already been used to investigate several geochemical and isotopic tracers at this site. Mg isotopes are an emerging tool in the investigation of dolomite formation, magnesium cycling, and may be useful in the investigation of past and continental weathering fluxes. This study employs Ca (δ^{44}Ca) and Mg (δ^{26}Mg) isotopes measured by MC-ICP-MS to trace the movement of dolomitization fluids through Devonian, Silurian, and Orovician carbonates. The first segment of this research focuses on the δ^{26}Mg of dolostones throughout the core to establish a baseline expectation of the δ^{26}Mg of the pore waters if they are primary, while generating a record of δ^{26}Mg of the oceans through the Paleozoic and investigating dolomite formation in deep time.

1 - Clark, ID *et al.* (2013) *Geology*. **41**: 951–954.

Abstract ID: 36819

Final Number: PP14A-0321

Title: The utility of chromium isotopes as a redox tracer

Presenter/First Author: Christopher Reinhard, Georgia Tech, Atlanta, GA

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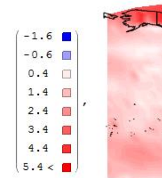
Co-authors: Noah Planavsky, Yale University, New Haven

Published Material: EPSL, v407, p9Science, v346, p635

Abstract Body: Advances in mass spectrometry allowing for the routine and precise measurement of metal stable isotope distributions in natural materials have revolutionized geochemistry. In particular, transition metal isotope systems have provided unique insight into the chemical evolution of Earth's ocean-atmosphere system on a range of timescales. However, the oceanic isotope mass balance of a given trace element and the fidelity of signal transmission into the sedimentary record are typically governed by a complex array of syn- and post-depositional processes. As a result, the ultimate utility of a metal isotope system is context-dependent and often quite different from that initially anticipated. This talk will focus on the chromium (Cr) isotope system as both a paleoceanographic proxy and a potential 'paleobarometer' for atmospheric pO_2 levels. Some recent applications of Cr isotopes to ancient sedimentary rocks and modern marine sediments will be discussed, along with data from a range of high- and low-temperature systems that help to constrain processes that do and do not induce significant stable Cr isotope fractionation near Earth's surface. In addition, the primary gaps and current frontiers in our understanding of modern Cr isotope mass balance at Earth's surface and how it has evolved with time will be highlighted.



Abstract ID: 35831

Final Number: PP21A-01

Title: Regional Climate Projections using Effective Climate Sensitivities

Presenter/First Author: Raphaël Hébert, McGill University, Montreal, QC

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Abstract Body: The relationship between temperature and anthropogenic forcings (especially CO_2), is so strong that the decomposition of climate variability into the sum of a deterministic anthropogenic component and a stochastic natural variability component turns out to be quite accurate. It was recently shown that the anthropogenic component can be well estimated by using the actual (historical) CO_2 radiative forcing as a linear surrogate for all the anthropogenic effects (regressing the global temperature against the logarithm base 2 of the global CO_2). The constant of proportionality is the "effective climate sensitivity" (i.e. the actual sensitivity to a historical CO_2 doubling). Alternatively, using instead the estimated equivalent CO_2^{EQ}, leads to nearly identical results with the sensitivities increased by a factor 1.08. For global annual temperatures, the residuals (the natural variability) is ±0.109K which is very close to GCM estimates of natural variability. This means that over the period 1880-2013, the global mean temperature is given to within an error of only ±0.109K once the global mean CO_2 is known. This provides a robust empirically based method for projecting global temperatures into the future using various Representative Concentration Pathways (RCP's).

In this presentation, we extend this method from global to regional effective sensitivities and regional projections at 5ºx5º resolution. We used local series of monthly gridded historical temperature records: HadCRUT4,

NASA Goddard Institute for Space Studies and NOAA National Climatic Data Center. To validate the method, we perform hindcasts for the period 1993-2013 comparing them with GCM hindcasts (the CMIP5 models). Our hindcasts are comparable or better than the CMIP multimodel mean hindcast. Our approach is based on observations and implies only a small number of parameters and assumptions, providing results which are completely independent from those obtained through GCMs, it can thus be used for benchmarking. This allows us to establish long term regional empirical projections of expected anthropogenic warming up to the IPCC target period 2081-2100, following the Representative Concentration Pathways, RCP, scenarios and we compare our projections with those from CMIP5.

Abstract ID: 35078

Final Number: PP21A-02

Title: Scaling linear Inverse Models (SLIM) for regional climate forecasting and the development of Global Macroweather Models

Presenter: Lenin del Rio Amador, McGill University, Montreal, QC

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Abstract Body: By using slightly different initial conditions, and exploiting the sensitive dependence on initial conditions, GCM's generate a statistical ensemble of future states. The high frequency "weather' is essentially treated as a source of noise. This has lead to attempts to directly generate the noise and the low frequencies that they force using stochastic models, the most well known are the linear inverse models (LIM). These have been presented as a benchmark for decadal surface temperature forecasts. For annual, global hindcasts, LIM skills superior to those of GCM's have been reported. Nevertheless, the exponential decorrelation in time of the LIM models is not only quite unrealistic (the true decorrelations are power laws), but also – as a consequence - limits its useful forecast horizon to roughly 1-3 years: We show that it enormously underestimates the memory of the system.

In this work we make a scaling analogue of the LIM: Scaling Linear Inverse Modelling (SLIM) that exploits the power law (scaling) behavior in time of the temperature field and consequently, make use of the long history dependence of the data to improve the skill. When applied to macroweather time scale range (from 10 days to 100 years) this allows us to achieve much better skills. The SLIM model is the predictive component of a new Global Macroweather Model (GMM) currently under development at McGill.

The prototype SLIM divides the planet into 10º x 10º regions from -70º to 70º latitude and analyzes the temperature series for each region. As a first step, we removed the anthropogenic component of each time series based on its sensitivity to equivalent CO_2 concentration for the last 130 years, the residue is our estimate of the natural variability that SLIM predicts. The parameters of the model can be obtained directly from the actual data. We report maps of theoretical skill predicted by the model and we compare it with actual skill based on hindcasts for some regions of interest. A comparison between our results and previous results using LIM or other GCM's is also shown. We also studied the interconnection between different regions and how they can mutually affect the corresponding predictability.

Abstract ID: 34958

Final Number: PP21A-03

Title: Holocene Labrador Current strength reconstructed from sediment sortable silt proxy

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Co-authors: David Piper, Bedford Institute of Oceanography, Dartmouth, NS, Canada; Kelly M Best, The Ohio State University, Columbus, OH; Francky Saint-Ange, Geological Survey of Canada-Atlantic, Dartmouth, NS, Canada

Abstract Body: Variability in the Atlantic meridional overturning circulation results from changes in the sea-surface conditions. During the early to mid-Holocene period, weakening of deep water formation in the North Atlantic has been partly attributed to the fluctuation of freshwater discharge to the Labrador Sea but direct evidence for this linkage is lacking. Furthermore, a recent study has shown no evidence of only temperature and salinity link between Labrador and Nordic seas for the mid to late Holocene period, implying that the subpolar gyres were not influenced by the Labrador Sea input but rather by a decrease in wind stress (Thornalley et al., 2009). Previous studies have been hampered by the lack of a high-resolution proxy for the flux of cold, low saline water from the Labrador Current. Here we present such a high resolution sediment proxy for variations in the strength of the Labrador Current for the Holocene from two northwestern Labrador Shelf cores. We compare variations in paleo-current strength inferred from the sortable-silt in conjunction with other paleoclimate proxies. Our data suggest that there were two prominent weakening of the Labrador Current strength centered at 8.4 ka and 7.8 ka which were accompanied by high detrital carbonate and notable changes in sediment geochemical tracers. The Labrador Current was strong between 7.6 ka and 3.5 ka with minor fluctuation in its strength. Furthermore, an enigmatic increase in the Labrador Current strength, which was not accompanied by any changes in the sediment geochemistry, was also observed at 3.4 ka. High sortable-silt values can result either by reworking off the adjacent sediments on the shallow shelf or by a very strong Labrador Current. If there was a large sediment input from the Labrador Shelf, the concentration of ice-rafted detritus would be diluted, which is not the case as the concentration of ice-rafted detritus increases from ~5.4 ka to the present. We therefore suggest that the sortable-silt data appear to represent variations in the Labrador Current strength.

Abstract ID: 36375

Final Number: PP21A-04

Title: North Atlantic temperature seasonality throughout the Holocene: isotopic evidence from micromilled bivalves

Presenter: Bruce M Eglington, University of Saskatchewan, Saskatoon,

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First Author Student?: No

Co-authors: William Paul Patterson, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: Poster presentations at Goldschmidt in 2012 (preliminary conclusions) and Arctic Science Workshop in 2010 (early part of the record). Manuscript is currently in review.

Abstract Body: We provide the first record of Holocene temperature seasonality for the North Atlantic, a climatically important region with significant transregional effects. Bivalves are particularly valuable proxies because growth bands of their shells archive high-resolution records of temporally discrete environmental information. High-resolution sampling enables reconstruction of variability of seasonal high and low temperatures, and therefore changes in seasonality—one of the most significant climatic variables that influences marine and terrestrial ecosystems. Thirty-five well-preserved aragonitic bivalves were extracted from a giant marine piston core in NW Iceland and sequentially sampled concordant with growth banding using a computer-controlled micromilling device. Carbonate aliquots were subsequently analyzed for $\delta^{18}O_{(CaCO3)}$ values to obtain snapshots of ambient seawater temperatures at a sub-monthly resolution. Previous research on this core observed significant variations in seasonal temperature over the last two millennia (Patterson *et al*., 2010). Here, we extend this seasonality record back to ~10,650 cal yr BP. Our temperature record is compared to other climate records around Iceland to produce a multi-proxy reconstruction of Holocene climate variability. Our data suggest that the Early Holocene (10,650 to 7,600 cal yr BP) exhibited the most persistently warm summers, with maximum summer temperatures ~2°C higher, and with greater seasonality than during the subsequent cooler Neoglacial period (7,000 to 4,750 cal yr BP). Our results indicate that the Neoglacial period was a relatively stable cold period, with the lowest summer maximum temperatures, as well as the lowest seasonality during the Holocene. Sporadic warm periods and increased seasonality are observed in the record after 4,500 cal yr BP, when maximum summer temperatures reached between ~7 and 9.5°C. The highest reconstructed temperatures of the entire record occurred during the Roman Warm Period centered at ~2,000 cal yr BP.

Abstract ID: 33630

Final Number: PP21A-07

Title: Hydro-climate of Subtropical North America since Last Glacial Maximum and Variations in the Dynamics of Atlantic and Pacific Moistures

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Published Material: A part was presented in AGU Fall meeting 2015 and a part of this is in review in Quaternary Research

Abstract Body: Modern day hydro-climate of subtropical North America (i.e. southern USA and northern Mexico) is controlled by the moisture sourced from both Atlantic and Pacific Oceans in the forms of summer as well as winter precipitations. Over the late last glacial and deglaciation, the dynamics of moisture from Pacific are better studied and geographical coverages of summer and winter precipitations are reconstructed by using several proxy records of continental deposits from southwestern USA and northwestern Mexico (Barron et al., 2012; Lyle et al., 2012; Kirby et al., 2013; Roy et al., 2013). The lack of records from northeastern Mexico and southeastern USA was a major hindrance for the reconstruction of dynamics of the moisture flow sourced from Atlantic. However, there is more paleoclimatic information from the eastern part of subtropical North America in the last decade (Grimm et al., 2003; Tripsanas et al., 2013; Feng et al., 2014). We present two different millennial-scale paleohydrological records from the northeastern and northwestern Mexico in order to reconstruct the dynamics of moisture sourced from both Atlantic and Pacific since the Last Glacial Maximum (LGM). Santiaguillo Basin located near the Pacific received more runoff during LGM and the amount of runoff decreased during deglaciation. The runoff record of El Potosi Basin located near the Atlantic is opposite of the Santiaguillo record and indicates more runoff during the deglaciation. The runoff into Santiaguillo over the Holocene was comparable with the proxy values of deglaciation, whereas El Potosi received less runoff during Holocene compared to the deglaciation. However both the sites registered reduced amount of runoff during the cooler Younger Dryas and Heinrich Stadial 1. Information about the variations in salinity, aeolian activity, productivity and source of productivity are reconstructed using multi-element concentrations, total organic carbon and C/N relation. A spatio-temporal reconstruction of the Atlantic moisture will be presented by comparing the paleohydrological information from northeastern Mexico with proxy records from Texas, Gulf of Mexico and Florida.

Abstract ID: 33060

Final Number: PP22A-01

Title: Paleolimnological evidence of global spread of hypoxia in freshwaters caused by local anthropogenic pressures

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Abstract Body: The recent development of seasonal or persistent hypoxia in many lakes and coastal environments around the world severely stresses ecosystems, causing a decline of fisheries, a loss of biodiversity, and an alteration of food webs, including mass mortality of fauna. In marine environments, global instrumental surveys showed that the number of hypoxic coastal sites exponentially increased since the 1950s. In lakes, however, long-term instrumental monitoring surveys remain limited, preventing a global reconstruction of hypoxia's dynamic and pinpointing long-term causes of these changes on the continents. Nevertheless, hypoxic conditions are recorded in lakes when varve sediments start to be preserved once thresholds in oxygen-depleted conditions are crossed. Here, we compiled the time when varves started to be preserved in lakes over the last 300 years from 365 sites across the world as an indication of the global evolution of hypoxia on continents, and compared these data with anthropogenic and environmental variables compiled for each of these 365 watersheds. Additional sites in Europe were included in the study to reconstruct changes during the Holocene epoch. Our results show that continental hypoxia started spreading worldwide before AD 1900, mainly because of local growth in population density, human footprint and land uses, leading to eutrophication. No significant correlation was found with changes in precipitation or temperature. Hypoxia in continental realm spread about 50 years prior to marine environments. Finally, no sign of general return to past well-oxygenated conditions are observed despite implementation of local restoration programs and implementation of policies limiting nutrients yields since several decades in Europe and North America. This highlights the low resilience of lacustrine systems in the context of the added likely stress due to global warming and population increase.

Abstract ID: 35425

Final Number: PP22A-02

Title: Non-Pollen Palynomorph Records of Natural (Climate-Driven) and Cultural Eutrophication

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Abstract Body: Algal palynomorphs (*e.g. Pediastrum*, dinoflagellate cysts, desmids, *Botryococcus*) in lake sediments from eastern North America record Holocene variations in nutrient availability. Eutrophication promotes the preservation of organic-walled planktonic microfossils while inhibiting benthic organisms (through BOD-induced bottom water anoxia) and corroding mineralized microfossils (through lowered pH in sediments due to organic acids). Non-pollen palynomorph (NPP) analysis is thus ideally suited to studies of eutrophication. Increases in algal biomass and changes in NPP assemblages (and decreases in biodiversity) identify both natural and cultural eutrophication in cores from Sluice Pond, Massachussetts and Lake Simcoe, Ontario. Natural, climate-driven, increases in nutrient availability are associated with Holocene warming, particularly with the lowstand during the hemlock decline. Cultural eutrophication is associated with impact of indigenous North Americans as well as European colonists, clearly evident in cores from Honey Harbour (Lake Huron) and Crawford Lake, Ontario.

Because these microfossils are present in slides prepared for pollen analysis, the main impediment to the exploitation of non-pollen palynomorphs (NPP) in paleolimnological studies appears to be relatively poorly understood taxonomy and ecology. Ongoing studies aim to remedy increase awareness of these microfossils and of their relation to the algal biomass that produced them, as well as investigating the effects of taphonomy on NPP assemblages; oxidation, for instance, selectively destroys more susceptible taxa, both *in-situ* and during acetolysis treatment. Pollen analysts are urged to pay attention to the valuable "by-products" in their slides, and to avoid acetolysis where possible, in order to obtain the maximum benefit from palynological preparations.

Abstract ID: 33811

Final Number: PP22A-03

Title: Identifying Regional Hotspots of Biodiversity Change Over the Past ~150 Years: Beta-diversity of Diatom Assemblages from ~400 US Lakes

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Co-authors: Beatrix E Beisner, , , ; Irene Gregory-Eaves, McGill University, Montreal, QC, Canada

Published Material: I presented a preliminary report on this project at the 2014 annual meeting of the Quebec Centre for Biodiversity Science. This presentation will include updated and more thorough results.

Abstract Body: There is growing acceptance that, over the past ~200 years, humans have fundamentally changed the functioning of the Earth's key processes. However, at present it is less clear how diversity has been altered over this period. Here we use the USEPA National Lake Assessment program, an open access database containing data from over 1000 lakes, including lake sediment records (~400 lakes), to explore questions of regional aquatic diversity change. The focus of this project therefore, is to compare diatom assemblages from pre-industrial (where possible) or baseline sediments, to those found in modern (2007) sediments, generating estimates of beta-diversity. Our specific objectives are to: (1) Quantify patterns in latitudinal richness across lakes and regions with different disturbance histories, testing the hypothesis that latitude as a weaker effect on diatom (alpha) diversity in modern sediments relative to pre-1850 sediments, (2) Map diatom beta-diversity through both time (bottom and surface sediment core samples) and space (between lakes), creating a visual depiction of beta-diversity hot spots across the US, and (3) Relate landscape-level anthropogenic changes/trends to diatom diversity and beta-diversity as well as functional diversity, with a particular focus on alterations that influence lakeshore condition. We have found longitudinal richness patterns with both pre-industrial and modern sediments as well as regional differences in beta-diversity. Additionally, high beta-diversity is more related to species replacement through time or across a landscape than species loss. This work will contribute to an understanding of how landscape-scale changes affect diatom (plankton) alpha and beta diversity across the US, through the combination of both long-term monitoring and paleolimnogical data.

Abstract ID: 33671

Final Number: PP22A-04

Title: Low-frequency Variability in the North and South Saskatchewan Rivers over the Past Millennium

Presenter/First Author: Jeannine-Marie St-Jacques, University of Regina, Regina, SK

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Abstract Body: The Canadian province of Alberta faces significant water challenges driven by an expanding population, accelerating economic growth, and the interaction between economic development and a changing climate. Nowhere in Canada are these issues more pressing than in semi-arid southern Alberta, where water supplies are under serious pressure and scrutiny. This region is known today for its highly variable hydroclimate. The instrumental record is only of centennial length and there is accumulating evidence suggesting that Euro-Canadians settled the region during a relatively wet period. This makes accurate proxy-reconstructions of paleo-flows extremely important in order for water managers to have a realistic idea of what is possible for already scarce surface water supplies under a changing climate due to global warming. We present reconstructions of the South and North Saskatchewan Rivers which are based upon treering series standardized by signal-free, regional curve standardization. With novel signal-free, regional curve standardization, treering series are processed in an unbiased manner to conserve low-frequency multi-centennial variability. Our reconstruction includes a *Pinus flexilis* treering chronology that begins in AD 549.

Preliminary results show river flows with a large amount of low-frequency variability, with a wet 20th century, dry Little Ice Age and a generally moist Medieval Warm Period. However, this region experienced an extremely dry half century beginning in the AD 1150s; a time period which researchers are finding to have been one of the most extreme megadroughts in western North America. The high amount of low-frequency variance observed in the reconstructed river flows would prove very challenging to water managers.

Abstract ID: 34449

Final Number: PP22A-05

Title: Application of Biochemical modeling in Paleoclimatic reconstructions from tree ring cellulose isotope data

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Abstract Body: Present scenario of climate change has lead to the requirement of detail knowledge of the climate system, long term climate change, its different components and their interactions [1,2]. One of the primary sources of climatic variability information in recent past are the tree ring cellulose isotope datasets due to their stable temporal resolution[3,4,5]. However the reconstructions produced from such data have variable dependabilities due to their site and species specificness in terms of parameter reconstructed and the calibration[1]. There are myriad reasons of statistical regressions having limited correlation with instrumental data, e.g. nearest meteorological station data might be hundreds of kms away. In some cases correlation are higher due to complex statistics applied but this does not remove the site specific characteristics of these analyses.
Cellulose formation in all of the trees is mostly the same basic physiochemical process as they all undergo C3 metabolic process. This process and resultant isotopic fractionation have been modeled from experimental information on live trees[6,7,8]. Evans[9] used these relations as forward models to determine isotopic values of wood cellulose. Managave et al[10] tested similar forward models for a trial and error interpretation of the unknown inputs. Although some papers e.g.[11] identified some processes in long term data, but no process based reconstructions were given till now.
Among many benefits of process based reconstruction models, the primary is that the parameter being reconstructed and their dependabilities will stay constant in time and space. This will make the resultant reconstructions more easily interpreted in terms of observed physical processes in present and their variabilities in the past.
In presence of basic meteorological data i.e. temperature and humidity estimates,
the pCO2 has been reconstructed from carbon isotope data from tree ring cellulose[12]. The processes involving oxygen and hydrogen isotope fractionations provide information about humidity, temperature and source water isotopic compositions. Some of these process based fractionation models along with resultant reconstructions from them will be discussed.

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Abstract ID: 33862

Final Number: PP22A-06

Title: Ground surface temperature histories from the Last Glacial Cycle to present as inferred from borehole temperature data

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Published Material: I presented parts of these findings at the AGU Fall Meeting in 2014.

Abstract Body: Twelve temperature-depth profiles (>1500 m) located in Eastern to Central Canada were studied to determine the ground surface temperature histories (GSTH) for the Last Glacial Cycle (LGC) and afterwards. The GSTHs were inferred by inversion. At three locations (Sudbury, Manitouwadge, and Thompson) with multiple boreholes, simultaneous inversion was used to illustrate regional trends. For all studied sites, the results indicate that ground surface temperatures throughout the LGC that range from -1.4-2.5°C, near the pressure melting point of ice. These ground surface temperatures are representative of the basal temperatures of the Laurentide Ice Sheet, which covered the region throughout the LGC. These temperatures allow for the possibility of basal flow and fast flowing ice streams, which have also been inferred from geomorphological data and are consistent with modeling efforts. Regional variations in basal temperatures are observed. A warming following the retreat of the ice sheet is noted at ~5-7.5 ka in all the GSTH reconstructions and is attributed to the Holocene Climatic Optimum. Only a portion of the sampled sites are suitable for studies of recent climate. These sites display

signs of a cold period from 200-500 yrs BP, corresponding to the little ice age.

Abstract ID: 34409

Final Number: PP22A-07

Title: A Warmer and Earlier High Arctic Holocene Thermal Maximum from Agassiz Ice Cap Core , Ellesmere Island

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Abstract Body: The Holocene Thermal Maximum (HTM) in the Arctic occurred during the first half of the present interglacial and represents a period when air temperatures were warmer than present-day. The melt-layer and

Abstract ID: 35874

Final Number: PP22A-08

Title: Environmental DNA preserved in lake sediments: Calibrating a new tool for biodiversity science

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Abstract Body: Biodiversity losses are a major cause of global change and could lead to significant alterations in aquatic ecosystems. Therefore, there is an urgent need to quantify biodiversity from aquatic ecosystems. Applying molecular methods to environmental DNA (eDNA) has the potential to greatly advance aquatic biodiversity science as these methods may allow for a more efficient and reproducible quantifications of biodiversity. These methods have proven to be effective in detecting endangered and invasive vertebrate and invertebrate species in water. In paleolimnology, eDNA utilization has the potential to widen the range of possible target taxa. However, more calibration is needed to elucidate the advantages and the limitations of using molecular tools in paleolimnology. The objectives of this project are then (1) to evaluate to the degree to which eDNA from sediment extracts preserve the biological dynamics apparent in the water column, and (2) to quantify the congruence between molecular approaches and traditional tools to identify taxa. To address these objectives, water samples are collected and sediment traps are deployed on a monthly basis in Cultus Lake, British Columbia. Diatoms are targeted in this study because they are adequately preserved in lake sediments and are then a suitable candidate for the calibration purpose. In addition, sockeye salmon are also studied to explore the potential of molecular methods to detect species without diagnostic features preserved in lake sediments. This study will provide great insights of the limitations and the advantages to use molecular methods to reconstruct past community dynamics.

Abstract ID: 33929

Final Number: PP23A-01

Title: Testate amoeba assemblages of southern Patagonian peat bogs record drastic 20th century shifts: unprecedented climate change or increased UV-B radiation?

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Published Material: We have published the testate amoeba transfer function in Journal of Quaternary Science (2014) 29: 463-474. Here we will present new, yet unpublished reconstructions.

Abstract Body: The ombrotrophic peat bogs of southern Patagonia are located within the southern westerly wind (SWW) belt, the position of which is the dominant mechanism of climate variability in this region. We have sampled cores from peat bogs to reconstruct water table depths during the last 2000 years and aim to relate past fluctuations in water table depth to shifts in regional climate in general and the position and intensity of the SWW in particular.

Cores were extracted from peat bogs located along a longitudinal transect across Tierra del Fuego. We reconstructed local water table depths based upon quantitative analyses of testate amoeba (TA) assemblages. These unicellular organisms live at the surface of humid ecosystems and create shells ('tests') that are generally well preserved in peat and their relative presence is closely linked to the local position of the water table. We therefore constructed a transfer function that allows for the quantitative reconstruction of past water table depths from historical assemblages. This transfer function has predictive ability, but relatively high prediction errors given the wide range of sampled water tables in excess of 100 cm. Statistical analyses of TA assemblages were performed to explore spatio-temporal patterns and relationships with climate and environmental variables.

Although water table depth remained the main environmental variable in explaining fossil TA assemblages, sensitivity to environmental factors varied between sites. During the last 2000 years, bogs recorded slightly wetter conditions between ~500-1000 AD, and drier conditions during the LIA. However, the sharpest change in both amoeba assemblages and reconstructed water table depths, suggesting important drying, was found during the 20th century. Given other evidence from previous publications and considering the regional climatic context, this shift, replicated at several sites, may have been forced by a decrease in precipitation. Nevertheless, we cannot exclude the influence of increasing UV-B radiation resulting from the local degradation of the ozone layer since the late 1970s. This may have affected and possibly still affects living TA

assemblages in the southern Patagonian region.

Abstract ID: 35533

Final Number: PP23A-02

Title: Recent afforestation of the Johnville Peat Bog, southern Québec, Canada, investigated using dendroecological and paleoecological techniques

Presenter/First Author: Matthew C. Peros, Bishop's University, Sherbrooke, QC

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Abstract Body: Recent dendroecological and paleoecological investigations at the Johnville Peat Bog, in southern Québec, Canada, have provided insight into the evolution of ombrotrophic bogs (those that receive all precipitation and mineral input from the atmosphere) as well as their response to human impacts, such as drainage. Many peat bogs in eastern North America experienced afforestation during the 20th century due to factors such as fire or landuse changes. The Johnville Peat Bog also underwent afforestation during the 20th century, possibly related to its drainage for agricultural purposes. The purpose of this study is to examine how Picea mariana (black spruce) responded to this drainage in terms of both its spatial distribution and its annual growth. Eighty black spruce trees, in different areas of the bog, and 20 hemlock trees (Tsuga canadensis), around the margin of the bog, were cored to determine the minimum age of the trees and also their rates of annual growth. The results show that the most rapid expansion of black spruce occurred in the area of the bog close to the area of drainage and that trees in other areas of the bog were relatively unaffected. Annual growth rates were determined by scanning and measuring the rings using WinDENDRO software, but showed more equivocal results. This study indicates that tree growth in ombrotrophic bogs is complex but that there is potential for using tree rings from these systems to infer hydroclimatic variability.

Abstract ID: 36163

Final Number: PP23A-03

Title: Peat bog as geochemical archives of atmospheric dust deposition in eastern Canada: a multi-proxy approach

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Abstract Body: Atmospheric mineral dust plays an important role in the Earth's climate through parameters such as atmospheric radiation, cloud properties and biogeochemical cycles. While variations in dust deposition during the Holocene are not of the same magnitude as those occurring on a glacial-interglacial scale, the complex spatial and temporal variability in climate during this period was important enough to affect dust production and transport. Ombrotrophic peatlands (bogs) have proven to be valuable archives of atmospheric dust deposition as their accumulation rate over the Holocene are rarely matched by other archives.

Two peat bogs, located on the North Shore region, eastern Canada, were sampled to investigate dust deposition/palaeowinds in north eastern North America over the mid and late Holocene. Here we present geochemical (major and trace elements, Pb and Nd isotopes) records combined with ash content, particle size, plant macrofossils and bulk density for both cores. The distribution of lithogenic element (REE, Ti, Sc) concentrations within the cores show periods of increased dust deposition at Baie and IDH. The range of dust deposition varies from 0.5 to 4 g m^{-2} yr^{-1} in the Baie bog and from 0.1 to 2.7 g m^{-2} yr^{-1} in the IDH bog respectively. The higher dust fluxes in the Baie bog were recorded from 100-600 and 1000-1500 cal yr BP, originating either from greater wind intensity or drier climatic conditions. The most significant episode of dust deposition at IDH occur around 3.8 yr cal BP with a maximum of 2.1 g m^{-2} yr^{-1}. Both cores record higher dust fluxes during the last century which suggests an anthropogenic impact on the dust cycle in the region. Before the 19th century (1850AD), the stable Pb isotopes ratios ($^{206}Pb/^{207}Pb$) in the Baie bog range between 1.188 and 1.215, which corresponds to the value of the Canadian Shield. Neodymium isotopes analyses (on going) will allow to identify potential change in dust source which might not be recorded by stable Pb isotopes.

Abstract ID: 36378

Final Number: PP23A-04

Title: Late Holocene climate of coastal Labrador: subseasonal evidence from stable isotope values of tree-rings

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Published Material: Manuscript is under review.

Abstract Body: Three centuries of subannual/annual climate data were retrieved from the $\delta^{18}O$ and $\delta^{13}C$ values of tree-ring cellulose in the temperature-sensitive region of central-coastal Labrador, Canada, situated near the northernmost boundary of the boreal forest. A large cookie of a white spruce (*Picea glauca*) tree was micromilled using a custom-made computer-controlled micromilling device to retrieve multiple samples per year and/or early and late wood that were subsequently analyzed for $\delta^{18}O_{cellulose}$ and $\delta^{13}C_{cellulose}$ values. The coastal Labrador/Nunatsiavut region is a climatically dynamic region that is significantly influenced by ocean-atmosphere interactions and thus has exceptional potential for studying both, terrestrial and marine climate variability, and their interactions. $\delta^{18}O_{cellulose}$ values were calibrated to the mean-annual temperature (°C), while $\delta^{13}C_{cellulose}$ values were interpreted to represent long-term water budgets. We found a good agreement between reconstructed mean-annual temperatures and major climatic trends and events, including multidecadal warm and cold climate episodes, historical meteorological measurements collected by the Moravian missionaries, modern mean-annual temperatures and salinity anomalies in the NW North Atlantic Ocean, as well as cooling trends induced by major volcanic eruptions such as Lakagígar in 1783-84, Tambora in 1815, and Krakatoa in 1883. Persistent cold intervals are found from 1790 to 1810, 1875 to 1895, and 1950 to 1970, while the warmest intervals are found during the mid-18th and 19th centuries. A sharp increase in Suess corrected $\delta^{13}C_{cellulose}$ values since the 1960s is possibly related to moisture stress induced by the persistent positive North Atlantic Oscillation (NAO) phase. Moreover, continuous transform wavelet analysis was used to analyze $\delta^{18}O_{cellulose}$ and $\delta^{13}C_{cellulose}$ periodicities and suggest that their interannual and multidecadal periodicities are similar to those of the NAO.

Abstract ID: 35864

Final Number: PP23A-05

Title: A Time-transgressive Two-phased Hypsithermal Warm Period Across the Boreal Region of Northwest Ontario: A Multiproxy Study From Deep-water and Near-shore Cores

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Co-authors: Donya Danesh, Queen's University, Kingston, ON, Canada; Kathleen R Laird, Queen''s University, Kingston, ON, Canada; Moumita Karmakar, , ,

Published Material: The pollen that will be presented has not been published or submitted. The information on changes in water levels from the nearshore core was just published in The Holocene (2015) Vol. 25. It is the time-transgressive nature of the change in the pollen and the linkage to the hydrological balance of these lakes that is unique, which together provides evidence for two-phased climatic optimum, or Hypsithermal Period.

Abstract Body: Climate warming is expected to have major effects on boreal ecosystems situated near the prairie-forest boundary in central North America. To investigate the impact of past climate change on boreal ecosystems in northwest Ontario over the Holocene, we developed a network of deep-water and near-shore cores from three headwater lakes that spanned a distance of over 250-km from boreal regions near the forest-prairie boundary to spruce-dominated forests to the east (i.e. northwest of Kenora to north-east of Sioux Lookout). Center cores were used to reconstruct large-scale changes in climate based on changes in pollen assemblages in the cores. The lake closest to the forest-prairie boundary exhibited a prolonged period of early-to-mid Holocene aridity, as indicated by a decline in spruce and increases in shrubs and grasses, from approximately 10,000 to 3,000 cal yr BP. Sites located further into the boreal forest had a much shorter period of enhanced aridity that extended from approximately 8,500 to 4,500 cal yr BP. We used near-shore sediment cores to track changes in water levels in these three lakes over the Holocene based on changes in diatom assemblages to reconstruct past water balance. In all cores, planktonic diatom assemblages increased during the later phase of the Hypsithermal Period (as indicated by the pollen), with changes in the lake closest to the forest-prairie boundary showing the longest and most pronounced changes. Taken together, this study supports a two-phased Hypsithermal Period: a warm-dry phase followed by a warm-wet phase. Further, the extent of the Hypsithermal was substantially longer closer to the forest-prairie boundary, with an earlier onset and later termination, in comparison to the sites that are today well within the boreal region. This study also suggests that high water levels in northwest Ontario have occurred only over the last four-to-five thousand years, and that many boreal lakes were more productive during the Hypsithermal Period.

Abstract ID: 34998

Final Number: PP23A-07

Title: Documentary Data Rescue In Canada: Daily Temperature Records For The St-Lawrence Valley In The Past 270 Years

Presenter/First Author: Victoria Slonosky, Organization Not Listed, Montreal,

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Published Material: Some of this work has been presented in a seminar at McGill Univsersity and at the 7th ACRE meeting. The methodology used (which will be very briefly explained for purposes of clarity) was published in 2014.

Abstract Body: Daily weather observations in Montreal and Québec City from the mid-1700s until the end of the 19th century have been digitized by a crowd-source citizen science data rescue project. Sub-daily (typically two or three observations per day) temperature readings from 14 different sources were assessed for quality using observational frequency techniques by comparing the historical observations with modern hourly data. A series of regression models were constructed and validated to estimate historical daily minimum and maximum temperature from the sub-daily historical measurements. The reconstructed minimum and maximum temperatures were used to compile a single series of daily minimum and maximum temperatures for the St-Lawrence Valley region between 1742 and 2010, with nearly continuous observations from 1798 to 2010. These daily temperatures were analyzed for changes and variability over the past two and half centuries. Cold conditions prevailed in the 1810s, 1830s and 1880s, while warm summers were observed in 1808, 1825, and 1955. Documentary evidence also suggests warm summers and frequent drought in the mid-18th century, with the hot and dry summer of 1754 described in particular detail. While there are warming tendencies in minimum temperatures, especially in winter with no very cold winters since the 1930s, little change over the century time scale is seen in maximum temperatures. Climatic indicators such as heat wave and cold spell counts suggest considerable decadal scale variability over the past 200 years.

Abstract ID: 34534

Final Number: PP23A-08

Title: Impact of Holocene Climate Variability on Arctic Vegetation

Presenter/First Author: Konrad J Gajewski, University of Ottawa, Ottawa, ON

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Abstract Body: Using all available postglacial pollen data from across the Canadian Arctic and around Greenland, the regional vegetation history was studied in the context of Holocene climate variability. Pollen records from several islands in the Canadian Arctic Archipelago show that most taxa arrived immediately after local deglaciation, in spite of the apparent obstacles to dispersal. The fossil pollen records were compared to modern samples from the Arctic to determine if the vegetation during the early to mid-Holocene warm period resembled the modern vegetation. Most Holocene pollen samples find analogues in the modern data, although the values of squared chord distance (SQD), which defines similarity between fossil and modern data, tend to be larger in samples older than 5000 cal yr

BP. Plant production, as measured by pollen influx tended to be greater during warmer periods.

Abstract ID: 33910

Final Number: PP24A-0324

Title: The paleoecological record of gray birch (*Betula populifolia*) in eastern North America

Presenter/First Author: Martin Lavoie, Laval University, Québec,

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Co-authors: Patricia Beauregard, , , ; Stéphanie Pellerin, , ,

Abstract Body: Gray birch (*Betula populifolia* Marshall) is a tree species native to North America, with a continuous distribution range extending east to west from Novia Scotia to southern Ontario, and south to New Jersey and Pennsylvania. It is a fast-growing, short-lived pioneer species that prefers poor, dry soils. Present notably on abandoned fields, the species can colonize diverse habitats. Little paleoecological information about the postglacial dynamic of gray birch is available, largely due to the fact that it is virtually impossible to identify its pollen in pollen assemblages. In order to document its past presence, we examined all sites within and beyond the species' current distribution range in eastern North America that have been subjected to macrofossil analyses. Periods during which the species was present were estimated based on available ^{14}C data. In total, more than 20 sites with gray birch remains were inventoried. The first occurrences date from the Late Glacial and Early Holocene. Gray birch was present during the period when the first forests formed, and fires were more frequent than they are today. Few sites show a long continuous presence of gray birch in macroremains assemblages during the Holocene. These sites are situated in pine barrens where fires seem to have always been frequent. Several ombrotrophic peatlands are characterized by gray birch establishment during approximately the last hundred years, very probably due to drier hydrological conditions in response to anthropic activities (agriculture, urbanization), conditions that favor the species' expansion.

Abstract ID: 34253

Final Number: PP24A-0325

Title: Radiocarbon Dates in Québec: Analyzing Paleopopulations and Environmental Change

Presenter/First Author: Michelle A. Chaput, University of Ottawa, Ottawa, ON

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Co-authors: Konrad J Gajewski, University of Ottawa, Ottawa, ON, Canada

Abstract Body: The extent to which North American paleopopulations influenced the environment and contributed to global atmospheric change remains unknown, partly due to a lack of data concerning population densities. The analysis of archaeological radiocarbon dates is one way of obtaining paleopopulation densities since the frequency of dates can be interpreted as being proportional to the number of people living around a site. The Canadian Archaeological Radiocarbon Database (CARD) contains more than 35,000 radiocarbon dates derived from cultural and paleoecological material spanning the last 25,000 years. These data form the basis of our study of past human-ecosystem-climate dynamics.

A first step in the analysis of any database is to identify problematic data, which can occur due to many causes, including contamination by older or younger carbon and stratigraphic problems. To obtain an accurate representation of human impact on North American ecosystems, these dates must be identified and corrected, and additional dates must be obtained for locations with insufficient data. The issue of taphonomic loss must then be addressed such that the true human population density is revealed. Although shown to provide reasonable results at a continental scale, more work is needed to determine at what point the "dates as data" approach is applicable at regional scales.

Six hundred and sixty two CARD dates from Québec spanning 13,000 years were analyzed as a function of ecoregion. Most dates are located in coastal regions, along the St. Lawrence River, or are associated with resource development projects. All ecoregions display a similar trend in the frequency of dates, which generally increases towards the present, with the exception of a sharp increase between 1,000 and 3,000 cal BP. Further analyses will reveal whether the sharp increase in date frequency is a result of taphonomic loss or population growth. Humans appear to have settled all ecoregions following the retreat of the Laurentide Glacier. One site in coastal northern Québec, where glacial ice remained until approximately 7,000 years ago, had a clearly anomalous date (8,428 cal BP). The uneven spatial distribution of sites, a consequence of archaeological activity, also needs to be considered when mapping past population distributions.

Abstract ID: 34322

Final Number: PP24A-0326

Title: Space-time Millenial-Scale Evolution of Vegetation and Climate Gradients in Boreal and Mixed Forests of Western Québec since 9000 years

Presenter/First Author: Bianca Fréchette, GEOTOP-UQAM, Montréal, QC

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Co-authors: Pierre Grondin, Ministère des Ressources Naturelles, Québec, Canada; Martin Lavoie, Laval University, Québec, Canada; Pierre JH Richard, , ,

Abstract Body: Millenial-scale changes in vegetation gradients and climate conditions were reconstructed in more than 25 lacustrine cores of the boreal and mixed forests, in western Québec, based on the modern analogue technique applied to pollen assemblages. The modern database used includes 1010 sites from eastern Canada, east of 100°W. Pollen assemblages of surface samples and modern climate conditions are available in the database and a cluster (*K*-means) analysis applied to surface pollen assemblages helped in assessing the modern vegetation of the sites. The reconstructed vegetation types are illustrated on maps and postglacial changes in vegetation gradients are evidenced. The reconstructed climate parameters include July temperature, annual precipitation and summer sunshine. Here, the reconstruction of summer sunshine is used to document large-scale atmospheric circulation patterns. Although climate reconstructions from individual sites indicate some local differences, there are generally consistent features on a regional scale including a progressive 1°C decrease in July temperature since 9000 cal BP, a progressive 150mm/yr increase in annual precipitation and a 3% decrease in summer sunshine. Data also indicate notable climate and vegetation changes at 5000 cal BP. In western Québec, climate was warmer and drier than today before 5000 cal BP and the dominant westward winds were stronger. This climate transition is tentatively attributed to a weakening of atmospheric circulation. Maps of paleo-vegetation point to west to east gradients before 5000 cal BP and to more diversified vegetation. Thermophilous trees were then more abundant than today in forests of western Québec. Reconstructed vegetation also illustrates that modern latitudinal gradients were attained lately at ca. 3500 cal BP. Coniferous trees abundance then increased in vegetation landscapes and modern boreal forest established in western Québec.

Abstract ID: 35879

Final Number: PP24A-0328

Title: Impact of the Little Ice Age cooling and recent climate change on peatland vegetation and peat accumulation dynamics in northeastern Alberta, Canada

Presenter/First Author: Gabriel Magnan, GEOTOP-UQAM, Montreal, QC

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Abstract Body: Northern peatlands are one of the most important terrestrial sinks of organic carbon (C) and these ecosystems are highly sensitive to human activities and climate change. This study aims at understanding how the climate changes over the last 1000 years have affected peatland vegetation and peat accumulation dynamics in the boreal region of northern Alberta. The past changes in vegetation communities were reconstructed using high-resolution plant macrofossil analyses from multiple peat bogs located at the southern limit of permafrost peatland distribution in the Fort McMurray region (56-57° N). Our data show important changes in peatland vegetation and peat accumulation dynamics that coincide with the Little Ice age cooling period (~AD1600-1850) and the subsequent climate warming. In all the peatlands, the plant macrofossil data suggest a synchronous period of permafrost aggradation characterised by dry ombrotrophic conditions, increased peat decay and high abundance of ericaceous shrubs and black spruce (*Picea mariana*). In most sites, this period was followed by permafrost thawing characterised by a short-term local shift towards wetter minerotrophic conditions (*Sphagnum* sect. *Cuspidata*) and a decline in black spruce on the peatland. Finally, we have observed a subsequent shift to a relatively stable presence of *Sphagnum* sect. *Acutifolia* (e.g. *Sphagnum fuscum*) which indicates the establishment of relatively dry ombrotrophic conditions in all the peatlands. Our data suggest that the recent climate change has been particularly favourable to *Sphagnum* growth and peat accumulation in northeastern Alberta.

Abstract ID: 36570

Final Number: PP24A-0331

Title: Holocene Paleohydrological Changes in the Southern Bay of Biscay: New Insights from Planktonic Microfossil Assemblages

Presenter/First Author: Marie-Camille Gasparotto, GEOTOP-UQAM, Montréal,

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Co-authors: Sandra Brocheray, , , ; Frédérique Eynaud, , , ; Linda Rossignol, , , ; Marion Péral, , , ; Fabienne Marret, Univ of Liverpool, Liverpool, United Kingdom; Yannick Mary, , , ; Marie-Hélène Castéra, , , ; Sébastien Zaragosi, , , ; Michel Cremer, , ,

Published Material: M.-C. Gasparotto, S. Brocheray, F. Eynaud, L. Rossignol, M. Péral, F. Marret, Y. Mary, M.-H. Castéra, S. Zaragosi, M. Cremer, Holocene paleohydrological changes in the southern Bay of Biscay: new implements from planktonic microfossil assemblages., Poster for the XIVth International Symposium on Oceanography of the Bay of Biscay (ISOBAY 14), June 11-13, 2014, Bordeaux (France)

Abstract Body: The Bay of Biscay is a region where significant shifts related to the North Atlantic Oscillation variation occur, a mechanism that is considered to be a major internal forcing for the climate variation during the Holocene, but still not too well constrained in this region. A core (PP10-07, 43°40.63'N; 02°13.69'W, water depth of 1472 m and 2004 cm long) collected at Capbreton canyon, with an exceptional sedimentation rate has enabled to recover a continuous and undisturbed Holocene climate signal, with a decadal to secular resolution. The present study was focused on studying cysts of dinoflagellates (dinocysts) with the aim to quantitatively reconstruct surface hydrological paleo-parameters and paleo-productivity, and therefore highlighting the Holocene signal of oceanographic changes in this area of the North East Atlantic. The ecological significance of the analysed dinocyst assemblages, besides showing evidence of high biodiversity, does not indicate any important movement of water masses. Most of the identified species are cosmopolitan and adapted to a wide range of surface temperature and salinity. These species are typical from the North Eastern Atlantic subtropical to temperate bioclimatic assemblages, with especially high occurrences of the intra-neritic species such as *Lingulodinium machaerophorum*, together with the cosmopolitan *Operculodinium centrocarpum* and *Spiniferites ramosus*. However, the quantitative reconstruction of the surface hydrological parameters and paleo-productivity through modern analogue technique derived from transfer functions highlights changes in temperature significantly differing from both the current average temperatures and the temperature signal given by foraminiferal data. Moreover, a relation between temperature variations and productivity at some times was observed, which could be as much associated with a cold or warm episode. Coupled to the detailed investigations made on the sedimentary context of the deposits, these palynological data derived from dinocyst assemblages allow us, for the first time in the Capbreton canyon area, to: (1) test the reliability of the marine palynological flora record in this atypical sedimentological environment, and (2) tentatively draw a coherent paleoceanographical pattern along the Holocene.

Abstract ID: 36784

Final Number: PP32A-01

Title: Opportunities and progress in constraining future projections

Presenter/First Author: Gavin A Schmidt, NASA Goddard Institute for Space Studies, New York, NY

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Co-authors: Allegra N LeGrande, NASA Goddard Institute for Space Studies, New York, NY

Abstract Body: We will discuss opportunities and progress in constraining future projections using the paleo-climate simulations performed for both PMIP3 and additional paleo-climate experiments. Specifically, we will describe robust processes and features in the NASA GISS-E2 simulations of the Last Glacial Maximum, Early and Mid-Holocene as well as a suite of experiments for the Last Millennium, in comparison with the future simulations under multiple RCP scenarios.

Abstract ID: 34485

Final Number: PP32A-02

Title: Anthropogenic carbon release rate unprecedented throughout the Cenozoic

Presenter/First Author: Richard E Zeebe, University of Hawaii at Manoa, Honolulu, HI

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Co-authors: Andy John Ridgwell, University of Bristol, Bristol, BS8, United Kingdom; James C Zachos, University of California Santa Cruz, Santa Cruz, CA

Abstract Body: Carbon release rates from anthropogenic sources have reached a record high of about 10 Pg C/y in 2013. Due to uncertainties in climate system feedbacks, the impact of the rapid carbon release on ocean biogeochemistry and future climate change is difficult predict. Geological analogues from past climate episodes are therefore urgently sought after to guide future climate change assessment. Based on data and models of various past eras and climate episodes, this presentation will provide a paleo-perspective on the magnitude and rate of anthropogenic CO2 emissions, including effects on seawater chemistry, carbonate mineral dissolution, and ocean biogeochemical cycles. Given currently available records, we demonstrate that the present anthropogenic carbon release rate is unprecedented throughout the Cenozoic (past 66 million years). Our results have important implications for our ability to use past analogues to predict future changes, including constraints on climate sensitivity, ocean acidification, and impacts on marine and terrestrial ecosystems.

Abstract ID: 35159

Final Number: PP32A-03

Title: THE PAST AND FUTURE DYNAMICS OF ECOSYSTEM COMBUSTION AND CLIMATE

Presenter/First Author: Richard Paul Guyette, University of Missouri Columbia, Columbia, MO

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Co-authors: Michael C Stambaugh, University of Missouri-Columbi, Columbia, MO; Daniel C Dey, , ,

Published Material: Partially presented at Great Plains Drought Conference, Omaha, Nebraska.Parts of this presentation in scientific Journals: Forest Science and Ecosystems

Abstract Body: Society is confronted with the effects of climate change on fire in ecosystems. Bringing paleo data and ecosystem processes into the future will increase the strength of estimating future conditions. We develop and calibrate an ecosystem combustion model (PC2FM[1]) with pre-climate change fire data, abiotic atmospheric variables (temperature K, H_2O, and O_2), and biotic variables (proxy reactant concentration) for predicting fire intervals and probability. We demonstrate a method for estimating changes in fire probability based on temperature and precipitation output from global climate models (GCMs). We calculated change in fire frequency and probabilities from the difference between current and future climates and map climate forced percent changes in fire probability under GCMs. Future fire probability estimates increased in cooler northern and high elevation regions, but decreased slightly in some hotter and drier regions. Our approach's greatest strength may be reliance on only climate data and the basic principles of physical chemistry.

[1]Guyette, R.P., M.C. Stambaugh, D.C. Dey, and R.M. Muzika. (2012). Estimating fire frequency with the chemistry of climate. Ecosystems 15: 322-335.

Abstract ID: 35183

Final Number: PP32A-04

Title: Stability of the AMOC depends on the background climate

Presenter/First Author: Aixue Hu, National Center for Atmospheric Research, Boulder, CO

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Co-authors: Gerald A Meehl, National Center for Atmospheric Research, Boulder, CO; Ayako Abe-Ouchi, University of Tokyo, Bunkyo-ku, Japan

Abstract Body: Atlantic Meridional Overturning Circulation (AMOC) is an important global scale oceanic circulation which contributes significantly to the global heat balance. Previous theoretical and modeling studies suggest that the stability of this circulation can affect the regional and global climate and may be the primary cause of the abrupt climate change event in the ice core records. Here we use two version of the Community Climate System Model (CCSM3 and CCSM4) to study the hysteresis of the AMOC under present day and mid-glacial conditions with two ensembles for each background condition. This is the first time that we clearly demonstrate the AMOC's hysteresis not only depending on the background climate but also depending on the status of the Bering Strait. With an open Bering Strait, the AMOC strength is only determined by the strength of the external haline or thermal forcing, not the background climate, and does not have hysteresis behavior. However, with a closed Bering Strait, the AMOC could collapse/restart suddenly and induces abrupt climate change events regardless the background climates. Further, the width of the AMOC hysteresis loop is affected by the background climates with a much narrower width under glacial conditions, suggesting that with a closed Bering Strait, the AMOC is much more sensitive to the freshwater perturbation in the subpolar North Atlantic than under present day condition. For the future warmer climate with an open Bering Strait, the AMOC could collapse due to strong greenhouse gas effect, but would restart as soon as the greenhouse gas forcing weakens, indicating the absence of the AMOC hysteresis. We conclude that the AMOC is possibly mono-stable under present day condition with an open Bering Strait, and multiple stable under glacial condition when Bering Strait is closed.

Abstract ID: 35788

Final Number: PP32A-05

Title: Pliocene Climates and the Pliocene Model Intercomparison Project

Presenter/First Author: Mark A. Chandler, CCSR / NASA GISS, Madison, WI

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Co-authors: Alan M Haywood, University of Leeds, Leeds, United Kingdom; Harry J Dowsett, USGS, Baltimore, MD; Aisling M Dolan, University of Leeds, Leeds, LS2, United Kingdom; David B Rowley, University of Chicago, Chicago, IL; Ayako Abe-Ouchi, University of Tokyo, Bunkyo-ku, Japan; Bette L Otto-Bliesner, National Center for Atmospheric Research, Boulder, CO; Dan John Lunt, University of Bristol, Bristol, United Kingdom; Ulrich Salzmann, Northumbria University, Newcastle-Upon-Tyne, United Kingdom

Published Material: Similar material will be presented by the same group of authors at the April 2015 EGU. Little overlap in participation is expected, thus the dual presentations.

Abstract Body: The mid-Pliocene Warm Period probably bears a closer resemblance to the CMIP5 RCP8.5 scenario than any other well-studied geologic interval (see Masson-Delmotte et al., 2013, Box 5.1). Marine and terrestrial data point to high-latitude temperature amplification, decreases in sea ice and land ice, higher sea levels, and poleward expansion of warm climate biomes. But uncertainty remains regarding how nearly representative mid-Pliocene regional climates and processes are of Earth's future climate. The Mid-Pliocene CO2 level was 350-450 ppm, higher than pre-industrial, but far lower than projections for even the mid-21st century. Yet sea level rise was probably much greater than will occur in the coming century. The IPCC 5th assessment points to significant melting of Greenland and West Antarctic ice sheets, plus some ice loss from East Antarctica, during the Pliocene. This, along with other geologic evidence, yields *high confidence* that sea level was above present, with 20 meters being an upper bound. An additional disparity between Pliocene and future climate simulations exists in the North Atlantic, where warming surpasses all other regions during the Pliocene but lags in RCP8.5. The next phase of model-model-data comparisons, designated PlioMIP-2, will attempt to address some of these uncertainties.

PlioMIP Phase 1 (2008-2014) resulted in the most complete analysis to date of Pliocene climate, including: detailed analyses of ocean circulation and monsoon behavior, an examination of large-scale global climate features and the ability of models to reproduce regional climates reconstructed from marine and terrestrial paleodata. We will highlight some of the PlioMIP-1 results before discussing the new PlioMIP-2 experiment design. PlioMIP-2 will incorporate significant updates to the paleogeographic boundary conditions, including a new land/sea mask, topography, bathymetry, and the Greenland and Antarctic ice-sheets. Within the PlioMIP-2 framework modelling groups will also have the option of using dynamic global vegetation models. Finally, the long-term partnership with the USGS Pliocene Research Interpretation and Synoptic Mapping Project (PRISM4), will give PlioMIP-2 participants access to an expanded, high-resolution data set of marine proxy records designed to aid data/model comparisons.

Abstract ID: 35960

Final Number: PP32A-06

Title: Volcanoes and Water Vapor Feedback in the Past and Implications for the Future

Presenter/First Author: Allegra N LeGrande, NASA Goddard Institute for Space Studies, New York, NY

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Co-authors: Kostas Tsigaridis, Columbia University of New York, Palisades, NY; Susanne Bauer, NASA Goddard Institute for Space Studies, New York, NY; Gavin A Schmidt, NASA Goddard Institute for Space Studies, New York, NY

Abstract Body: The 1991 eruption of Mt. Pinatubo has long been used as a key forcing to assess the skill of GMCs in simulating feedbacks associated with tropospheric water vapor, radiation and dynamics. In particular, tropospheric water vapor decreases significantly after the eruption, magnifying the directly-induced surface cooling. In contrast, stratospheric water vapor increases in response to volcanic eruptions. Previous work has speculated that the climate response to historical volcanic eruptions, such as Krakatoa in 1883, may have in fact been mitigated by the direct addition of water vapor into the stratosphere.

We will describe in detail the water vapor response to volcanic eruptions over the last millennium to the present. We have tested two versions of the GISS-E2 model, one in which volcanic aerosol distribution and properties are prescribed, and another where we use prognostic model of aerosol microphysics (MATRIX) and model physics to produce a distribution consistent with direct emissions of volcanic output. Where possible, especially for the 1815 Tambora eruption (one of the largest and well constrained eruptions of the last millennium), we assess the skill of the model in simulating the appropriate sized temperature response to the volcanic forcing.

We find that in contrast to the prescribed-aerosol version, the stratospheric water vapor feedback in the MATRIX version of the model is much longer lasting. In addition, additional water vapor injection to the stratosphere in the MATRIX version does not attenuate the climate response, rather expedites the chemistry to convert the emissions to aerosols. We assess the impact that these contrasting responses could have on our ability to simulate future climate change – not only in response to volcanic forcing, but any strong global radiative perturbation, including greenhouse gases.

Abstract ID: 34633

Final Number: PP32A-07

Title: Using the Paleo-Record to Constrain Future Arctic Climate Change from Global Climate Models

Presenter/First Author: Bruno Tremblay, McGill University, Montreal, QC

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Co-authors: David B Huard, David Huard Solutions, Quebec City, QC, Canada; Gavin A Schmidt, NASA Goddard Institute for Space Studies, New York, NY; Anne de Vernal, University of Quebec at Montreal UQAM, Montréal, QC, Canada

Abstract Body: The Coupled Model Intercomparison Project, Phase 5 (CMIP5), include historical simulations from the 20th century, future climate simulations following different Representative Concentration Pathways (RCPs) for the 21st Century and beyond, and, for the first time in CMIP, three sets of paleo-climate simulations of the recent past for which more paleo-proxi-data exist. We use simulations of the Mid- Holocene (MH) climate (6K BP) from General Circulation Models participating in CMIP5 to constrain future projections of Arctic climate change by the same models. During the Mid-Holocene, the Arctic received approximately 50 W/m2 more solar radiation at the top of the atmosphere during summer, a similar increase to what is projected from greenhouse gas forcing for the middle of the 21st century. The constraint in our analysis arise from a measure of the ability of GCMs to hindcast MH climate using a suite of both land paleo-records – which are much more abundant for high latitudes than ocean proxy - and ocean paleo-record. Results show that GCMs with skill at simulating the MH climate and today's climate give more realistic future projections of the sea ice decline in forced climate simulations of the 21st century participating in the IPCC-AR5.

Abstract ID: 35059

Final Number: PP32A-08

Title: Using scaling fluctuation analysis to determine the accuracy of climate records and multiproxy reconstructions and the return periods of climate events

Presenter/First Author: Shaun Lovejoy, McGill University, Montreal, QC

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Published Material: The return period part (in the coclusion of the talk) has appeared in GRL last summer, but the rest has not been published.

Abstract Body: There has been much debate about the reliability of climate records and multiproxy reconstructions. There are now half a dozen global scale climate records and a dozen or so multiproxy reconstructions, each based on somewhat different data and different methodologies. We argue that a) we can only have high levels of confidence when there is substantive agreement between them, b) due to numerous sources of bias, that the most difficult problem is accurate rendition of the low frequencies. Using three instrumental records and a reanalysis and nine last millenium multiproxy reconstructions, we therefore determined the variabilities as functions of time scale as well as

the differences between series as functions of time scale using fluctuation analysis (based on easy to understand and interpret Haar wavelets).

Although due to increased temporal averaging, we might naively expect the discrepancies between records to diminish with scale, on the contrary we find that for the global temperature over the range 1 month to one hundred years, that the RMS fluctuations in the differences are constant at around ±0.03K. While this is sufficient for many purposes, it cannot be easily accounted for - we discuss various hypotheses. An analogous analysis of the multiproxies shows a) an improvement of the more recent ones (post 2003) with respect to the older ones, b) agreement to within about ±0.05 K for scales below a century, but rapidly rising at longer time scales. We conclude that for centennial scale studies of pre-industrial statistics (including the determination of return times for natural temperate fluctuations and statistical hypothesis testing), that the data and multiproxies are sufficiently accurate. However, this may not be true of the multicentennial, and longer scale variability.

Abstract ID: 34260

Final Number: PP33A-01

Title: Wandering, uplifting, and eroding continents: impact on silicate weathering and carbon cycle

Presenter/First Author: Yves Godderis, GET CNRS, Toulouse,

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Abstract Body: The geological evolution of the carbon cycle is pending on many complex processes. Among them, continental silicate weathering is known to be a controling factor of first importance, able to modulate the atmospheric CO2 and the Earth climate. But this process is itself a function of many processes. Specifically, the role of mountain uplift and basaltic weathering has been particularly discussed in the recent years. But much less attention has been paid to the role of continental drift, which modulates the climate over large regions, and hence the CO2 consumption by silicate weathering.

Here we discuss the combined effects on the Earth climate of two major continental reorganizations: one in the late Neoproterozoic and the other in the late Paleozoic. The investigation tool is the coupled carbon-climate numerical model GEOCLIM. In the first case, the tectonic context is the dislocation of the Rodinia super continent, with the onset of many highly weatherable large igneous provinces, all processes leading to a global cooling. In the second case, antagonistic forcings (the equatorial hercynian range promoting weathering and the Pangea assembly inhibiting weathering through aridification) produces first a global cooling from 330 to 290 Ma. This cooling is concomittant with the Late Paleozoic Ice Age. Then the demise of the range and the rising aridity allows CO2 to rise to high level in the late Permian, ending the glacial episode.

In both case, the scenarios are in agreement with the strontium isotopic ratio evolution, which traces the relative contribution of the weathering of various lithologies to the global strontium and carbon budgets.

Abstract ID: 35525

Final Number: PP33A-02

Title: Continental Magmatic Arcs as Drivers of Neoproterozoic and Phanerozoic Icehouse-Greenhouse Transitions

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Published Material: Similar results were presented in a poster at the GSA annual meeting

Abstract Body: Tectonic outgassing from volcanic and metamorphic degassing contributes the major CO_2 flux to the atmosphere, whereas silicate weathering and organic matter burial draws down CO_2 on multimillion-year timescales. Variation in silicate weathering is generally consider the dominant controller of atmospheric pCO_2 and shifts in global climate regimes. Recent studies, however, postulate that continental arc magmatic systems in particular may play the major role in pCO_2 variation. Here we present a compilation of ~120,000 new and published single grain detrital zircon U-Pb age-dates acquired from globally dispersed siliciclastic sedimentary rocks with depositional ages that span the last ~720 million years. Globally, age distributions are skewed towards relatively young detrital zircon populations during periods of greenhouse climates, e.g., the Cambrian, Jurassic, and Cretaceous, whereas age distributions during the Cryogenian and Permian icehouse climates are broader with relatively low concentrations of young grains. These shifts in the relative abundance of young zircon grains indicate that continental volcanic arcs were spatially extensive during greenhouse climates and spatially reduced during icehouse climates. Based on this relationship, we propose that major shifts in atmospheric pCO_2 have been principally controlled by the continental arc volcanic flux, which drove major icehouse-greenhouse transitions from the Cryogenian to the modern.

Abstract ID: 33852

Final Number: PP33A-03

Title: Coupled tectonic-ocean-atmosphere-weathering-pCO_2 feedback as a trigger for Eocene-Oligocene Antarctic glaciation

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Published Material: 2013 AGU Fall Meeting

Abstract Body: Rapid emplacement of the Antarctic ice sheet spanning the Eocene-Oligocene Transition (EOT) was initially attributed to thermal isolation of Antarctica due to tectonic widening of Southern Ocean gateways, but in recent years it has been more frequently attributed to atmospheric pCO_2 drawdown. A combination of geochemical evidence and modeling results suggest the possibility that a series of Earth system feedbacks actually linked these two mechanisms together by reducing atmospheric pCO_2 in response to an initial tectonic change and thereby triggering Antarctic glaciation. Large vertical gradients in benthic foraminiferal $\delta^{13}C$ in the Southern Ocean, evident from ODP Sites 689 [*Diester-Haass and Zahn*, 1996] and 1090 [*Pusz et al*., 2011], suggest that strong stratification of the Southern Ocean developed during an ~2 million year interval of the latest Eocene. We suggest that during this time, the deepening of Southern Ocean gateways prevented southward geostrophic transport of saline subtropical water to high southern latitudes, causing

the North Atlantic to salinify in compensation, and thereby strengthening the Atlantic Meridional Overturning Circulation. The consequent effects of changes in ocean heat transport, amplified by radiative cloud feedbacks, would have resulted in a warming of the northern hemisphere relative to the southern hemisphere [*Yang et al*., 2013], consistent with temperature reconstructions [*Plancq et al*., 2014; *Zanazzi et al*., 2007]. Because the northern hemisphere contains more land area, the interhemispheric temperature shift would have accelerated the global rate of silicate weathering, providing a mechanism for the drawdown of atmospheric pCO_2 and global cooling during the latest Eocene. The decline of atmospheric pCO_2 below a certain threshold would have enabled rapid growth of the Antarctic ice sheet across the EOT, with the subsequent formation of cold, dense waters ventilating the Southern Ocean and subsequently eliminating the vertical benthic foraminiferal $\delta^{13}C$ gradient. This series of Earth system feedbacks – initiated by the tectonic deepening of Southern Ocean gateways and culminating in atmospheric pCO_2 drawdown driven by silicate weathering – reconcile competing hypotheses for the mechanisms responsible for onset of Antarctic glaciation during the EOT.

Abstract ID: 35031

Final Number: PP33A-04

Title: Testing for supply-limited and kinetic-limited chemical erosion in field measurements of regolith production and chemical depletion

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Published Material: I spoke on a similar subject at the AGU 2014 Fall Meeting. These results have not been published anywhere.

Abstract Body: Understanding the controls on silicate weathering rates is of wide interest because silicate weathering influences nutrient supply, landscape evolution, and Earth's long-term climate. Some studies have suggested that silicate weathering rates are proportional to rates of mineral supply to the regolith, a condition known as supply-limited chemical erosion. Because this condition implies that silicate weathering rates should be strongly coupled to regolith production rates, and because regolith production rates are strongly coupled to rock uplift rates, this also implies that silicate weathering rates (and hence climate, via the carbon cycle) should be strongly coupled to tectonics over long timescales. Although theoretical considerations suggest that silicate weathering rates should scale with supply rates, it has been difficult to test whether chemical erosion rates are in fact supply-limited at any given field site. One obstacle is that the quantities that are most frequently used to test for supply limitation (i.e., rates of denudation and chemical erosion in regolith-based studies, and fluxes of sediment and solutes in river-based studies) are spuriously correlated, which complicates attempts to quantify effects of one variable on the other. Here we discuss a statistical method for testing for supply-limited chemical erosion, and we apply it to a number of published datasets. Our results suggest that chemical erosion rates in most of these datasets depend more strongly on supply rates than on dissolution kinetics, but they also suggest that the uncertainties in many datasets are too large to conclude whether regolith chemical erosion is or is not supply-limited. These analyses suggest that new measurements across a wide range of supply rates will be needed to quantify the strength of the coupling between chemical erosion and mineral supply, and, ultimately, to test hypotheses about the influence of tectonics on the long-term evolution of Earth's climate.

Abstract ID: 34751

Final Number: PP33A-05

Title: The Importance of Terrestrial Weathering for Climate System Modelling on Extended Timescales: A Study with the UVic ESCM

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Abstract Body: The chemical erosion of carbonate and silicate rocks is a key process in the global carbon cycle and, through its coupling with calcium carbonate deposition in the ocean, is the primary sink of carbon on geologic timescales. The dynamic interdependence of terrestrial weathering rates with atmospheric temperature and carbon dioxide concentrations is crucial to the regulation of Earth's climate over multi-millennial timescales. However any attempts to develop a modeling context for terrestrial weathering as part of a dynamic climate system are limited, mostly because of the difficulty in adapting the long timescales of the implied negative feedback mechanism with those of the atmosphere and ocean, the latter typically operating on timescales several orders of magnitude lower than the former. As a result we still have but a rudimentary understanding of the chemical weathering feedback mechanism and its effects on ocean biogeochemistry.

Much of the earlier work on this topic is based on box-model approaches, abandoning spatial variability for the sake of computational efficiency and the possibility to investigate the impact of weathering on climate change over time frames much longer than those allowed by traditional climate system models. Only one such attempt [Meissner et al., 2012, Global Biogeochemical Cycles 26] has been made with the University of Victoria Earth System Climate Model (UVic model), to investigate the role of weathering as a dynamic component of the global carbon cycle. Using a land map which takes into account a number of different rock lithologies as well as changes in sea level, and an empirical model of the temperature and NPP dependency of weathering rates for the different rock types, we introduce a two-dimensional representation of weathering processes into the carbon cycle component of the UVic model. Taking the last deglacial period (c. 21000BP to 13000BP) as a contextual timeframe, we compare results between our 2-D version of the weathering feedback mechanism and a simulation using only the box-model parameterizations of Meissner et al. [2012]. In doing so we hope to assess the importance of two dimensional factors (i.e., changes in sea level and rock type distribution) within the weathering negative feedback mechanism.

Abstract ID: 34763

Final Number: PP33A-06

Title: Global carbon burial in deep-sea sediment across the last glacial cycle based on a comprehensive sediment proxy database.

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Abstract Body: The ultimate fate of most carbon released from the solid Earth through volcanoes (and now human activity) is as organic carbon and carbonate minerals in marine sediments. As such, the marine burial of carbon exerts a strong control on long-term climate, via its impact on CO2,

and modulated by the silicate weathering feedback. But the sensitivity of these fluxes and feedbacks to climate remains uncertain.

Here, we sought to evaluate and quantify past changes in the organic carbon and carbonate burial in deep-sea sediment over the last glacial cycle, taking advantage of a comprehensive global marine sediment proxy database we have built. Our strategy consists of three consecutive steps. First, to produce a global map of modern burial in the sediment. Second, to subdivide the ocean into provinces with consistent biogeochemical properties. Third, to modulate the modern burial in each province over time, according to the mean changes in burial rates calculated using sediment cores from the same province.

Our results suggest a significant change in global deep-sea organic carbon burial over glacial interglacial timescales, with a peak in organic carbon burial during glacial maxima, that represent 150-175% of interglacial burial rates (±25%). In contrast, despite regional heterogeneity, preliminary results do not suggest consistent and significant variations of the global burial of carbonates in the deep-sea over glacial/interglacial timescales and during glacial termination. Rather, the increase of carbonate burial in the Atlantic during the deglaciation was compensated by a decrease in the Pacific and Indian Ocean. Considering the large burial flux of carbonate on continental shelves that has existed throughout the Holocene, which was essentially absent during glacial maxima, implies that the total carbonate burial has been substantially greater in the Holocene. Given the relatively short timescale of carbonate compensation (a few thousand years) this suggests that silicate weathering rates were also substantially larger during the Holocene.

Abstract ID: 36450

Final Number: PP34A-0300

Title: Searching for an extinction event at the end of the Earth

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Abstract Body: Disentangling the events surrounding the K-Pg extinction remains hotly debated with specific questions unanswered about the kill mechanism of both terrestrial and aquatic species, and the response of the marine environment to these events. Evidence has been presented that shows surface water foraminifera being severely impacted, however it is still unclear if global primary production was significantly affected. Novel isotopic techniques emerging are providing new insights to the geologic record, specifically Zn isotopes are showing promise as a proxy for paleo-productivity. Here we present new data from IODP core 577A, currently located approximately 2000 km east of Japan, spanning events before, during and after the K-Pg transition. Our novel approach first explores seawater eNd, and $^{87/86}$Sr isotope ratios to observe any perturbations over this period. Preliminary eNd, results show a primitive signal, with an average value of -2.5, that may be a possible result of Deccan volcanism, which interestingly $^{87/86}$Sr values display a delayed response. Exploring possible impacts on global productivity, d^{66}Zn values indicate that despite the dramatic events unfolding, seawater isotope ratios recorded in carbonates deposited on the other side of the Earth saw no significant changes in these isotope ratios.

Abstract ID: 35656

Final Number: S11A-01

Title: PEER NGA-East Overview: Development of a Ground Motion Characterization Model and Ground Motion Prediction Equations for Central and Eastern North America

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Published Material: Partial findings of this study has been previously presented in NGA-East workshops (Berkeley, CA), which were made public and accessible online. Other progress reports on NGA-East have been presented at various meetings, such as SSA meetings and hazard workshops hosted by the USGS (multiple US locations).

Abstract Body: The Next Generation Attenuation project for Central and Eastern North America (NGA-East) is a large multi-disciplinary project tasked to develop a new ground motion characterization (GMC) model for the Central and Eastern North-America (CENA) region. The GMC model consists in a set of ground motion prediction equations (GMPEs) for median and standard deviation of ground motions and their associated weights, combined into logic-trees for use in probabilistic seismic hazard analyses (PSHA). NGA-East faced many technical challenges, most of them related to the relatively small number of earthquake recordings available for CENA. To address this shortcoming, the project relied on ground motion simulations to supplement the available data. Other important scientific issues were addressed through targeted research projects on topics such as the regionalization of seismic source, path and attenuation of motions, the treatment of variability and uncertainties and on the evaluation of site effects. Seven working groups were formed to cover the complexity and breadth of topics in the NGA-East project, each focused on a specific technical area. Through its multi-year span, NGA-East developed a comprehensive database of ground motion records, numerous interim products for the quantification of ground motions in CENA as well as new GMPEs. An overview of the project is presented, followed by highlights on latest progress, notably on the development of new GMPEs and their integration into the GMC model.

SEISMOLOGY

Abstract ID: 36340

Final Number: S11A-02

Title: PEER NGA-East Database

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Published Material: Christine A. Goulet, Tadahiro Kishida, Chris H. Cramer, Robert B. Darragh, Walter J. Silva, Youssef M. A. Hashash, Joseph Harmon, Jonathan P. Stewart, Katie E. Wooddell, Robert R. Youngs (2014), "PEER NGA-East Database", Pacific Earthquake Engineering Research Center, PEER Report 2014/09.

Abstract Body: We summarize the attributes of a comprehensive ground motion database developed for the Central and Eastern North America (CENA) region. The database was developed as part of the Next Generation Attenuation Project for CENA (NGA-East), a large multi-disciplinary project coordinated by the Pacific Earthquake Engineering Research center (PEER).The NGA-East database includes the two- and three-component ground-motion recordings from numerous selected events (M ≥ 2.5, distances up to 1500 km) recorded since 1988. The final database contains over 9,600 records from 81 earthquake events and 1379 recording stations. The NGA-East database constitutes the largest database of processed recorded ground motions from Stable Continental Regions (SRCs). The motivation behind the development of the empirical database is the same as for other NGA projects (NGA-West1 and NGA-West2), which is to be used, along with other information and data, for the development of ground motion prediction equations (GMPEs). The NGA-East ground motion database, similar to those from the NGA-West projects, includes pseudo-spectral acceleration (PSA) for the 5%-damped elastic oscillators with periods ranging from 0.007 to 10 sec. Additionally, the NGA-East database includes Fourier amplitude spectra (FAS) of the processed ground motions. The NGA-East database therefore consists of three groups of complementary products: the summary file referred to as the flatfile, which contains metadata, ground motion information and intensity measures on a record-per-record basis, the time series (acceleration, velocity, and displacement), and the corresponding Fourier spectra files. The NGA-East database products will also be made available to the public through the PEER online ground motion tool. An overview of the NGA-East database attributes and development is presented.

Abstract ID: 36831

Final Number: S11A-03

Title: Ground-Motion Prediction Equation Development Using Random Vibration Theory, Bayesian Regression, and Finite Fault Simulations: The PEER NGA-East Example

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Co-authors: Nicolas Martin Kuehn, University of Potsdam, Potsdam, Germany; Christine A. Goulet, University of California Berkeley, Los Angeles, CA; Norm A Abrahamson, , ,

Abstract Body: Central and eastern North America (CENA) presents a challenging problem in regards to ground-motion modeling as there is a lack of data in areas critical to engineering design. The two cases where data is both sparse and necessary are for large magnitude and short source-to-site distance. Here, we present a methodology used to develop ground-motion prediction equations (GMPEs) for pseudo spectral acceleration (PSA) that utilizes both finite fault simulations and regionalized data from around the world. This methodology allowed us to produce several alternative models for predicting PSA all the way up to magnitude 8.2. Since there is little to no useable amplitude data in CENA for magnitude greater than 6.0 many alternative models are necessary to capture the epistemic uncertainty of the median prediction. This methodology was implemented for development of GMPEs as part of the Pacific Earthquake Engineering Research center (PEER) NGA-East Project.

There are two other relatively uncommon steps taken to develop these alternative models: the majority of the model development is performed on the Fourier Amplitude Spectrum (FAS) of acceleration, and a Bayesian inference scheme was used to estimate both fixed and random effects of the GMPE. In general, GMPEs for PSA are developed using PSA values themselves. However, working in FAS space allowed for better integration of the finite fault simulations and other seismological models for extrapolation. Using the Bayesian inference scheme allowed for the integration of data from regions thought to have different seismological properties. The hierarchical nature of the model accounts for regional difference in how ground motions scale with distance. The way in which our model was set up inherently assumes that the scaling of ground motion with magnitude is similar across regions. The methodology enabled us to produce alternative median GMPEs in CENA that behave reasonably well up to magnitude 8.2.

Abstract ID: 34430

Final Number: S11A-04

Title: A Hybrid Empirical Ground Motion Prediction Model for Eastern North America

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Published Material: Pacific Engineering Research Center NGA-East

Abstract Body: A hybrid empirical method (HEM) is utilized to develop two new ground-motion prediction equations (GMPEs) for Eastern North America (ENA) using five new NGA-West2 GMPEs developed by the Pacific Earthquake Engineering Research center (Bozorgnia *et al.,* 2014). The two new GMPEs are derived for a moment magnitude (**M**) range of 4 to 8 and shortest distances to the fault rupture (R_{RUP}) as far as 1000 km. The GMPEs are developed for the 5%-damped pseudo-acceleration response spectra and the peak ground acceleration (PGA) for hard-rock sites with V_{S30} = 3000 m/sec.

Seismological parameters for ENA are adopted from the most recent research and published information in ENA (Yenier and Atkinson, 2015a; Chapman, *et al.,* 2014; Boore and Thompson, 2015; Hashash, *et al.,* 2014). Seismological parameters for western North America (WNA) are adopted from a study by Zandieh and Pezeshk (2015) in which they performed a set of point-source inversions to match the median NGA-West2 GMPEs for **M** ≤ 6.0, R_{RUP} ≤ 200 km, V_{S30} = 760 m/sec, strike-slip faulting, and sediment-depth parameters equal to the default values recommended by each of the NGA-West2 developers.

The two new sets of ENA GMPEs are based on two approaches: (1) using HEM to model magnitude scaling over the entire range of magnitudes; and (2) using HEM to model magnitude scaling for **M** ≤ 6.0 and using the magnitude-scaling predicted by the NGA-West2 GMPEs for **M** > 6.0.

The new GMPEs can be used as an alternative to those developed for ENA by other methods (e.g., stochastic and numerical simulation).

Abstract ID: 33247

Final Number: S11A-05

Title: A Preliminary Model of Site Amplification for use in Ground-Motion Modeling in Southern Ontario

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Co-authors: Hadi Ghofrani, University of Western Ontario, London, ON, Canada; Gail Marie Atkinson, University of Western Ontario, London, ON, Canada

Abstract Body: A critical component in the understanding and interpretation of earthquake ground motions is the role that site effects play. In southern Ontario, Canada, the soil layers which overlie glaciated bedrock produce strong and highly variable site responses. We use horizontal-to-vertical (H/V) response spectral ratios as the indicator variable by which to characterize the salient characteristics of site response in southern Ontario. We show that site response can be modeled using two key descriptive variables that are readily obtainable: (i) peak resonant frequency (f_{peak}), as determined from H/V or soil depth; and (ii) overall soil type (or stiffness). We use these variables to create a preliminary model of site amplification across southern Ontario that can be used in the development of ground-motion prediction equations (GMPEs) and in real-time interactive ground-motion (IGM) map applications.

The key to the site characterization is the relationship between f_{peak} and drift thickness (depth to bedrock), which we derive using H/V data from earthquakes in the region, combined with a detailed digital drift thickness map available online from the Ontario Geological Survey (OGS). The OGS map also provides information on soil type, which is correlated with peak amplitudes (A_{peak}) of response. H/V spectral shapes may be associated with four main soil categories, which in decreasing order of stiffness are: bedrock, till, sand/clay, and organic soil/fill. The value of A_{peak} increases as stiffness decreases. We model site response by defining a generic site amplification curve, which is dependent only on f_{peak} and soil category. The generic curve enables an estimate of site amplification to be made over the entire frequency band from 0.1 to 20 Hz, knowing just the site depth and type. These site amplification curves can be applied in the development of regional GMPEs, and in the construction of robust near-real-time IGMs.

Abstract ID: 33565

Final Number: S11A-06

Title: An ENA Empirical GMPE based on the NGA East Database and Intensity Observations

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Co-authors: Md. Nayeem Al Noman, , , ; Philip Ogweno, , ,

Abstract Body: We have developed an empirical GMPE for Eastern North America (ENA). Our GMPE is based on the two-stage regression approach of Joyner and Boore (1993, 1994). This approach provides both within event and between event variability along with event and site terms. Besides ground motion observations from the latest NGA East flatfile, we included ground motion observations from the 1976 M6.8 Gazli and 2001 M7.6 Bhuj earthquakes plus intensities converted to ground motion estimates for the M>6 ENA historical 1811-1812 New Madrid, 1886 Charleston SC, 1925 Charlevoix, and 1929 Grand Banks earthquakes. We fit linear regressions to median $\log_{10}$ ground motions vs. Modified Mercali Intensity (MMI). Community Internet intensity (CII) observations (Did You Feel It?) have been corrected to MMI using the approach suggested by Hough (2014). We have applied a magnitude correction based on residuals, which corrects for the effect of shifting source spectral corner frequency with magnitude. The magnitude correction (an increase in estimated ground motion with increasing magnitude) is more pronounced at longer periods, as expected. Magnitudes for historical events were taken from Cramer and Boyd (2014) for the 1811-1812 and 1886 M7 earthquakes and from Bent (1992, 1995) for the 1925 and 1929 earthquakes. Our empirical GMPEs are for 23 periods, including PGA and PGV. Empirical observations were restricted to mid-continent crustal regions, avoiding Gulf Coast and western US Q regions for both earthquakes and recording stations. Site conditions were modeled with a Vs30 term using NGA East provided Vs30 estimates at each site. The reference Vs30 is 760 m/s. Geometrical spreading is modeled by a single term due to the limited observations at distances less than 50 km. We included a magnitude-dependent geometrical spreading term to help model magnitude saturation at large magnitudes. Alternative terms are also provided for focal mechanism type (reverse, strike-slip, and undefined).

Abstract ID: 33287

Final Number: S12A-01

Title: Regionally-Adjustable Generic Ground-Motion Prediction Equation: Application to Central and Eastern North America

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Co-authors: Gail Marie Atkinson, University of Western Ontario, London, ON, Canada

Published Material: This study is currently under review in the Bulletin of the Seismological Society of America. The findings of this study has been previously presented in the NGA-East Workshop in October 2014, in Berkeley, CA.

Abstract Body: We develop a generic ground-motion prediction equation (GMPE) that can be adjusted for use in any region by modifying a few key model parameters. The basis of the GMPE is an equivalent point-source simulation model whose parameters have been calibrated to empirical data in California, in such a way as to determine the decoupled effects of basic source and attenuation parameters on ground motion amplitudes. We formulate the generic GMPE as a function of magnitude, distance, stress parameter, geometrical spreading rate and anelastic attenuation coefficient. This provides a fully adjustable predictive model, allowing users to calibrate its parameters using observed motions in the target region. We also include an empirical calibration factor to account for residual effects that are different and/or missing in simulations compared to observed motions in the target region. As an example application, we show how the generic GMPE can be adjusted for use in central and eastern North America (CENA), and calibrated with the NGA-East database. We provide median predictions of ground motions in CENA for average horizontal-component peak ground motions and 5%-damped pseudo spectral acceleration, for magnitudes **M**3 to **M**8 and distance up to 600 km.

Abstract ID: 33374

Final Number: S12A-02

Title: Estimation of Moment Magnitude and Stress Parameter from ShakeMap Ground-Motion Parameters for Real-Time Applications

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Abstract Body: For many applications ranging from real-time ShakeMaps to the development of ground-motion prediction equations (GMPEs) it is useful to have estimates of moment magnitude and stress parameter; these parameters control the low-frequency and high-frequency amplitudes of shaking, respectively. In many regions of low to moderate seismicity, such as eastern North America (ENA), estimates are required for the small to moderate events that happen several times per year. Such events may not be very damaging but rapid information on the amplitudes of shaking is required to inform the public, and government or regulatory officials as appropriate.

We describe a method to determine moment magnitude and stress parameter from ShakeMap ground motion parameters (5%-damped pseudo spectral acceleration [PSA] at 1s, peak ground acceleration [PGA] or PSA at 0.1s), suitable for regions having a sparse network, in the immediate aftermath of a small to moderate earthquake. The methodology is based on relating ShakeMap parameters to source and attenuation parameters within the context of a stochastic point-source model, in order to provide an event-specific GMPE that will reliably predict amplitudes across the region. An example application is provided for southern Ontario. Here, we initially develop a simulation-guided regional generic GMPE model based on the available database. Then, using the estimated regional attenuation and source parameters, we obtain simple equations to express ShakeMaps parameters as a function of magnitude and distance. Using these equations alongside ShakeMap parameters enable us to estimate moment magnitude and stress parameter in real-time, in order to provide reliable event-specific GMPEs. The event-specific GMPE are then used to provide robust, calibrated ShakeMaps that are fully consistent with ground-motion observations.

Abstract ID: 34452

Final Number: S12A-03

Title: Comparison of V_{s30} mapping and observed intensity distribution in the Greater Montreal

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Abstract Body:

Abstract ID: 34663

Final Number: S12A-04

Title: Scenario Shakemaps for Use in Earthquake Risk Studies in Montreal

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Co-authors: Gail Marie Atkinson, University of Western Ontario, London, ON, Canada; Luc Chouinard, McGill University, Beaconsfield, Canada; Philippe Rosset, McGill University, Montreal, QC, Canada; Kristy French Tiampo, University of Western Ontario, London, ON, Canada

Published Material: The findings of this study has already been submitted for publication in the Canadian Journal of Civil Engineering on 20-Nov-2014 and it is under review.

Abstract Body: Montreal ranks second after Vancouver among Canadian urban areas in terms of seismic risk. A recent research analysis estimated that, for a 2% in 50 years scenario event, roughly 5% of the building stock would be damaged; this might result in direct economic losses of around 1.5 billion dollars and projected casualties of 500 people injured or killed. In a different insurance industry study, total losses were estimated to be as much as $61 billion for the Quebec province in case of a larger earthquake scenario in the Saguenay area. Scenario studies to date have been based on primitive data for the soil conditions and limited consideration of likely event locations and ground motions; these parameter could greatly affect the outcome in a large event. We develop a set of scenario shakemaps for Montreal using forecasts of most-likely earthquake locations, combined with recent ground motion modeling validated with local recorded data and microzonation information on site amplification, to assess the expected motions for realistic scenario shaking. The target probability level for the scenarios is near the 2%/50 yr ground motions, as used for design of new structures in Montreal according to the National Building Code of Canada (NBCC 2010). The shakemaps provide the expected ground-shaking intensity distribution patterns by considering the occurrence of a scenario (a given magnitude event) at various likely locations in the region. The results of this study may be used as new input to improved seismic risk studies in this region.

Abstract ID: 35176

Final Number: S12A-05

Title: Seismic and Liquefaction Hazard Maps for the St. Louis Metropolitan Area

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Published Material: These results will also be reported at the April 2015 Seismological Society of America meeting in Pasadena, Calif.

Abstract Body: Seismic and liquefaction hazard maps, that include the effects of local geology, have been completed for the greater St. Louis urban area. Geological, geophysical, and geotechnical information for the 29 quadrangles of the study area were provided by the Illinois State Geological Survey, the Missouri Geological Survey, and the Missouri University of Science and Technology. This information includes maps of surface geology and bedrock depth, and reference shear-wave velocity profiles and liquefaction probability curves keyed to the surface geology. Maps were generated using the approach of Cramer et al. (2004, 2006, 2008, 2014), and were based on the 2014 update of the USGS national seismic hazard model (Petersen et al., 2014), including source models, attenuation relations, and weights. The seismic and liquefaction hazard

maps were developed on a 0.005 degree (500 m) grid for peak ground acceleration (PGA), and 0.1, 0.2, 0.3, 0.5, 1.0, and 2.0 s spectral acceleration (Sa). Liquefaction hazard maps are for Liquefaction Potential Index (LPI) values exceeding 5 and 12. Both probabilistic and scenario hazard maps have been created, with the probabilistic maps being generated using the fully probabilistic methodology of Cramer (2003, 2014) and Cramer et al. (2008). Scenario hazard maps include results for a repeat of a M7.5 earthquake on the northern segment of the New Madrid seismic zone and a hypothetical M5.8 earthquake beneath downtown St. Louis. Probabilistic seismic and liquefaction hazard maps show moderate (0.1 – 0.25 g PGA) shaking hazard and low (LPI > 5 below 30% probability for the uplands) to high (LPI > 5 above 60% for Missouri River flood plain) liquefaction hazard in the St. Louis area.

Abstract ID: 34029

Final Number: S14A-0334

Title: Sensitivity analysis of Eastern Canada High Resolution Seismic Hazard Maps to the Ground Motion Prediction Equations

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Abstract Body: Eastern Canada has been known as a region, where detailed source characteristics and wave propagation properties of particular active fault sources are generally unavailable. However, several generations of the source zones models, earthquake occurrence patterns and ground motion relations have been developed to quantify seismic hazard characteristics in the region. The variety of proposed models increases the resulting level of uncertainty and results in potential error in the decision making process, related policies and standards. As a result, there is a strong interest in the sensitivity analysis of hazard maps as they relate to the main input parameters for seismicity rates and ground motion prediction equations (GMPEs) in order of total possible uncertainty estimation. Atkinson et al. 2011 investigated the effect of seismicity models and new GMPEs on seismic hazard assessment for four Canadian cities and concluded that the selection of correct GMPEs model has an important effect on the resulting hazard assessment. Our motivation in this study is not a re-evaluation of seismic hazard in Canada, but is to expand the boundaries of the GMPEs sensitivity analysis. Here, three sets of representative GMPEs (the medium, low and high) developed by Atkinson, 2013 have been used as an input for ground motion estimation for eastern crustal, western crustal, interface, inslab and offshore events and all for B/C site conditions (Vs30=760 m/s). The sensitivity analysis performed with different sets of assumed weights for the low, medium and high equations of the representative GMPEs. The analysis is complicated by the fact that for high-resolution map calculations must be carried out on a large number of sites, a process requires powerful computational resources. Here, high-resolution hazard maps production in real-time are made possible using corrections in EqHaz1 and EqHaz2 Fortran source programs developed by Assatourians et al., 2012. These are compiled into system object libraries and used as IBM InfoSphere Streams operators to implement the base PSHA procedures and functions in the streaming environment and to overcome EqHaz limitations by pipelining. The number of records in the synthetic catalog are increased up to 10,000,000 records and number of sites for hazard maps are stepped up to 2,500,000 sites.

Abstract ID: 36373

Final Number: S14A-0335

Title: Modeling of Strong Motion Generation Areas of the 2011 Tohoku, Japan Earthquake using Modified Semi-Empirical Technique Incorporating Frequency Dependent Radiation pattern

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Published Material: Yes this kind of finding has been earlier published in Natural Hazards Journal. Still this is a further extended part of the workA. Joshi, Sandeep, Kamal (2014) Modeling of Strong Motion Generation Area of the 2011 Tohoku, Japan earthquake using Modified Semi-Empirical Technique. Nat Hazards 71:587-609.   Sandeep, A. Joshi, Kamal, Parveen Kumar, Ashvini Kumar (2014) Effect of frequency dependent radiation pattern in simulation of high frequency ground motion of Tohoku earthquake using modified semi empirical method. Nat Hazards 73:1499-1521This kind of work has already been selected for best poster award at Indian Geophysical Union held on 19-21 November 2014 at Kurukshetra University, Kurukshetra

Abstract Body: Abstract In the present work strong ground motion has been simulated using a modified semi-empirical technique, with frequency dependent radiation pattern model. Joshi et al. (2014) have modified the semi-empirical technique to incorporate the modeling of strong motion generation areas (SMGAs). A frequency dependent radiation pattern model is applied to simulate high frequency ground motion more precisely. Identified SMGAs (Kurahashi and Irikura 2012) of the 2011 Tohoku earthquake (M_w 9.0) were modeled using this modified technique. Records are simulated for both frequency dependent and constant radiation pattern function. Simulated records for both cases are compared with observed records in terms of peak ground acceleration and pseudo acceleration response spectra at different stations. Comparison of simulated and observed records in terms of root mean square error suggests that the method is capable of simulating record which matches in a wide frequency range for this earthquake and bears realistic appearance in terms of shape and strong motion parameters. The results confirm the efficacy and suitability of rupture model defined by five SMGAs for the developed modified technique.

Keywords Strong ground motion · semi-empirical · strong motion generation area. frequency dependent radiation pattern. 2011 Tohoku Earthquake

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Abstract ID: 35711

Final Number: S21A-01

Title: Assessing the Hazard of Increasing Earthquake Activity in the U.S. Midcontinent: A Short-Term Hazard Model for Natural and Induced Earthquakes

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Published Material: Some of the introductory material and initial models were presented at the Fall 2014 AGU meeting. This report will build on the previous work with new results and conclusions.

Abstract Body: The dramatic rise in earthquake activity in selected portions of the central U.S. since 2009 is suspected to be a consequence of industrial activities, principally injection of wastewater co-produced with oil and gas from tight formations. In Oklahoma alone, the earthquake rate in 2014 for M ≥ 3 exceeded the rate in 1970-2008 by more than a factor of 100. Oklahoma also experienced 15 earthquakes with MMI ≥ VI, as reported to the USGS DYFI website in 2014, compared with a century-long historical rate of MMI ≥ VI of less than twice per decade. Higher earthquake rates imply higher hazard, but how much higher? And for how long? We are adapting standard Probabilistic Seismic Hazard Analysis methodology to combine the contributions to hazard from natural and suspected induced earthquakes. Because the statistics of the two earthquake populations may be very different, it is necessary to treat them as separate contributions to hazard. Differences may include magnitude-frequency statistics, spatial extent of sources, clustering, focal depth, source parameters, maximum (or corner) magnitude, ground-motion prediction equations, and temporal variations in earthquake rate. Forecasting more than "last year's earthquakes" will require a deeper understanding of the physical processes and conditions that link human perturbations to the Earth system to its response in seismic events. A key challenge is to develop an operational earthquake forecasting capability that not only accounts for temporally varying activity rates, but also anticipates where induced earthquakes may either initiate or shut-off in response to changing industrial activities.

Abstract ID: 33740

Final Number: S21A-02

Title: Investigation of Induced Seismicity Related to the Development of Shale Gas in Northeast British Columbia and Northwest Territories, Canada

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Abstract Body: The majority of seismicity in British Columbia (BC) and Northwest Territories (NT) are related to tectonic processes along the western and northern margins of the North American continent. Since late 2006 when the shale gas development started in northeast BC, a clear change of pattern in background seismicity was observed, correlating with the practice of hydraulic fracturing (HF). To understand the physical relationship and the significance of seismic risk associated with induced seismicity, the Natural Resources Canada (NRCan) initiated the Induced Seismicity Research (ISR) in 2012. Collaborating with provincial partners and with contributions from both academia and industry, NRCan's ISR focused on enhancing seismic monitoring for major shale gas basins across Canada where the development has started or was imminent. Historical seismograms were re-examined to better calibrate the patterns of regional background seismicity for both pre- and post-HF eras. A detailed database of operation parameters, including both HF and wastewater reinjection, was compiled from reports collected by the BC Oil and Gas Commission. Our results confirm that the increased level of background seismicity in the Horn River Basin, northeast BC, was related to the expansion of local HF operation. Some earthquakes in the Montney Trend of BC were probably associated with wastewater disposal. A dense array was set up in the Norman Wells area to verify any change in local seismic pattern that might be related to a limited HF operation in early 2014. Preliminary analysis reveals that the new array has improved the detection of local earthquakes by a factor of 10 within a radius of 400 km. The higher resolution for small seismic events is critical to establishing a reference baseline should commercial development of shale gas occurs in the future. Collectively, these new observations provide more insight to the understanding of seismogenic processes associated with induced seismicity in a variety of different tectonic and geological settings.

Abstract ID: 34750

Final Number: S21A-03

Title: A catalog search for triggered seismicity in Canada and near fluid injection sites in Western Alberta using a match-filter approach with continuous waveform data.

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Abstract Body: Earthquakes can be triggered by transient stresses generated from passing seismic waves of other distant earthquakes. Here we look for triggered earthquakes in Canada following global mainshocks occurring from 2004 to present with $M_s > 6$, and depths < 100 km. We also require potential triggering mainshocks to have estimated ground motions > 2 cm/s (PGV) in Canada inferred from empirical ground motion regressions. We first search for triggering indicated by increases in cataloged seismicity. We use the NRCAN earthquake catalog data to calculate R-statistical and β-statistical values in 1°1° bins within a 9-day window before and after the mainshocks. While cataloged seismicity is generally low in Canada, the statistical analysis suggests triggering may occur near Vancouver Island, in the Charlevoix seismic zone, and in western Alberta. Based on the results of the catalog approach, we look for triggering near injection sites in Western Alberta (WA) area where seismic station coverage is dense. We search for triggered earthquakes using a match-filter approach on continuous waveform data from the TransAlta Monitoring Network (TD) in time windows surrounding three potential triggering mainshocks during the TD operation period: the 10/14/2014 M_s 7 Nicaragua earthquake, the 07/25/2014 M_s 6.1 southeast Alaska earthquake, and the 08/24/2014 M_s 6 earthquake off the coast of California. After removing the events with approximate M > 0 presumed related to hydrofracturing, preliminary results suggest remote triggering for the California mainshocks, with 119 vs. 336 earthquakes before and after the mainshocks with a 10-day window. We also observe noticeable increases in M > 1 earthquakes following the Nicaragua mainshock in a 24-hour window (0 vs. 5) and increases in M>0 earthquakes following the Alaska earthquake in a same 24-hour window(1 vs. 17), which may suggest triggering. The increased number of naturally triggered local earthquakes suggests that vigorous earthquake activity related to hydrofracturing may result from the local faults being in a critically stressed state.

Abstract ID: 33734

Final Number: S21A-04

Title: Hazards from Induced Seismicity: Crooked Lake Case Study

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Published Material: The study is submitted to the Seismological Research Letter on Oct 16, 2014 and it is under review.

Abstract Body: A case study of seismicity induced by hydraulic fracturing operations near Fox Creek, Alberta, is used to evaluate the extent to which the potential for induced seismicity at a site alters the pre-existing hazard from natural seismicity. We find that in low-to-moderate seismicity environments, the hazard from an induced-seismicity source, if one is activated in close proximity to a site, can greatly exceed the hazard from natural background seismicity at most probabilities of engineering interest, over a wide frequency range. The most important parameters in determining the induced-seismicity hazard are the activation probability, and the b value of the initiated sequence. Uncertainty in the value of the key input parameters to a hazard analysis implies large uncertainty (more than an order of magnitude) in the likelihood of strong shaking.

Abstract ID: 34510

Final Number: S21A-05

Title: Hydraulic fracturing of the Alberta Bakken and the Cardston Earthquake Swarm

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Abstract Body: More than 60 small earthquakes (ML 0.7–3.0) were detected from December 2011 to March 2012 north of Cardston, Alberta, an area with little evidence for previous seismic activity. The timing of these events correlate (>99.7% confidence) with hydraulic fracturing completions of the Mississippian aged Alberta Bakken at a nearby horizontal well. Unanimous waveform multiplicity within the swarm suggests that the events share a similar origin and source mechanism. This observation is corroborated by the strong focusing of hypocentres within the crystalline basement from robust, double-difference relocations. Furthermore, the presence of a pre-existing fault is confirmed via formation offset mapping and interpreted to be a Late Cretaceous extensional fault. The confirmation of this fault at depth provides a plausible means of rapid hydraulic communication from the fracturing interval into the crystalline basement. Results of our regional moment tensor inversion provide tectonic constraints which we compare to the regional structural geology and ambient stress regime. We conclude that the genesis of this earthquake swarm was likely due to increased pore pressure within the basement fault during fracturing stimulation.

Abstract ID: 34799

Final Number: S21A-06

Title: PASSIVE SEISMIC MONITORING OF CO_2 STORAGE SITES

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Published Material: Stork, AL, Verdon, JP & Kendall, JM 2015, 'The microseismic response at the In Salah Carbon Capture and Storage (CCS) site'. *International Journal of Greenhouse Gas Control*, vol 32., pp. 159-171Verdon, J, Kendall, J-M, White, DJ & Angus D 2011, 'Linking microseismic event observations with geomechanical models to minimise the risks of storing CO2 in geological formations'. *Earth and Planetary Science Letters*, vol 305., pp. 143 - 152

Abstract Body: Carbon capture and storage (CCS) projects capture carbon dioxide (CO_2) at large point-source producers, e.g. power stations, and subsequently sequester CO_2 in suitable geological formations for permanent storage. Passive seismic monitoring of such sites provides a useful diagnostic tool to understand the geomechanical response to CO_2 injection and to verify CO_2 remains at depth. It is vital that a monitoring programme provides warning of potential leaks at CCS sites. Here, we present and compare passive seismic monitoring results from three large-scale projects, Weyburn, In Salah and Aquistore, to highlight similarities and differences between sites and monitoring methods.

CO_2 injection at the Weyburn site is on-going since 2000 with >30 millions tons (Mt) sequestered; nearly 4 Mt of CO_2 were injected at In Salah between 2004 and 2011; and the Aquistore project is due to begin injection in early 2015. As expected, we have found that rates of microseismicity (small seismic events, generally with magnitudes < 0) increase with injection rate and the distribution of events correlates with the volume occupied by CO_2. However, rates of seismicity differ considerably between the In Salah and Weyburn sites. At In Salah >9000 events were detected 2009 – 2011 with moment magnitudes, M_w, up to 1.6, whereas at Weyburn only ~100 events were detected 2003 – 2007 with $-3.0<M_w<-1.0$. At both sites a small number of microseismic events occur in the overburden above the injection interval but we propose this is not caused by fluid migration or pore pressure changes in the overburden but by stress transfer. Anisotropy studies, using shear-wave splitting analysis, indicate that fractures sampled by the data have strikes consistent with observed pre-existing fracture sets, suggesting seismic activity occurs on pre-existing fractures.

These current and past CCS projects provide important learning opportunities to improve the design and effectiveness of future passive seismic deployments.

Abstract ID: 34647

Final Number: S22A-01

Title: Possibilities and Challenges for Mitigating Seismic Hazard from Earthquakes Induced by Disposal of Wastewater by Deep Injection

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Abstract Body: Within North America east of the Rocky Mountains, earthquakes induced by fluid-injection activities associated with oil and gas production account for much of the contemporary seismic hazard (e.g., Ellsworth, 2013). This component of hazard is mostly due to disposal by deep injection of co-produced wastewater. Only a small fraction of wastewater disposal operations induce earthquakes large enough to be felt because the injection target is most often a deep aquifer that can readily accept large volumes of injected liquid with little or no seismic response. The exceptions, as reported in various case histories (e.g., Horton, 2012), evidently occur if elevated pore pressure due to injection is transferred into the zone of a fault that is prone to slip seismically in the ambient stress field. This pore pressure transfer may occur where the fault intersects the aquifer or it may involve an intermediate high-permeability channel between the aquifer and the earthquake-prone fault, which is often located in the crystalline basement. Accordingly, one way to reduce the likelihood of inducing earthquakes large enough to be felt or damaging is to avoid fluid injection in the vicinity of faults that are prone to reactivation. Because these faults are rarely mapped beforehand, it is necessary to have seismic networks in place capable of detecting and locating earthquakes at low magnitude thresholds. Timely evidence of fault reactivation could be used to avoid inducing earthquakes of greater consequence. Traffic Light systems, which use seismic data to decide when injection operations need to be adjusted, have proven to be effective for short-term injection activities such as development of Enhanced Geothermal Systems. More research is needed, however, to find out if earthquake control based on early identification of fault reactivation is feasible for longer-term wastewater injection projects.

Abstract ID: 34396

Final Number: S22A-02

Title: Induced Aftershock Sequences and Swarms in Geothermal Systems

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Abstract Body: Many natural geothermal systems are associated with high seismic activity. This can be related to large scale injection of fluids to enhance geothermal recovery. Other factors, such as changes in the stress field and pore pressure, can also stimulate the occurrence of earthquakes. These systems are also prone to triggering of seismicity by the passage of seismic waves generated by large distant main shocks. In this particular study, we analyze clustering and triggering of seismicity at the Geysers geothermal field, California, due to the occurrence of relatively large local events as well as due to the occurrence of significant long distant main shocks. For the analysis we use the Northern California Earthquake Data Center Earthquake Catalog. The recent Mw 6.0 South Napa main shock triggered a ml 4.5 event and a subsequent swarm of seismic activity at The Geysers. We compare this sequence of events to several other earthquake sequences generated by local large events with magnitudes greater than 4.5 and sequences generated by several other long distant main shocks. We show that the rate of decay of the aftershock sequences generated by local large events in the first day after the main event follows the modified Omori law reasonably well. On the other hand, the swarms of activity triggered by large distant earthquakes cannot be described by the simple modified Omori law. In almost all cases the frequency-magnitude statistics of triggered sequences follow Gutenberg-Richter scaling to a good approximation with relatively large b-values. The analysis indicates that the seismicity triggered by relatively large local events can initiate sequences similar to regular aftershock sequences. In contrast, the distant main shocks trigger swarm like activity with faster decaying rates.

Abstract ID: 33571

Final Number: S22A-03

Title: Are ENA Potentially Induced Earthquakes Different from Natural Earthquakes?

Presenter/First Author: Chris H Cramer, University of Memphis, Memphis, TN

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Abstract Body: The question of whether induced earthquakes have significantly different source characteristics than naturally occurring earthquakes (NOE) is important if such a difference exists. I review the Brune stress parameter (stress drop) estimates from some recent potentially induced earthquakes (PIE). Transverse velocity Fourier spectra are examined for a corner-frequency peak, taking into account the possible presence of a neighboring spectral peak due to the strong surface waves from shallow events. Brune stress parameters for an assumed geometrical spreading of R^{-1} are estimated from observed magnitude and corner-frequency for each event. (An assumed geometrical spreading of $R^{-1.3}$ would yield a proportionally higher stress parameter as stated by Boore et al., 2010.) Atkinson and Boore (2006) found that the average ENA Brune stress parameter of this type to be 14 MPa. PIEs in Arkansas, Oklahoma, Texas, Kansas, and Ohio have Brune stress parameters ranging from 5 to 10 MPa. Shallow NOEs (depth less than 5 km) appear to have a similar range of Brune stress parameters. Ground motions for a given earthquake can be influenced by stress parameter and by crustal attenuation (Q). PIEs in Arkansas, Oklahoma, Texas, and Kansas are near a Q boundary at about 35N latitude between ENA mid-continental and Gulf Coast Q, which influences ground motions (and intensities) observed to the north differently than to the south. Justin Hollenback for the NGA East project at the PEER Center also shows that event terms from a mixed effects analysis for the NGA East database are similar for PIEs and shallow NOEs and lower than deeper NOEs. Thus both a Brune stress parameter analysis and an event term analysis (allowing for regional Q) show that ENA PIEs are similar to shallow NOEs and lower for deeper NOEs and hence may not be distinct from shallow NOEs.

Abstract ID: 33715

Final Number: S22A-04

Title: Ground Motions from Three Recent Earthquakes in Western Alberta and Northeastern British Columbia and their Implications for Induced-Seismicity Hazard in Eastern Regions

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Co-authors: Karen Assatourians, University of Western Ontario, London, ON, Canada; Burns Cheadle, , , ; Daniel Wesley Greig, Nanometrics Inc, Kanata, ON, Canada

Published Material: Findings are review for an article in Seism.Res.L.

Abstract Body: A key issue in the assessment of hazard due to induced seismicity from fluid injection activity is to determine the potential ground motions. Though waste water disposal typically receives the most attention, hydraulic fracturing is increasingly recognized as a significant source of seismic hazard. We present an analysis of the ground motions from the three largest recent events that occurred along the deformation front marking the western boundary of the stable Canadian craton: a **M**4.0 and a **M**4.2 near Fort St. John, British Columbia, and a **M**3.9 near Rocky Mountain House, Alberta. The two Fort St. John events were likely induced by hydraulic fracturing activities in the region. Though the cause of the Rocky Mountain House event remains unclear, it is of interest because it is of similar magnitude to the other events and had significant consequences to the public. The event triggered an automatic shut-down of a nearby gas plant, and a subsequent precautionary flaring of gas; moreover several hundred people were without power for a prolonged period. We examine the ground motions and intensities for these events. We find that ground motions at frequencies up to about 2 Hz are in agreement with corresponding observations for events in California and with the predictions of applicable empirical GMPEs. However, high frequency ground motions appear to be consistently lower than those predicted, suggesting that these events may be associated with a low stress drop; we believe that this is likely a focal depth effect, which may be a mitigating factor that limits high-frequency ground motions from induced events.

Our preliminary findings suggest that moderate induced events (**M**4 to 5) may be damaging to nearby infrastructure, because the shallow focal depth may result in localized strong ground motions to which some infrastructure may be vulnerable; this is a particular concern in low-to-moderate seismicity regions because seismic design measures for structures in these regions may be minimal. Our results highlight the importance of seismic monitoring in the immediate vicinity of fluid injection sites (both waste water disposal and hydraulic fracturing) in order to accurately characterize injection induced seismicity and ultimately mitigate the associated risk.

Abstract ID: 34491

Final Number: S22A-06

Title: Source and attenuation parameters for induced seismicity in the Crooked Lake Region of Alberta

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Abstract Body: From December 2013 to present an ongoing sequence of over 70 small earthquakes (M_w 2-3.5) was detected in the Crooked Lake region, near Fox Creek, Alberta. The event hypocenters and timing correspond closely to hydraulic fracture treatments of oil and gas production wells in the immediate vicinity, suggesting a causal relationship. The events thus provide a unique opportunity to study the seismological characteristics of earthquakes triggered by hydraulic fracturing in this region. We obtain all available seismographic data from Alberta and B.C., including data from the TransAlta/Nanometrics, GSC, CRANE and AGS stations, to obtain a rich library of waveforms at distances from a few tens of km to a few hundred km. All waveforms are processed to obtain instrument-corrected Fourier and response spectra. We compare the moment estimates from inversion to those obtained using a new algorithm for moment magnitude estimation from regional seismographic ground-motion. Distance cutoffs are established for magnitude ranges in order to reduce noise effects of distant stations while maintaining accuracy in the magnitude estimation. We present our results on ground motion attenuation and source spectra for this sequence of events relative to natural earthquakes of similar size.

Abstract ID: 34460

Final Number: S22A-07

Title: Development of a Ground Motion Prediction Method for Carbon Dioxide Injection Induced Earthquakes

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Abstract Body: The process of injecting carbon dioxide into geologic reservoirs as a means of carbon sequestration is believed to increase the risk of induced seismicity in the region of injection. An important component in characterizing induced seismicity risk is the development of application-specific ground motion prediction (GMP) methods. A method is developed for a proposed injection site utilizing the induced seismicity GMP equations of Douglas et al., 2013, and incorporating site-specific adjustments. Development of the GMP model focuses upon situations in which there is very little in-situ data from the proposed site of injection. The resultant model can estimate ground motion response for induced events between M_w 1.0-4.0 at epicentral distances of 1-50 km, periods of ground motion between 0.01 and 0.5 seconds, and Vs_{30} between 100 and 2000 m/s. A statistical consideration of input uncertainties for an uncharacterized site demonstrates that the total uncertainty of the method is large compared to regional-specific GMP models. However, analysis considering the reduction of input uncertainty through in-situ data collection indicates that the total uncertainty of the method could be reduced to levels appropriate for engineering applications, including probabilistic seismic hazard assessment.

Abstract ID: 33108

Final Number: S24A-0336

Title: Analysis of Microseismic Events during a Multi-stage Hydraulic Stimulation Experiment at a Shale Gas Reservoir

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Abstract Body: Microseismic events are a useful indicator of fluid migration associated with hydraulic fracturing and thus monitoring of microseismic events has made significant contributions in understanding the geometry of fractures associated with hydraulic stimulation. The key is to track the creation of fractures during and after the stimulation. One of the most important steps in determining the geometry is to detect and accurately locate microseismic events. In this study, we process and analyze 176 events generated during a multi-stage stimulation experiment at a shale gas reservoir in Saudi Arabia. The monitoring array includes a downhole array of 12- 3C sensors that were deployed in a vertical well with a 100 ft level spacing. There were 12 stages of stimulation and we only focus on the events located during the first 6 stages. Our aim was to analyze microseismic events to better understand fracture growth and fracture directions. This work was conducted as part of a larger study in developing a methodology for generating dynamic, high-resolution seismic and geomechanical models of shale reservoirs before, during, and after stimulation, and interpreting the models in terms of fracture susceptibility and fracture dynamics. Preliminary results show that the data signal to noise ratio is satisfactory for locating local magnitude (M_L) events up to -4.0 during the early stages. We observed events with M_L >+1.0 to a maximum of +1.97 near the injection well in the latter stages. During the initial stages, most events are scattered near the injection well, however, in later stages, they migrated westerly towards the monitoring well and show increased vertical distribution. Additional processing is currently underway to precisely relocate some selected events and estimate the focal mechanism as well as to carry out a magnitude analysis. We believe that this study will provide additional information needed to identify fluid migration associated with the stimulation.

Abstract ID: 33842

Final Number: S24A-0337

Title: Compilation of Composite Alberta Seismicity Catalog (CASC) for Earthquake Hazard from Induced Seismicity in Alberta

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Co-authors: Azadeh Fereidoni, University of Western Ontario, London, ON, Canada; Gail Marie Atkinson, University of Western Ontario, London, ON, Canada

Abstract Body: The compilation of a comprehensive, high-quality and easy-to-use catalog of earthquake events in Alberta and the surrounding region is a fundamental step for the evaluation of the impact of industrial activity on the seismicity in the region. For this purpose, we have developed the Composite Alberta Seismicity Catalog (CASC) by combining the information from several national and international data sources: TransAlta/Nanometrics Network (NMX catalog), the Geological Survey of Canada (GSC catalog), the Alberta Geological Survey (AGS catalog), the Canadian Composite Seismicity Catalog (CCSC), and the Advanced National Seismic System catalog from the US Geological Survey (ANSS catalog). The CASC catalog covers the region of 48°- 59° N latitude, 110°- 121° W longitude, and currently includes events through December 2014. For each event, the CASC lists the occurrence time in Universal Coordinate Time (UTC), hypocentral location, the set of all available magnitude types, and an assigned preferred magnitude. We applied a semi-automatic procedure to identify and remove duplicate information from the alternative source catalogs, while retaining information on alternative estimates of locations and magnitudes from different sources. The magnitudes of all events to the end of 2013 have been converted to moment magnitude where required (i.e. if no estimate of moment magnitude is available in any of the original sources), using the empirical equations in Fereidoni et al (2012). The output files for pre-2014 and post-2014 events are available for download at http://www.inducedseismicity.ca, along with their documentations. Updated files will be available on the website on monthly basis. This compiled catalog provides a useful baseline for studying earthquake hazard due to the induced seismicity in Alberta.

Abstract ID: 34576

Final Number: S24A-0338

Title: 3D Finite Element Modeling of Slip on a Well-Oriented, Critically Stressed Fault due to Pore Pressure Increase

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Abstract Body: Simulation of activation of slip on a pre-existing fault due to a perturbation in pore pressure is important for characterizing and understanding potential induced-seismicity hazards. We present a 3D model using a widely used finite-element package, ABAQUS, to simulate activation of slip on a pre-existing fault due to an imposed perturbation in pore pressure on a subregion of the fault. The model inputs are 3 initial principal background stresses, elastic properties of the medium, coefficient of friction and geometry of the fault. Initial stresses are assigned according to Mohr Coulomb theory based on the assumption that the crust is in a critically stressed state. Our proposed method is shown to be stable, consistent with displacement calculations using Okada's analytical formula, and predicts rupture characteristics and stress changes that are generally compatible with observed values. Our results indicate that the fault rupture area is generally larger than the initially perturbed area; moreover, the rupture area, and thus the earthquake magnitude, increases with the size of the perturbed area, irrespective of the overall fault dimensions. For one realization, our model predicts that a 2km by 2km area perturbed by a relatively small pore pressure increase results in a magnitude 4.4 earthquake with 1 MPa (10 bar) of shear stress drop. For a particular fault geometry, stress state and perturbation parameters, we interpret our calculations to constitute an upper limit for earthquake magnitude, as the equivalent stress release could be achieved with a sequence of smaller events.

Abstract ID: 33987

Final Number: S24A-0339

Title: Identifying quarry blast events in seismicity catalogs based on the ground motion parameters

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Abstract Body: Discrimination of quarry and mine blasts from natural seismicity or induced seismicity is a preliminary and fundamental step in compiling a seismicity catalog. It is particularly challenging to discriminate blasts from potentially-induced events, as both induced events and blasts will be characterized by shallow depths. Such discrimination can be done by examining waveforms and seeking information on nearby quarry operations. However, such an approach is tedious and time-consuming, requiring manual review by a seismologist. Using purely statistical approaches is more efficient, but may not be as reliable, as some natural tectonic or induced events may be falsely discriminated as blasts, while some blasts may not be properly identified. In this study, we investigate whether we can identify quarry blasts by an automated analysis of index ground motion parameters. We hypothesize that ground motion parameters from blasts may have definitive characteristics that could be used in automated discrimination procedures. To test the hypothesis, we analyze the data from the TransAlta/Nanometrics seismic network in Alberta, Canada. We focus on the parameters of peak ground acceleration (PGA), peak ground velocity (PGV), pseudo-spectral acceleration (PSA) at different frequencies, and their vertical to horizontal-component ratios. These ground motion parameters are commonly calculated in routine, automated data analysis; therefore, they can be used in a process that automatically identifies quarry blasts. Having a reliable automated process that is based on the spectral characteristics is very useful for the compilation of reliable seismicity catalogs in near-real time.

Abstract ID: 34041

Final Number: S24A-0340

Title: Statistical Analysis of Seismicity in Alberta

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Abstract Body: In western Canada, hydraulic fracturing treatments as well as extended fluid injection operations have been linked to the generation of seismicity in some areas. An increase in seismographic stations over the last few years enables improved modeling of induced seismicity processes.

Characterization of the statistics of these events is vital to developing a predictive understanding of induced seismicity, which is ultimately required for the mitigation of future induced seismicity.

Using a compiled earthquake catalog (www.inducedseismicity.ca), we perform a statistical analysis to characterize the frequency-magnitude distributions of seismicity across western Alberta, from a regional perspective. We also look more closely at the seismicity distributions within concentrated areas where clusters of activity in time and/or space are evident. The average b-value (the slope of the Gutenberg-Richter relation) is determined for each chosen area, using the Maximum Likelihood Method. We map the b-value variation spatio-temporally. We consider alternative statistical models to describe the observed distributions, including the Poisson process and an ETAS (Epidemic Type Aftershock Sequence) model. We seek preliminary correlations between the properties of the seismicity distributions and industrial activities that may have induced them.

Abstract ID: 35657

Final Number: S24A-0341

Title: Induced earthquakes associated with the Haynesville shale play identified near Bienville Parish, Louisiana in 2011

Presenter/First Author: Jacob I Walter, University of Texas at Austin, Austin, TX

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Co-authors: Cliff Frohlich, Univ Texas, Austin, TX; Julia Gale, University of Texas at Austin, Austin, TX; Peter Dotray, , ,

Abstract Body: In the last decade, incidences of increased felt seismicity throughout the central United States have been correlated with wastewater disposal to support hydrofracturing operations. However, the relatively few incidences of induced seismicity compared to the number of operating injection wells over different regions is rather surprising. Thus, further investigation and positive identification of incidents of induced seismicity is needed. We focus an investigation of recent seismicity across the broad geographic region of the Haynesville shale play, which encompasses parts of eastern Texas and northwestern Louisiana. We utilize temporary (~2 years) deployments of seismographs during the USArray Transportable Array experiment and analyze seismicity from February 2010 through the end of 2012. In addition to generating a seismicity catalog through standard detection methodologies, we utilize a matched-filter technique whose widespread use in seismology is able to detect potential missing earthquakes within continuous seismograms. We identify many earthquakes in eastern Texas and Louisiana that had not been previously identified. While some earthquakes exist outside two distinct zones, most seismicity is confined to zones near Timpson, in east Texas, and Bienville Parish, in northwestern Louisiana. The Timpson sequence has been studied and discussed extensively by Frohlich et al. (2014). In Bienville Parish, a total of 8 earthquakes between magnitudes 1-2.4 occurred over just a few months (August-October 2011). Further, during this activity a number of the smaller magnitude earthquakes occur without a preceding larger event, which is consistent with classification as a seismic swarm. We are currently investigating the environmental conditions (i.e. injection/production values) associated with the Bienville Parish sequence and will present our findings at the meeting. Regulatory records indicate the existence of 51 active injection wells in Bienville Parish, though the data is inconsistently reported and appears to be missing for all wells prior to 2012. We are currently investigating this issue. This work highlights the continued need for investments in monitoring seismicity in areas of active oil and gas extraction.

Abstract ID: 35726

Final Number: S24A-0342

Title: *Focal Mechanism Solutions for Earthquakes in Eastern Canada and Alberta Using the Generalized Cut and Paste (gCAP) Method*

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Abstract Body: Earthquake focal mechanism solutions (FMSs) provide information on the fracture orientation and the ambient stress field under which seismic ruptures take place. In this study, we first applied the generalized Cut and Paste (gCAP) method (Zhu and Helmberger, 1996) to several recent earthquakes in the Charlevoix Seismic Zone (CSZ) and the Western Quebec Seismic Zone (WQSZ). One attribute of the gCAP method is that it can invert the five phases (two P and three S phases) independently, increasing the weight of P waveforms for the overall inversion and decreasing the influence of earthquake location. Using waveform recordings of high signal-to-noise ratio from a combined 11 CNSN and Earthscope Transportable Array stations in the gCAP, we found the May 17th, 2013, Ladysmith earthquake in the WQSZ was a reverse-faulting event on a high-angle fault, with Mw=4.5 and depth at 12 km (variance reduction of 85.6). Our result is consistent with the FMS determined by another study using the inversion of long-period Rayleigh waves from more distant stations (Ma and Audet, 2014).

Next, we will apply gCAP in the source characterization of induced seismicity from hydraulic fracturing operations in Alberta. We will focus specifically on the Rocky Mountain House (RMH) cluster in August 2014, which includes a magnitude 4.3 event on August 9th that was possibly induced by hydrofracturing. We will also use the USGS Coulomb software to calculate the local stress field perturbations due to injection. By 1) comparing the RMH cluster focal mechanisms to earthquakes duringperiods without injection in the same regionand 2) quantitatively evaluating the spatial correlation in RMH seismicity and Coulomb stress change, we will work toward clarifying the relationship between the RMH seismicity sequence and hydraulic fracturing activity.

Abstract ID: 35878

Final Number: S24A-0343

Title: Modified Fibre-Bundle Model to Simulate Induced Seismicity

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Abstract Body: An increase in the number of earthquakes in the last ten years or so has been linked to human activity in areas of oil and gas production in the Midwestern United States. This induced seismicity has raised public concerns over the safety of operations of energy-related activities such as wastewater disposal and hydraulic fracturing. Because of the economic effect that the extraction of oil and gas can provide to regions rich in these resources, there has been a significant amount of interest and investment put into these types of operations in Alberta. However, an increased number of earthquakes, including those of larger

magnitude, could be problematic when considering critical infrastructure such as industrial facilities, power plants, dams, etc. located in these regions. Here we apply a modified version of the fibre-bundle model to simulate the process of failure leading to an earthquake due to induced seismicity. This model has been successful in simulating the failure processes in various applications, including earthquakes, damage mechanics models, communication networks, and traffic systems. The fibre-bundle model represents a solid material as a collection of fibres in a bundle, similar to cables composed of intertwined wires. An applied stress is distributed to each fibre within a bundle. The failure of these fibres over time provides valuable insights into the failure of solid materials. In the proposed model the interevent times and frequency-magnitude statistics of the model earthquakes are computed over multiple simulations. The model couples the standard fibre bundle with a fluid that is introduced and diffused into the system and is shown to impact earthquake statistics due to the lowering of the critical thresholds of the fibres exposed to the fluid. The resulting change in statistics observed helps to highlight the effect of decreasing the effective stress within the rock and how this relates to induced seismicity.

Abstract ID: 36669

Final Number: S24A-0344

Title: Slip Tendency Analysis and Risk of Induced Seismicity

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Abstract Body: The correlation between unexpected, presumed induced, seismic activity and nearby hydraulic fracturing and its commonly associated water disposal has not gone unnoticed. Elevated pore fluid pressure is usually considered to be the cause of this induced seismicity, triggered by decreased stability (increase in slip tendency) on pre-existing faults and fractures as pore fluid pressure rises. Most active faults experience high slip tendency under present-day stress, and cases of induced seismicity can be explained by increased slip tendency driven by increased pore pressure. Felt earthquakes typically have magnitudes greater than about 2.5, and damaging earthquakes have magnitudes higher than this. Such events can only occur on relatively large slip surfaces, implying that a well-oriented, potentially detectable, fault would need to exist within the rock volume prior to the increase in pore fluid pressure responsible for inducing slip. A well-conducted geological investigation of the proposed site of fluid injection can provide an assessment of existing geologic structures, rock permeability characteristics, and ambient stress states. Combining these into a geologic model and simulating the proposed fluid injection conditions provides a risk evaluation of induced seismicity. Our approach to this simulation uses slip tendency analysis coupled with an anisotropic effective permeability tensor and analytical well hydraulics models provides an alternative to complex numerical models, and provides sufficiently rapid feedback to test a wide range of scenarios. Thus far our results indicate that the most significant variables are the threshold slip tendency at which a fault will slip, and complex permeability anisotropies affecting the pressure distribution within the rock mass.

Abstract ID: 36670

Final Number: S24A-0345

Title: Reservoir-Triggered Seismicity in the Canadian Shield as an Analogue to the Activity Induced by the Deep Injection of Wastewater

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Published Material: Because I will present an overview of what we have learned on Reservoir-Triggered Seismicity in Canada, I will refer to some previously published papers on the topic.

Abstract Body: There are numerous examples of seismicity induced by wastewater injection. Although the injection of fluids is made within Palaeozoic sedimentary layers, it appears that most injection-induced earthquakes occur along pre-existing faults of the Precambrian basement. In these areas of deep injection, little is known about the distribution of Precambrian faults and their susceptibility to reactivation when subjected to an increase in pore-fluid pressure. An interesting analogue is the impoundment of large hydro-electric reservoirs that triggers earthquakes in the Canadian Shield.

In the Canadian Shield, the Precambrian basement is found beneath every hydro-electric reservoir and lineaments and faults are clearly visible in remote sensing imagery. The history of reservoir-triggered seismicity (RTS) can help define some characteristics of fault reactivation. Out of the tens of reservoirs with water depth greater than 50 m, only a small proportion caused RTS, similar to the very few deep wells that led to seismicity. Also, RTS does not necessarily occur in the deepest reservoirs. For example, the Manic-5 reservoir (the largest in terms of volume and depth; so large that it is visible from space), has not led to RTS.

Lessons learned from four decades of RTS in the Canadian Shield are: 1) Although 50 m of water depth appears to be the minimum, one cannot predict the likelihood of RTS for greater depth. 2) Although the increase in pore-fluid pressure at the base of the reservoir can exceed 1 Mpa; this does not necessarily translate into RTS. 3) Prominent regional-scale faults are not necessarily those reactivated. 4) The few meters of seasonal water level variations are not sufficient to create RTS. 5) RTS is generally within a few km of the reservoir shoreline. 6) Prior to the 1980’s, it is possible that RTS cases with earthquakes of magnitude less than 3 were not detected due to poor monitoring.

Abstract ID: 36786

Final Number: S24A-0346

Title: Characteristics of the Earthquake Activity in Southeast New Brunswick, an Area With Shale Gas Potential.

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Co-authors: Denis Lavoie, , , ; Shutian Ma, Carleton University, Ottawa, Canada; Kenneth B Burke, Retired, Washington, DC; Ian D Bastow, Imperial College London, London, United Kingdom

Published Material: I have presented some preliminary results at the European Seismological Commission Meeting last September. Since then, much progress has been done in the data acquisition and analysis. The results have not been published yet, but they will be submitted to the Seismological Research Letters for a special number on Induced seismicity.

Abstract Body: This project aims at defining the regional natural seismicity of the Moncton and Sussex sub-basins of southern New-Brunswick prior to an eventual full-scale hydraulic fracturing program in this area. This project

gives us the opportunity to define some of the characteristics of the local earthquakes.

New Brunswick is a region of moderate seismicity. From 1764 to 1980, only five events have felt area magnitudes in the 5.4-6.0 range; two in the Central Highlands, two in the Passamaquoddy Bay region and one near Moncton (1855; magnitude 5.4). After 1980, earthquake activity has been monitored by the Canadian National Seismograph Network (CNSN) which provides earthquake location completeness to slightly above magnitude (mN) 2.0. Since 1980, the strongest earthquakes recorded in the sedimentary sub-basins have been two mN 3.6 events, both located just to the southwest of Moncton. A study helped define the depth distribution of earthquakes in SE NB using conversional and regional depth phase modeling (rdpm) methods. A velocity inversion was also performed.

To better monitor the Sussex Basin area, five additional seismographs with broadband sensors were installed (one in 2012 and four in 2013) to complement the permanent CNSN station LMN. Thanks to these additional stations, the area is currently monitored by a dense six-station seismograph network that can improve the monitoring of the background seismicity and allows for the calculation of focal depths within the array. Since 2010, only four seismic events in the Sussex Basin were recorded but the long period between its occurrence and hydraulic fracturing at McCully field (almost two years) makes a connection unlikely. Thanks to the new network, numerous small earthquakes have been detected in the surroundings.

Abstract ID: 33965

Final Number: S31A-01

Title: Structural and hydrologic controls on subduction zone slow earthquakes

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Published Material: These findings were reported separately in various conferences (e.g., SSA 2014, GSA 2013, AGU 2011). This presentation will be a summary of recent results published in various papers.

Abstract Body: Recent discoveries of slow slip events that recur at intervals of <6 to >24 months (episodic tremor and slip, or ETS) on subduction zone thrust fault have elucidated a down-dip transition in slip behavior from frictionally-controlled slip to continuous plastic creep. In this presentation I review seismic evidence for the role of fluids on the seismogenic behaviour of slow earthquakes. In the slow slip region there is evidence for subducting low-velocity channel with extremely high P-to-S velocity ratio (Vp/Vs) interpreted to manifest elevated pore-fluid pressures generated through the release of water from pro-grade metamorphic dehydration reactions within the subducting oceanic crust. Elevated pore pressures weaken the fault and allow slip to occur at low differential stress. Accordingly, the plate interface likely represents a low-permeability boundary that controls vertical migration of fluids into the overlying crust. Direct evidence of factors controlling the variability in recurrence times is more elusive. We compile seismic data from subduction zone forearcs exhibiting recurring slow earthquakes and show that the average Vp/Vs of the overlying forearc crust ranges between 1.6 to 2.0 and is linearly related with the average recurrence time of slow earthquakes. In northern Cascadia, forearc Vp/Vs values decrease with increasing depth of the plate interface and with decreasing tremor-episode recurrence intervals. Low Vp/Vs values require significant addition of quartz in a dominantly mafic forearc environment. We propose that variable silica enrichment by 5-15% from slab-derived fluids and upward mineralization in quartz veins can explain the range of observed Vp/Vs values as well as the downdip decrease in Vp/Vs. The solubility of silica depends on temperature, and deposition prevails near the base of the forearc crust. We further propose that the strong temperature dependence of healing and permeability reduction in silica-rich fault gouge controls overpressure development and low effective fault-normal stress, and therefore recurrence times of slow slip. Our results imply that temperature-dependent silica deposition, permeability reduction, and overpressure development play an important role in controlling slow earthquake behavior.

Abstract ID: 35096

Final Number: S31A-02

Title: Tectonic Tremor observations in Guerrero, Mexico and how SSE strain field modeling including pore fluid evolution explain the observations

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Published Material: The observations have been partly published in the following publication: Frank, W., N. Shapiro, A. Husker, V. Kostoglodov, A. Romanenko, M. Campillo (2014), Using systematically characterized low-frequency earthquakes as a fault probe in Guerrero, Mexico, *J. Geophys. Res.*, *119*, 7686–7700, doi:10.1029/ 2014JB011457.The modeling will be presented in the SSA meeting in April.This presentation in Montreal will be the first of the two together.

Abstract Body: Tectonic tremor (TT) in Mexico has a complicated behavior. All tremors occur close to the plate interface near 40 km depth. The area of TT activity is divided into 3 zones. The transient zone located ~130 km – 165 km from the trench. The buffer zone, which has very little TT and is located ~165 km – 190 km from the trench. The Sweet Spot (~190 km – 245 km) has the overwhelming majority of TT. Previous studies have shown near continuous TT within the Sweet Spot with large bursts of activity about 3 - 5 times a year. Low frequency earthquake (LFE) studies show that during a burst LFE streaks are seen in the Sweet Spot that travel trench perpendicular (10's km/hr). After several days LFE's are found within the transient zone, however they do not appear to streak or be related to the streaks in the other zones. These bursts correlate with small slip seen on the GPS record and are considered small, short-term slow slip events (small SSE). The Sweet Spot also has a near continuous amount of smaller bursts that do not streak, do not cross into the buffer zone and do not provoke LFE's in the transient zone. The large, long-term slow slip events (SSE) that occur approximately every 4 years in Guerrero provoke a very large number of TT bursts. The LFE's farthest from the trench show no difference in their rate during the majority of the SSE. The closer the LFE's are to the trench the more they are found to occur in separate bursts, which suggests that they are more "stick-slipy". In the last stage of the SSE, the number of LFE's declines dramatically with the greater the decline the further the distance from the trench. Poroelastic modeling of fluid transport during the large SSE shows that fluid migrate toward the Sweet Spot with maximum velocities of ~10^{-3} km/day, which is more than 3 orders of magnitude slower than all of the LFE/TT migration speeds mentioned above suggesting that fluid transport cannot explain these observations. However, Coulomb Failure Stresses due to the SSE strain field including pore pressure evolution (through the effective stresses) are consistent with the time-dependent occurrence frequency of LFEs during the large SSE. A small SSE strain field could potentially produce the smaller

SSE/TT episode observations that fluid migration cannot explain due to the wildly varying TT time scales and velocities.

Abstract ID: 35681

Final Number: S31A-03

Title: Constraints on Slab Morphology in Southwest Japan from Low Frequency Earthquakes

Presenter/First Author: Xuejun Han, University of British Columbia, Vancouver,

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Abstract Body: Slab morphology below 20 km depth in southwest Japan has been previously mapped using receiver functions and double-difference seismic tomography where a low-Vs, high-Vp/Vs layer is associated with the subducting oceanic crust. Low frequency earthquakes associated with deep tectonic tremor afford an alternative and more direct means of mapping depth to top of plate in the depth range of 35-45 km depth range as these events are usually inferred to represent shear slip on the plate interface. We are compiling catalogues of LFE detections and LFE templates along the Nankai subduction zone from Kyushu east to the Tokai district using waveform data obtained from multiple seismograph networks in southwest Japan. The improved signal to noise ratio of LFE templates over individual LFE detections enables precise measurement of both P and S wave times and estimation of accurate hypocentral depths. We will present a preliminary map of plate depth contours between 35-45 km depth for SW Japan from LFE templates for comparison with estimates based on tomographic and receiver function imaging of the low velocity layer. This comparison should enable insight into the spatio-structural relation between regular seismicity, slow earthquakes and the subducting oceanic plate.

Abstract ID: 34459

Final Number: S31A-04

Title: Interfacial controls on glacier stick-slip rupture dynamics and implications for slow earthquakes

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Published Material: Half of the material was recently published this month as Walter, J. I., I. Svelitsky, J. Fineberg, S. Tulaczyk, E. E. Brodsky, C. G. Barcheck, and S. P. Carter (2015), Rupture speed dependence on initial stress profiles: Insights from glacier and laboratory stick-slip, Earth and Planet. Sci. Lett., 411: 112-120, http://dx.doi.org/10.1016/j.epsl.214.11.025.

Abstract Body: Slow slip events are now well-established in natural faults occurring under a myriad of physical conditions, though the processes controlling slow rupture remain poorly understood. The Whillans Ice Plain provides a window into these processes through bi-daily stick-slip seismic events that displace an ice mass over 100 km long with a variety of rupture speeds observed at a single location (e.g. Bindschadler et al., 2003). During periods between fast slip events, the ice flows downhill at a steady rate of less than 0.001 m/min, then suddenly increases its speed by more than an order of magnitude at tidal periods, slipping up to ~0.5 m in ~30 min. Typically individual rupture fronts initiate at two distinct nucleation regions that vary with the tide (Winberry et al., 2009). Events occurring during high tide have an average rupture speed (when averaged across the Ice Plain) that is faster than low tide events. Though, counter-intuitively, the low tide events tend to have significantly higher initial rupture speeds. We attribute this behavior to local stress configurations that are spatially and temporally heterogeneous and utilize laboratory measurements of stick-slip sliding on plastic blocks to mimic the WIP behavior (Walter et al., 2015). Basal interfacial stresses are known to control rupture speed in numerous laboratory analog experiments. We hypothesize a similar control on the WIP behavior and show that laboratory experiments can explain most of the rupture speed behavior. In addition, we show evidence that nucleation of the events is sensitive to triggering from distant earthquakes. If we simplify our notion of slow slip to events that rupture under the same conditions as earthquakes but at significantly reduced rupture velocities, then the glacier events provide a path forward for understanding slow slip on natural faults. The central conclusion of our studies is that the observed systematic variations in rupture velocities are governed by the applied stresses and may provide insight into some slow slip source processes.

Abstract ID: 34905

Final Number: S31A-05

Title: Mechanism of spontaneous and triggered continental shallow creep events

Presenter/First Author: Meng Wei, University of Rhode Island Narragansett Bay, Narragansett, RI

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Co-authors: Yajing Liu, McGill University, Montreal, QC, Canada; Yoshihiro Kaneko, GNS Science, Lower Hutt, New Zealand; Jeffrey Joseph McGuire, Woods Hole Oceanographic Ins, Woods Hole, MA; Roger G Bilham, University of Colorado, Boulder, CO

Published Material: First half of the presentation has been published.Wei, M., Y. Kaneko, Y. Liu, and J. McGuire (2013), Episodic fault creep events in California controlled by shallow frictional heterogeneity, Nature Geoscience 6, 566–570, doi:10.1038/ngeo1835.

Abstract Body: Slip on tectonic faults take place over a wide range of spatial and temporal scales as earthquakes, continuous aseismic creep, or episodic creep events. Shallow creep events on continental strike-slip faults can occur spontaneously or being triggered by nearby earthquakes. Despite more than five decades of observations, the mechanism of shallow creep events and their implications for seismic hazard are still not fully understood.

To understand the mechanism of spontaneous and triggered creep events, we developed a physics-based numerical model to simulate shallow creep events on a strike-slip fault with rate- and state-dependent frictional properties. We show that a widely used synoptic model cannot explain the wide variability in observed shallow creep characteristics on strike-slip faults in California. Rather, a frictionally unstable layer embedded in the shallow stable zone is required to match the geodetic observations of the creep behavior. We then introduced static and dynamic stress perturbations to this theoretical fault model, to further investigate the observed behavior of triggered creep events. We find that many creep events were likely dynamically triggered because the static stress changes

caused by nearby earthquakes are typically less than 0.1 MPa thus too small to instantaneously trigger creep events. In contrast, we can reproduce the instantaneously triggered creep with dynamic perturbations alone, where the triggering threshold depends on the peak amplitude of and the time-integrated dynamic Coulomb stress change. Based on observations and simulations, the stress change amplitude required to trigger a creep event of 1 and 0.01 mm slip is 0.8 and 0.6 MPa, respectively. This is at least one magnitude larger than the triggering threshold of non-volcanic tremor (2-60 KPa) and earthquakes in geysers (5 KPa), which may due to the difference in the effective normal stress and other friction properties in these systems or different triggering mechanisms. We conclude that shallow frictional heterogeneity on strike-slip faults can explain both the spontaneous and dynamically triggered creep events.

Abstract ID: 33703

Final Number: S31A-06

Title: Detecting Very-Low-Frequency Earthquakes in Parkfield, California: Evidence for Slow-Slip Events

Presenter/First Author: Andres Felipe Pena-Castro, McGill University, Montreal, QC

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Abstract Body: Geodetically observed slow-slip events (SSEs) occur in many subduction zones around the world, and are indicative of slip on the plate interface below the brittle-ductile transition, at depths of roughly 30-50 km. SSEs are commonly associated with tremor and low-frequency earthquakes (LFEs) at the up-dip boundary of fault patches hosting SSEs. Another type of seismic signal, termed very-low-frequency earthquakes (VLFs), may potentially represent the seismic signature of SSEs in the region of a fault where tremor and LFEs occur (~20-30 km depth). VLF signals have been observed in association with tectonic tremor and LFEs in the Nankai through subduction zone, and their focal mechanism solutions suggest they result from slip along the plate interface. Here we search for VLF events on the San Andreas Fault near Parkfield, California, where vigorous tremor and LFEs occur in the absence of geodetically observed slip. We test a procedure that analyzes seismograms in the LFE band (2-8 Hz), the VLF band (0.02-0.05 Hz) and the waveform envelope, and stack multiple time windows containing co-located tremor events in the VLF band. We base our stacking time windows on LFE arrival times, and use waveform envelopes to determine peak amplitudes for aligning waveforms in the VLF band. The objective of stacking multiple records is to increase the signal-to-noise ratio of the VLF signal, which is often not visible above the noise level on a single waveform. We use a combination of data from permanent stations and seismic data collected from a temporary deployment of 13 broadband stations installed < 30 km from the San Andreas Fault near Cholame, California in 2010-2011. The postulated VLF origin times result from a LFE catalog calculated using a high resolution 3D velocity model. Our procedure will test wheter VLFs can be detected in the Parkfield region, which will support the existence of slow-slip events that may be below the limits of detection by geodetic methods.

Abstract ID: 35320

Final Number: S31A-07

Title: Low-Frequency Earthquakes on the Queen Charlotte Plate Boundary

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Co-authors: Michael G Bostock, University of British Columbia, Vancouver, BC, Canada

Abstract Body: The Queen Charlotte Fault is a major plate boundary located off the northwest coast of North America that has produced large earthquakes in 1949 (M8.1) and more recently in October, 2012 (M7.8). The 2012 event was dominated by thrusting despite the fact that plate motions at the boundary are more nearly transcurrent. We have identified seismic tremor in the region of the Queen Charlotte plate boundary below Haida Gwaii within the frequency band 3 to 12 Hz. The Queen Charlotte Fault region is typified by intermittent tremor activity every few days, which is similar to the San Andreas Fault and in contrast to subduction zones where distinctly episodic tremor and slip is observed. The tremor includes low-frequency earthquakes (LFEs) that are of particular interest due to their relatively high signal-to-noise ratios compared with other areas of investigation such as the northern Cascadia subduction zone, and their distinct phase arrivals. We are currently assembling LFE detection catalogues and templates with two main goals in mind. First, we wish to determine whether LFEs occur predominantly on a shallow crustal transform (*i.e.*, analogous to the San Andreas Fault), a deeper thrust fault (*i.e.,* analogous to the Cascadia subduction zone), or a combination of the two. This information will indicate which portions of the plate boundary system undergo slow slip. Secondly, we will compare LFE activity before and after the 2012 M7.8 earthquake to investigate the influence of the earthquake on fault frictional properties and the stress field.

Abstract ID: 35327

Final Number: S31A-08

Title: Slow Slip Processes On Frictional Faults - Simulations in a Laboratory Setting

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Co-authors: Steve Glaser, University of California Berkeley, Berkeley, CA

Abstract Body: We present laboratory observations derived from a direct shear test subjected to a normal stress and a controlled direct shear, where the effective strength heterogeneity is governed by the non-uniform distribution of asperities throughout the interface. We were able to map out the asperities and normal stress upon them using a pressure sensitive film. Prior to rapid sliding, we observed slow slip, which accumulated non-uniformly along the fault. Large, densely distributed asperities retarded slow slip and produce a 'locked' section with relatively low shear displacement. Slow slip was measured using slip sensors place at seven locations along the fault and a nucleation zone was seen to grow (at rates ~ 3 to 12 mm/s) from the free edge into a 'locked' section of the fault. Slow slip showed intermittent, 'burst-like' increases in spectral power between the frequencies of 60 to 150 Hz. These events lasted between ~ 12 seconds and were accompanied by burst-type acoustic emissions lasting ~ 0.5 to 3 µs. A local increase in slip rate was observed after its cessation. This increase in slip rate is consistent with observations of slow slip made before and after the 2013-2014 Boso slow slip event [Fukuda et al. 2014]. Further examination of these events shows a spatiotemporal dependence described by a time delay between adjacent along-strike slip sensors. Foreshocks were recorded using Glaser-type acoustic emission sensors and they occurred at the latter stages of the slow slip phase and indicated a source radius ranging from 0.21 to 1.09 mm – similar to larger asperity size measured with the film. Duration of these foreshocks were 7 orders of magnitude shorter than the 'burst-like'

signals – similar observations have been made in actual geological settings [Ide, 2007]. These results will aid the development of a mechanistic model of slow slip that will improve the understanding of the interaction of slip and effective fault strength heterogeneity.

Abstract ID: 33930

Final Number: S32A-01

Title: Lower Crustal Detachment in the Cordillera and Other Hot Backarcs

Presenter/First Author: Roy D Hyndman, Geological Survey of Canada Sidney, Sidney, BC

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Abstract Body: Lower crust horizontal detachment is widespread in hot backarcs like the Cordillera, based on four lines of evidence. (1) Temperature-depth estimates (~800 C at Moho) and laboratory rheology data indicate the lower crust in backarcs is likely very weak. In contrast, craton crusts are cold and strong, 400-500 C at Moho. Although the crust is more mafic with depth so stronger at the same temperature, the strength generally decreases downward. However, the lowest part of crust may be in dry granulite conditions, >730 C, so stronger than just above in amphibolite conditions (~700C). The uppermost mantle is stronger than the crust because of the rock type. The effective elastic thicknesses, Te, provides a check on the depth to the weak lower crust. (2) Regional lower crust horizontal seismic reflectors are interpreted to indicate current or past horizontal shear detachment; e.g., SW British Columbia, western US, UK, Spain, Germany, Japan. The top of the reflectors is commonly at 15-20 km, ~450-500 C; the base at ~30 km, ~730 C. The base of the reflectors is often ~5 km above Moho, consistent with underlying strong dry granulite rocks. (3) Structural and tectonic evidence for lower crustal detachment include: long distance crustal strain transfer, i.e., Yakatat collision northern BC, southwestern BC overthrusting of craton in Rocky Mtns, Andes thrusting in foreland. Also, many long-distance terrane motions and associated horizontal deformation in oroclines are best explained by motion of only the upper crust. (4) Extensive outcrop sections of former lower crust that exhibit horizontal fabric shearing at 750-800 C and 30 km., e.g., Athabasca granulite terrane. The strong evidence of horizontal detachment in the lower crust means that geological structural and tectonic interpretations need to allow for common 15-20 km thick upper crust transport and deformation, independent of the mantle.

Abstract ID: 34493

Final Number: S32A-02

Title: The role of a sharp cratonic keel edge for lithospheric delamination and rapid orogenic plateau uplift, Canadian Cordillera

Presenter/First Author: David W S Eaton, University of Calgary, Calgary, AB

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Co-authors: Xuewei Bao, University of Calgary, Calgary, AB, Canada; Bernard Guest, University of Calgary, Calgary, AB, Canada

Published Material: A large fraction of this work was recently published in Nature Geoscience.

Abstract Body: The interior of the Canadian Cordillera is part of an exhumed fossil plateau located in a back-arc tectonic setting. Using data compiled from western Canada and USArray, we integrate new analysis of teleseismic Rayleigh-wave tomography with thermochronology data to investigate lithospheric structure and exhumation history in this region. The edge of the North American craton is marked by a remarkably abrupt change in lithospheric thickness, from > 200 km to < 50 km, coincident with a significant step in surface heat flow. This sharp plate edge delineates the eastern limit of a fossil orogenic plateau that experienced rapid uplift and exhumation (10 to 15 km) during the mid to late Eocene. Our tomographic images show evidence for a high-velocity block in the sub-Cordilleran mantle, at depths greater than 165 km, which we interpret as foundering lithospheric mantle; we propose that delamination of this block was triggered by edge-driven convection and led to rapid uplift, voluminous magmatism and transition from compressional to extensional regime. Similar processes may have resulted in removal of the lithospheric keel beneath the North China craton and regional uplift of the Altiplano.

Abstract ID: 33829

Final Number: S32A-03

Title: Lithospheric Structure Across the Northern Canadian Cordillera from Teleseismic Receiver Functions

Presenter: Pascal Audet, University of Ottawa, Ottawa, ON

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First Author Student?: Yes

Published Material: AESRC 2014 Geodiversity, University of Ottawa, March 28-30, 2014.Oral presentationPart of the research presented as oral presentation.

Abstract Body: Let's begin, Anaxagoras' atom's building blocks of the universe; Aristotelian concentric celestial spheres; the middle ages Christian Heaven - a spiritual cosmic shell enclosing a number of concentric shells; Kantian hierarchical, and Cartesian vortex fractal universes. We recognise two states of Universal manifestation: crystalline, structural, or liquid, fluid, vortexial. The vortex dynamics manifestation within a fractal pattern is fundamental to all entities: atoms, star-planetary systems, galaxies, super galaxies. We accept 4D-space vortex treatise: a double helix spiral, two spirals creating a standing wave, stationary oscillation. Now one can stress attention on seismonomy treatise of seismoids' dynamics manifestation in the realm of solid media: stochastic emergence of indestructible quantum oscillating units through their life-span; its five postulates with insight into Universal Coherentism, the Doctrine of Dynamics Monism. Seismoid is a unitary entity which can not contain the same fractal level seismoids as its structural parts. Energy exchange between seismoids can be called Machian-energy quanta radiation. Obviously the basic vortex unit in essence is a seismoid, also possessing electromagnetic attributes. Evidently, the universe is a fractal! Beginning by first stratum with its master unit and subordinate units, which are rotating and revolving around it. This pattern is progressively replicated top-down in varying forms on each hierarchical stratum till Planck's scale. Thus, the whole quantum unit oscillation is the master control over its subordinates and constitutes segregated space-time of the stratum, but in turn it is an element in a greater whole. Contemplating on outermost stratum, its master entity limits further ascension, and can not be a subordinate, one can assume that the entire universe is encapsulated into this superior entity which is devoid of space-time of its own. Obviously cosmogenes in that treatise is plausible from top to down.

Abstract ID: 33152

Final Number: S44A-0316

Title: Structural and seismic facies analysis of Tytoolz-fiy Field, onshore Niger Delta

Presenter/First Author: Emmanuel A Titus, University of Lagos, Somolu, Lagus,

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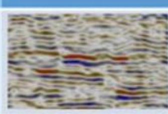
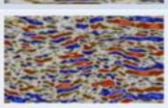
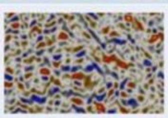
Co-authors: Elijah Ayolabi, , , ; Ayodele Ogunniyi, , ,

Abstract Body: Summary:

3D seismic cube from the Tytoolz-Fiy Field, was interpreted based on the reflection continuity, amplitude strength and internal configuration to understand the subsurface geology and depositional environment. This was integrated with the analysis of five well logs, and was carried out to ascertain and control the interpretation of the seismic facies analysis. A sequential workflow involving the identification and analysis of different seismic facies, generation of a synthetic seismogram and seismic attribute analysis was employed. Four seismic facies namely Facies A, B, I and T were identified and classified based on their reflection continuity, internal configuration and amplitude strength. The well log facies results were correlated and tied to the seismic facies analysis results and were used to infer the depositional environment - the delta front, delta plain and pro delta environments. Structural interpretation revealed the different fault systems, simple rollover anticlines and shale diapiric regions. Seismic attribute analysis was also carried out to identify regions of similar lithology and geomorphic features. This supported and aided the interpretation, especially to confirm the shale diapiric region.

FACIES NAME	SEISMIC FACIES	REFLECTION ATTRIBUTE (a) Internal configuration (b) Continuity (c) Amplitude strength
Facies A		(a)Parallel to sub-parallel (b)Semi continuous (c)low to moderate
Facies B		(a)Sub-parallel to Hummocky (b)Disrupted to discontinuous (c)Moderate to High
Facies I		(a)Parallel (b)Semi continuous to Continuous (c)Moderate to High
Facies T		(a)Chaotic (b)Discontinuous (c)Moderate to High

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Abstract ID: 33508

Final Number: S44A-0317

Title: New Methods for Acquiring and Visualizing Surface Wave Data

Presenter/First Author: Brian Miller, Slippery Rock University of Pennsylvania, Slippery Rock, PA

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Co-authors: Georgios P Tsoflias, University of Kansas, Lawrence, KS; Don W Steeples, , Palco, KS

Abstract Body: The use of surface waves to analyze the upper several tens of meters of the subsurface has become an important technique for near-surface investigations. Typically surface waves are acquired using a single row of geophones which limits visualization to a 2D profile of shear wave velocity versus depth. Acquiring surface wave data along multiple, coincident geophone lines allows a volume of data to be created providing the opportunity to view the data in 2D or 3D. A new method for acquiring surface wave information in 2D or 3D is demonstrated, providing a method of visualization not previously available.

The Autojuggie, developed by The University of Kansas, is a hydraulically driven geophone deployment system capable of deploying a grid of 220 geophones in under two minutes. Employing the Autojuggie an active source surface wave seismic survey was conducted on the campus of The University of Kansas. Rayleigh wave data were simultaneously acquired along eleven coincident receiver lines which was then processed using the Multichannel Analysis of Surface Waves (MASW) method. The current 2D visualization of data processed using the MASW method was expanded by developing a series of computer algorithms allowing seismic shear wave velocity information to be plot within a 3D environment.

Using these new methods seismic shear wave data can be viewed in new and unique ways. The data can be viewed in a traditional 2D profile showing shear wave velocity versus depth along each geophone receiver line. Additionally 2D or 3D profiles can be displayed at selected intervals between, or across, each of the geophone receiver lines. Lastly shear wave velocities throughout the surveyed area can be viewed at selected depths. Using these new methods I was able to identify velocity inversions and lithology changes interpreted to be both a result of natural and construction practices.

Abstract ID: 35985

Final Number: S44A-0318

Title: Focal depth distribution of the 1982 Miramichi, New Brunswick, earthquake sequence, retrieved by analyzing regional depth phases

Presenter/First Author: Shutian Ma, Carleton University, Ottawa,

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Abstract Body: A magnitude mb 5.7 earthquake occurred on 9 January 1982 in the Miramichi region, New Brunswick, Canada. The earthquake was felt throughout much of the Maritime Provinces, Canada and the New England States, United States. The mainshock was followed by an extensive aftershock sequence. The 1982 Miramichi mainshock is the largest earthquake in eastern Canada since the Cornwall-Massena earthquake of 1944. It is the first earthquake in eastern North America recorded on modern seismograph networks world-wide, so its source parameters can be determined by many modern techniques. Focal depth is an important source parameter. As the contribution from forcal depth to travel times are much smaller than that from the distance, the error in focal depth is much larger than that in epicenter obtained by conventional locating method. Regional depth phases are often detectable at regional distances. As the epicentral region of the Miramichi earthquakes lies within the northern Appalachian Mountains, regional depth phases are very well developed and recorded at several seismic digital stations. The waveforms generated by the aftershock sequence are very well saved at GSC database, so these regional depth phase records can be used to retrieve focal depths for the sequence by modeling method which has not been used before. In the epicentral region of the mainshock the documented aftershock number is about 700. To abstract main features we first retrieved waveform records for the aftershocks with magnitude mN >= 2.8 (about 100). These earthquakes are representative and have

clear depth phase records. Then we performed regional depth phase modeling. We found the dominant focal depth range is from 5 km to 7 km. About one third of the analyzed aftershocks occurred at about 6 km. Another small group has focal depths at about 3 km. Some aftershocks have very shallow focal depths, almost near the ground surface, which was confirmed by strong Rg phase records. The deepest is at about 10 km.

Abstract ID: 35698

Final Number: S44A-0319

Title: The Lamont Cooperative Seismographic Network (LCSN)

Presenter/First Author: Mitchell Evan Gold, Lamont Doherty Earth Observatory, Palisades, NY

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Co-authors: Patrick Bastien, Lamont-Doherty Earth Observatory, Palisades, NY; Won-Young Kim, University of Tokyo, Yayoi 1-1, Bunkyo, Tokyo, Japan

Abstract Body: The Lamont Cooperative Seismographic Network (LCSN) consists of 35 broadband seismographic stations and an additional half dozen short-period stations. Stations located in New York, New Jersey, Connecticut, Pennsylvania, Delaware, Maryland, Vermont and New Hampshire, are operated by 40 cooperating partners, with Lamont Doherty Earth Observatory (LDEO) serving as the lead institution. Partners include colleges and universities, community colleges, secondary schools, museums, a state geological survey, conservation organizations, research institutes, and a tourist attraction. The LCSN offers unique educational opportunities for students at a variety of levels, for public officials, and for the general public.

The LCSN serves as one of seven regional seismic monitoring and data center for the Advanced National Seismic System (ANSS) led by US Geological Survey. The backbone of the LCSN real time data acquisition for earthquake monitoring in the northeastern US is the Internet based Earthworm system with the back-end using the ANSS Quake Management System (AQMS) software. All seismogram data acquired by LCSN are archived at the IRIS-DMC in Seattle, Washington in real time, while much of the earthquake data such as catalogs, maps, recent earthquakes, felt reports (Did-You-Feel-It?), and event waveform data are hosted on our website: http://www.ldeo.columbia.edu/LCSN.

The LCSN modernized most of its seismic hardware in 2011 and has continued a strong program of station improvements for greater data availability and quality. We share resources with our partners to minimize costs for telemetry by using their high speed internet, and recently sharing a county's microwave Emergency Management link. Along with these improvements, we continue to test and upgrade with more reliable power and backup systems for our solar-powered stations.

Abstract ID: 35650

Final Number: S44A-0320

Title: The Central and Eastern United States Network and Repeating Earthquakes in ENA

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Co-authors: Mitchell Evan Gold, Lamont Doherty Earth Observatory, Palisades, NY; Patrick Bastien, Lamont-Doherty Earth Observatory, Palisades, NY; John G Armbruster, Columbia University of New York, Palisades, NY

Abstract Body: The recent deployment of Transportable Array (TA) seismographic stations of the USArray project by the Incorporated Research Institutions for Seismology (IRIS) in the eastern United States has greatly improved the earthquake monitoring and research in the region. Over 160 TA stations in the eastern United States were selected to be retained beyond their nominal deployment period of about two years. These selected TA stations will be gradually upgraded from 40 to 100 samples/second by the fall of 2015 and will form the Central and Eastern United States Network (CEUSN) with network code "N4". CEUSN will be operated by IRIS until the end of 2017. The CEUSN and existing permanent seismographic stations of the national and regional networks in the region such as, Canadian National Seismic Network (CN), US National Seismic Network (US), Lamont Cooperative Seismographic Network (LD), New England Seismic Network (NE), Cooperative New Madrid Seismic Network (NM) and Penn State Network (PE) provide an unprecedented opportunity to study earthquakes in the stable Eastern North America (ENA).

The initial objective of the USArray component of the EarthScope project was to explore the structure and evolution of North America using continuous recordings from broadband seismometers of TA stations. While research goals of the EarthScope in ENA are still carried out by the EarthScope project, we have begun to look at broad regional scale crust and uppermost mantle structure using receiver function analysis (EARS: EarthScope automated receiver survey) and automated surface wave tomography tools developed during EarthScope project, and report our results on crustal thickness variation and lithosphere-asthenosphere boundary in the eastern US. We report results of our effort to find repeating earthquakes from waveform archives in the Adirondacks, New York and Western Quebec, Canada by employing a waveform cross-correlation technique.

Abstract ID: 33169

Final Number: S44A-0321

Title: A STUDY ON ACTIVE TECTONICS OF NORTHEASTERN INDIA FROM FOCAL MECHANISM SOLUTIONS

Presenter/First Author: Santanu Baruah, CSIR-North East Institute of Science and Technology, Jorhat,

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Co-authors: Saurabh Baruah, , ,

Abstract Body: Focal mechanism solutions of 132 numbers of local earthquake events ($3.5 \leq M_W \leq 5.9$) in NER, India are determined. Solutions in the Eastern Himalayan zone confirm that the earthquakes in this region are mainly dominated by thrust or thrust with strike-slip component. The P-axis of most of the events is found to be oriented nearly along NNW direction. The focal mechanism solutions in the western and eastern part of Shillong Plateau are found to be mainly pure thrust or pure strike slip in nature. The Mikir Plateau earthquakes are mostly thrust in nature. The earthquakes in the Tripura fold belt may be interpreted as plate-boundary earthquakes and most of them are strike-slip in nature. The P-axis orientation of most of the events associated to Indo-Burma ranges are found to be roughly north-south directed and shows dominance of thrust kind of mechanism. The main objective of the present work is to study the active tectonics of NER, India by characterizing the different active faults and lineaments based on new and reliable fault plane solutions determined through waveform inversion.

Abstract ID: 33688

Final Number: S44A-0322

Title: Seismic Mapping of the Fenchuganj Structure, Surma Basin, Bangladesh.

Presenter: Al-Tamini Tapu, Jahangirnagar University, Dhaka,

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Abstract Body: The Surma Basin is a sub-basin of the Bengal Basin occupying the northeastern part of Bangladesh. It is the prime hydrocarbon producing region of Bengal Basin. The Fenchuganj structure is located along the eastern margin of the Surma Basin. This present work comprises the seismic, gravity, magnetic and well data for interpreting the subsurface geology, structural configuration and tectonics of the Fenchuganj structure. The research also involves integrated interpretation of gravity and magnetic data to delineate the subsurface structural condition of the Surma Basin and its surrounding region. In order to interpret the study area, five seismic sections have been considered. Based on the analysis of the sections and correlation with well data, four reflecting horizons are marked, viz., top of Lower gas sand, Bhuban Formation, Bokabil Formation and Tipam Formation. Time and depth contour maps of these four horizons are constructed using the two way travel time of the sections and T-Z curve of the study area. Preparation of subsurface geological maps and interpretation of subsurface features suggest that the Fenchuganj structure is a reversibly faulted, NNE-SSW trending assymmetrical anticline with sharp dip in eastern flank than western. The seismo-stratigraphic study of the area furnish three formations- Bhuban, Bokabil, and Tipam. An attempt has been made to analyze the gravity and magnetic data to configure the subsurface structural features of the Surma Basin and adjoining areas. It is an east-west trending oval shaped basin and is characterized by significant gravity low. The upward continuation and second vertical derivative (VZZZ) methods have been used to enhance residual gravity effects. Regional and residual anomaly maps for gravity field continued to 7.5km, 10km and 15km have been prepared. The three regional anomaly maps show almost similar structural configuration of the basin. Residual anomaly maps are characterized by some positive effects, possibly related with positive density contrast. Considering the findings of this study, the further investigation (3-D seismic survey, advanced software interpretation) can give more valuable information about real subsurface structure and hydrocarbon occurrence in this area.

Abstract ID: 33944

Final Number: S44A-0324

Title: Body-Wave Scattering from Seismic Interferometry: Preliminary Results from the San Andreas Fault near Parkfield, California

Presenter/First Author: Stephen Glenn Mosher, University of Ottawa, Ottawa, ON

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Co-authors: Pascal Audet, University of Ottawa, Ottawa, ON, Canada

Abstract Body: High-resolution direct tomographic imaging of subsurface Earth structures is generally limited by the poor distribution of seismic sources necessary for such studies. However, seismic interferometry has the potential to significantly overcome this issue through the use of ambient seismic noise recordings. Whereas the recovery of virtual surface waves via seismic interferometry techniques are the most abundant results produced by such studies, it has recently been shown that virtual body waves can also be recovered under appropriate conditions. Of particular interest is the scattering of body waves produced by velocity discontinuities in the subsurface, which dramatically improve our ability to characterize the seismic velocity structure. In this work we investigate the possibility of recovering body-wave scattering from interactions with velocity discontinuities associated with the San Andreas Fault using ambient seismic noise recordings across a network of stations near Parkfield, California. In particular we test whether mode-conversions (P to S waves) can be observed using these virtual Green's functions. Additionally, we examine the potential of seismic interferometry to produce time-lapse body-wave characterizations of the San Andreas Fault, in which properties of the fault can be seen to change in time.

Abstract ID: 34145

Final Number: S44A-0325

Title: Real-time Stress Monitoring Using Ambient-noise Tomography in Deep Mine Environments

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Abstract Body: Understanding the response of the rock mass to mining is of key importance for the planning of mine operations as well as assessing and mitigating the seismic risk. For decades, studies have shown that passive source tomography, also called local earthquake tomography, can provide information on the rock mass response through the estimation of the temporal variation and 3D distribution (spatio-temporal variations) of stress. The spatio-temporal resolution afforded by passive source tomography depends on the seismicity rate and the location of microseismic events. In a mine, seismicity is not stationary, i.e. the locus and rate of seismicity vary with time, thus limiting the spatio-temporal resolution of this technique. Recent developments in the field of ambient noise seismic interferometry (Green's function retrieval from ambient noise) provide hints that continuous recordings of ambient vibrations collected around mines could be used to obtain information on the evolution and 3D distribution of the stress in the rock mass by providing measures of seismic travel times between pairs of sensors. In contrast to passive source tomography that relies on the distribution of seismic events, the resolution afforded by ambient noise interferometry tomography depends solely on the locations of sensors and the frequency content of the ambient noise. We present preliminary results of temporal variations in body-wave travel times between pairs of sensors obtained through the cross-correlation of continuous recordings collected at an active mine. In addition, we present the adopted processing scheme that exploits Hadoop to parallelize the computation.

Abstract ID: 36464

Final Number: S44A-0326

Title: Seismic Interferometry for Mineral Exploration: Results from a Test Survey at the Lalor Mine, MB, Canada

Presenter/First Author: James A Craven, Geological Survey of Canada Ottawa, Ottawa, ON

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Co-authors: Saeid Cheraghi, , , ; Eric Roots, , , ; Gilles Bellefleur, Geological Survey of Canada, Ottawa, ON, Canada

Published Material: Preliminary results have been shown at SEG meeting recently in Denver and have been accepted for publication by Geophysical prospecting. We will be showing new beamforming analyses and f-K filerting designed to reduce artefacts in te haimge that have neverbefore been seen.

Abstract Body: Approximately 300 hours of ambient noise data were recorded on a grid of receivers covering an area of 4 km² over the Lalor mine, Canada, to test the capability of seismic interferometry to detect ore deposits in the crystalline rock environment. Underground mining activities create sources of ambient noise in the area which can be used to create virtual sources at the surface. Alongside the ambient noise survey, a larger 3D active-source seismic survey was also acquired and used to evaluate the interferometry results. The calculated virtual shot gathers retrieved by cross-correlating ambient noise at all receivers were processed following both 2D and 3D approaches using a sequence similar to the one applied to the active-source 3D data. The DMO stacked section reveals a number of events similar to those observed on the processed active seismic sections. The passive seismic interferometry results over the Lalor mining area are encouraging but image quality of passive survey is lower than the acquired active 3D survey at the area. A number of techniques such as beamforming and f-k filtering of the virtual data are being explored address this issue. Future ambient noise surveys with longer offset, shorter receiver spacing, and wider azimuth distribution could be acquired in crystalline rock environment to address the pros and cons of the method.

Abstract ID: 36804

Final Number: S44A-0328

Title: Crustal structure beneath northeastern Tibetan Plateau from teleseismic receiver functions and its relationship with the regional seismicity

Presenter/First Author: Xinfu Li, China University of Geosciences Beijing, Beijing,

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Co-authors: Hongyi Li, China Univ. of Geosciences(BJ), Beijing, China

Published Material: No

Abstract Body: More detailed studies of crustal structure in northeastern Tibetan Plateau can be of great benefit to the understanding of crustal deformation and plateau growth mechanisms. We investigate crustal structure beneath 58 seismic stations in northeastern Tibetan Plateau by using the P receiver function method to estimate the crustal thickness, Poisson's ratio and Vp/Vs ratio by analyzing the collected three-component teleseismic data. These data are recorded by 29 stations deployed by China University of Geosciences between June 2008 and July 2010, 19 Ascent stations deployed between May 2007 and August 2008, 2 stations from China National Seismic Network and 8 stations from Central China Network. The images of Moho depth suggests the lateral variations of the crustal thickness decreasing from Qilian Orogen (~63 km) to east Kunlun fault area (~40 km). High Vp/Vs and Poisson's ratio appear along a narrow band from southwest to northeast in the east Kunlun fault area, while lower Vp/Vs and Poisson's ratio appear in the Qilian Orogen.The observations disagree with the crustal composition beneath the northeastern margin of the Tibetan plateau. There is no simple correlation between the regional seismicity and the crustal thickness observed here. Our results of crustal structure and seismicity in this study area not only reveal the lateral inhomogeneity of the crustal structure but also provide some constraints on understanding the mechanism of uplift and crustal thickening of the Tibet.

Abstract ID: 36377

Final Number: S44A-0329

Title: Coda Q estimates of Bilaspur region of Himachal Lesser Himalaya

Presenter/First Author: Sandeep ., Indian Institute of Technology Roorkee, Roorkee,

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Published Material: THE WORK HAS BEEN ALSO PRESENTED IN INDIAN GEOPHYSICSL UNION HELD ON 19-21 NOVEMBER 2014. THIS WORK IS SOME EXTENDED TO INCLUDE MORE INFORMATION

Abstract Body: In the present work the quality factor (Q) of Coda waves of Bilaspur region of Himachal Lesser Himalaya has been estimated using the single backscattered model proposed by Aki and Chouet (1975). Coda waves of 94 local events located within 100 km of the region having magnitude (0.15<ML<3.03) has been used to study the attenuation of seismic waves in the frequency range of 1.5 to 24 Hz. These events were recorded on digital station in Sikandera (SKND) during the period from May 2008 to April 2011 employing a five station seismological network in the region. The vertical component records were used in the present study. Hypocenter parameters of these events have been estimated with HYPOCENTER computer program. A MATLAB code has been developed for the estimation for Coda Q (Qc). The code follows the guidelines of CODAQ subroutine of SEISAN. The waveforms whose signal to noise ratio (SNR) is greater than 5 are selected for analysis. Only those Coda Q (Qc) values having correlation coefficient 0.7 or more are considered for the region to obtain the reliable values of Qc. By analyzing the Coda waves at different frequencies from 1.5 to 24 Hz the estimated Qc values varies from 155 at 1.5 Hz to 3781 at 24 Hz for lapse time window of 30 sec. This shows that Qc is function of frequency and its value increases as frequency increases. A Q–f relation is obtained for the entire region as Qc=105 f 1.14 the medium covering an area about 21899 sq. km. having lateral extent of 204 km. and vertical extent of 102 km.The observed Qc relation is also compared with those observed in other seismically active regions of the India and found that the estimated Qc value around Bilaspur region of Himachal Himalaya is highly heterogeneous and seismically active as compared to the other seismically active regions of India.

Keywords: Coda waves, Qc, Back-scattering model. Himachal Lesser Himalaya. . Qc estimated in this way represents the average attenuation properties of

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Abstract ID: 36046

Final Number: S44A-0330

Title: Inclined strike-slip fault in a two layered model of the lithosphere-asthenosphere system

Presenter/First Author: Papiya Debnath, Organization Not Listed, Kolkata,

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Co-authors: Sanjay Sen, , ,

Abstract Body: The lithosphere-asthenosphere system has been represented by layered viscoelastic media consisting of a viscoelastic layer of Maxwell type overlying a viscoelastic half space of liner viscoelastic solid. A long inclined surface breaking strike-slip fault is taken to be situated in the first layer. The medium is taken to be under the action of a tectonic forces arising due to different tectonic phenomena such as mantle convection etc. Expressions for displacement, stresses and strain are obtained during the aseismic period in between two major seismic events. Stresses are found to accumulate near the fault leading to a sudden movement across it resulting in an earthquake. The movement across the fault effect the nature of stress accumulation in the region. In this paper an attempt has been made to obtained and estimate of time to the next major event. Such studies are directly associated with the prediction of an impending earthquake in a medium which has non-homogeneous character.

SOLID EARTH

Abstract ID: 33404

Final Number: SE13A-01

Title: A generalized quasi-geostrophic model of thermal convection

Presenter/First Author: Mathieu Dumberry, University of Alberta, Edmonton, AB

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Co-authors: Daniel Laycock, University of Alberta, Edmonton, AB, Canada; Moritz H Heimpel, University of Alberta, Edmonton, AB, Canada

Published Material: presented (poster) at SEDI 2014, fall AGU 2014

Abstract Body: It is well known that, under the influence of planetary rotation, convective flows tend to have a two dimensional (2D) structure, with small variations along the direction of rotation. Because of the primary force balance between pressure gradients and the Coriolis force, such flows are termed geostrophic. Convective flows are never purely geostrophic because buoyancy (which powers convection) is necessarily present and so is viscous dissipation. Nevertheless, provided rotation is dominant, the first order 2D nature of convective flows is preserved and these flows are often referred to as quasi-geostrophic (QG). QG numerical models of thermal convection, in which only equatorial variations are tracked, have been developed to take advantage of the predominant 2D structure of QG flows. These models can reproduce faithfully some of the features of fully three-dimensional (3D) numerical models. The chief advantage of such QG models is that, because of their 2D nature, a much higher numerical resolution is achievable than for 3D models for the same computing cost and can thus be used to study aspects of convection under a regime not accessible to 3D models. In existing QG models, the buoyancy force is restricted to its component perpendicular to the rotation axis and the modelled region of convection is limited to that outside the tangent cylinder. Here, we present an extension on these models by incorporating the axial component of the buoyancy force and by modelling convection inside the tangent cylinder. Our model can reproduce the salient features of 3D numerical models near onset. Further, our model also captures features of well developed, fully turbulent convection, such as production of zonal jets.

Abstract ID: 33487

Final Number: SE13A-02

Title: Crustal Heat Flow and a Global Crustal Model to Estimate the Crustal Geoneutrino Flux Near the Sudbury Neutrino Observatory (SNO) .

Presenter/First Author: Lidia Iarotsky, GEOTOP-UQAM, Montreal, QC

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Co-authors: Jean-Claude Mareschal, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Claude P Jaupart, Institut de Physique du Globe de Paris, Paris, France

Abstract Body: The main objective of geoneutrino observations is to determine the concentrations of uranium and thorium in the Earth's mantle. In order to calculate the mantle concentrations, one must precisely account for the crustal component of the geoneutrino flux. This requires knowledge of the crustal radioactivity. Crustal composition and radioactivity can be inferred from global crustal models or obtained directly by measuring the surface heat flow.

We have used heat flow data and the model CRUST1.0 to estimate the geoneutrino flux in eastern Canada where the Sudbury neutrino observatory is installed. The two estimates differ significantly because the global crustal models overestimate the heat production in many parts of the Superior Province. We find that the difference can be reduced by adjusting the heat production used in the global model to fit the heat flux measurements. Heat flux data are available in the Canadian Shield and within the Sudbury structure to constrain crustal radioactivity in the immediate vicinity of SNO and calculate the crustal geoneutrino flux.

Abstract ID: 33781

Final Number: SE13A-03

Title: Evidence for Instability in Earth's Fluid Core from Paleomagnetic Intensity Records

Presenter/First Author: Keith D Aldridge, York Univ, Toronto, ON

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Co-authors: David McMillan, , ,

Abstract Body: A search of composite stacks of relative paleointensity PADM2M, SINT2000 and PISO-1500 has found a signature of luni-solar tidal strain rate (LTSR) over the past 2 Myr. Our search for LTSR in relative paleointensity records is based on a representation of long term fluctuations in geomagnetic intensity as a sequence of growths and decays, which we suggest are due to a tidally-induced parametric instability in Earth's fluid core. Linear stability theory predicts that the external LTSR that could excite an instability can be estimated from the difference between the observed growth rate of the instability minus the decay rate of the previous instability. Under the assumption that the observed paleointensity is a proxy for the perturbation velocity of an instability, we find that estimates of the LTSR directly from the relative paleointensity record are in agreement with calculated LTSR.

An important consequence of this depiction is the precise temporal location of 6 reversal events over the past 2 Myr. Significantly larger fluctuations of LTSR are associated with these reversals. A parametric instability in Earth's core is consistent with both the success in predicting reversals and finding the LTSR in relative paleointensity records. Furthermore, our model predicts that strain rates prior to the onset of a new instability should show only decay of a previous instability and hence be unrelated to the occurrence of a subsequent event. With very few exceptions our results show this and hence are consistent with a parametric instability participating in the geodynamo.

Abstract ID: 33941

Final Number: SE13A-04

Title: The inertial modes of a uniformly rotating, homogenous, incompressible and inviscid spherical fluid shell: application to the Earth's fluid core

Presenter/First Author: Hossein Naseri, University of Lethbridge, Lethbridge, AB

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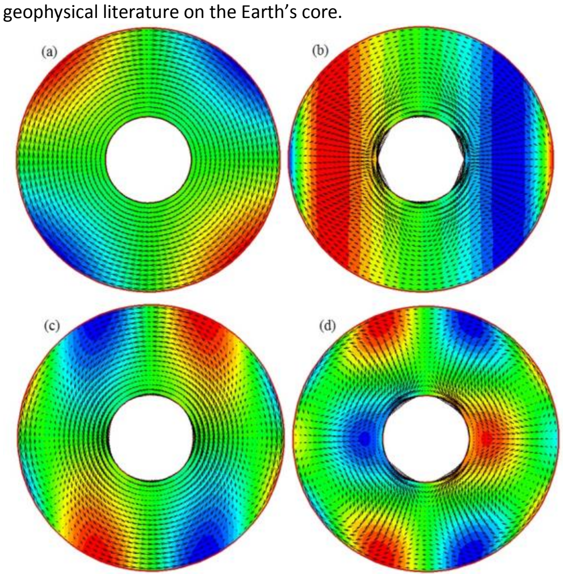
Co-authors: Behnam Seyed-Mahmoud, University of Lethbridge, Lethbridge, AB, Canada

Abstract Body: In this work we investigate the dynamics of a uniformly rotating, homogenous, incompressible and inviscid spherical fluid shell of rigid boundaries. Traditionally, the Poincar equation, a second order partial differential equation describing the perturbed pressure, is solved for the eigenfrequencies and eigenfunctions of the inertial modes of such model. This equation is of hyperbolic type which makes the boundary value problem ill-posed in the sense that the nature of the solutions is sensitive to the geometry of the boundary. General analytical solutions have not been found for thick spherical shell geometry. In recent years approximate solutions have been found using incompressible fluid of small viscosity. Here we use a Galerkin method and directly solve the momentum and the continuity equations subject to appropriate boundary conditions. We show that, as far as we have investigated, there is a one-to-one correspondence between the eigenfrequencies and eigenfunctions of this model and those of a rotating fluid sphere. We will discuss the results in the context of the geophysical literature on the Earth's core.



Abstract ID: 33977

Final Number: SE13A-05

Title: Structure and Dynamics of the Core from Surface Gravity Measurements - Theory Versus Observations Using the GGP Network

Presenter/First Author: David J Crossley, Saint Louis University Main Campus, Saint Louis, MO

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Published Material: 25% at Colloque G2, Strasbourg, France, November 2014.

Abstract Body: The Global Geodynamics Project (GGP) was initiated in Canada in 1987 to improve the exchange of data from the increasing number of superconducting gravimeters (SGs) that were being established worldwide. Theoretical speculations in the 1970's concerning the possible existence of a spectrum of modes of oscillation of the liquid outer core (or 'undertones') suggested that SGs would be the best instrument to detect such oscillations. GGP started in earnest in 1997 and now numbers some 30 instruments located in all major continents. Despite numerous papers concerned with the analysis of the large amount of high quality SG data now available, success has been achieved in only a small subset of problems related to the dynamics of the core. This includes well-determined values for the period and Q of the free core nutation (FCN), whereas other rotational modes such as the FICN and ICW are difficult to observe in gravity. Likewise there has been no indication of distinct periods in the SG data that could be unambiguously ascribed to either the Slichter triplet (short-period translation of the inner core) or to fluid core modes of the types known as inertial waves or internal gravity modes. SG data has, however, been effective in improving knowledge of some seismic modes such as ${}_0S_0$, ${}_2S_1$, and ${}_0S_2$ that contribute information about the core. In this paper we review all the above candidate core oscillations against the practical difficulties of their excitation and detection.

Abstract ID: 34856

Final Number: SE13A-06

Title: Theoretical Description and Excitation of the Translational and Rotational Normal Modes of the Inner Core

Presenter/First Author: Yves J G Rogister, EOST École et Observatoire des Sciences de la Terre, Strasbourg,

Presenter/First Author Email: Yves.Rogister@unistra.fr

Co-authors: Severine Rosat, IPGS-EOST, Strasbourg, France; Bernard Valette, , ,

Published Material: Parts of the results were reported inRogister Y., Valette B. (2009): Influence of liquid core dynamics on rotational modes, Geophysical Journal International, 176, 368-388Rosat S., Boy J.-P., Rogister Y. (2014): Surface atmospheric pressure excitation of the translational mode of the inner core, Physics of the Earth and planetary Interiors, 227, 55-60.

Abstract Body: The Free Inner Core Nutation (FICN), Inner Core Wobble (ICW) and the Slichter modes are the rotational and the translational normal modes of the solid inner core. For realistic Earth models, their periods in a reference frame co-rotating with the Earth range from a few hours for the Slichter modes to a few years for the ICW. We investigate the influence of the structure and dynamics of an inviscid liquid outer core on the rotational modes through the squared Brunt-Va\"\i s\"al\"a frequency N^2, the frequencies of the rotational modes being embedded into the continuous spectrum of inertia-gravity modes, which is governed in the complex domain by N^2 and the Earth's rotation speed. We show interactions between pseudo-modes of the liquid core and the FICN. By considering a very simple Earth model, we show that the dynamics of a neutrally stratified outer core may generate a family of ICWs with periods ranging from a few dozens to thousands of days. As for the Slichter modes, we investigate the efficiency of various excitation sources, such as atmospheric pressure variations, collision of the Earth with a meteoroid, and pressure variations at the outer core boundaries, to generate surface gravity variations above the detection limit by superconducting gravimeters. We show that pressure variations at the core boundaries, with time-scales shorter than the Slichter eigenperiods, provide the most efficient excitation process.

Abstract ID: 35184

Final Number: SE13A-07

Title: A synthetic model analysis of MT distortion parameters for anisotropic and inhomogeneous media

Presenter/First Author: Pavankumar Gayatri, Institute of Seismological Research, Gandhinagar,

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Co-authors: Yashavant Singh, Institute of Seismological Research, Gandhinagar, India; Mahender E, Institute of Seismological Research, Gandhinagar, India; Damodar K, Institute of Seismological Research, Gandhinagar, India; Ajay Manglik, National Geophysical Research Institute, Hyderabad, India

Abstract Body: Anisotropy in the lower crust and upper mantle has been inferred from various geophysical studies highlighting the significance of anisotropic modelling in geophysical data interpretation. Analysis of MT data for a 2-D medium in the presence of anisotropy is complex as the impedance tensor may not decouple into two polarization modes. Here, we present the results of a study comprising of two synthetic models, one having electrical anisotropy and the other constituted of inhomogeneous block structure. We have computed impedance tensors in the frequency range of 100Hz-10000s for these two models by using an algorithm [*Pek and Verner, GJI, 1997]* for 2-D modelling of anisotropic media. The apparent resistivity and phase curves show splitting for both models. However, the splitting occurs at the interface between the overlying isotropic and the underlying anisotropic block for the anisotropic model whereas the splitting is observed at the top and the bottom of the inhomogeneous block for the inhomogeneous model. The magnitude of splitting depends on the anisotropy ratio and the resistivity contrast of the anisotropic and inhomogeneous blocks from the overlying medium. The phase tensor (PT) analysis of the impedance tensors suggests the non-zero skew angles, representing the asymmetry in the medium along with deviation of the major axis from the regional strike of the body. Study of ellipticities of the telluric vectors (ETV) implies the non-zero ellipticities within the period band of the anisotropic block and splitting in the telluric distortion angle curve, similar to the impedance phase. In case of inhomogeneous medium, the PT-skew angle, ellipticities and distortion angles are zero. Direct proportionality relation between the PT-skew angle and the distortion angle is inferred from the present study.

Abstract ID: 35994

Final Number: SE13A-08

Title: Tidal Friction: a New Absorption Mechanism at the Sea-Subsea Interface

Presenter/First Author: Pierre Michel Rouleau, Memorial University of Newfoundland Grenfell, Corner Brook, NL

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Abstract Body: As the Earth-Ocean system rotates within the lunisolar gravitational field, its figure nominally deforms into prolate ellipsoidal extensions – the tides - over slight but finite time intervals. The delayed response for the principal semidiurnal lunar tide is well-constrained by satellite tracking and altimetry; the associated phase lag is a manifestation of tidal friction which, conventionally, is attributed in a large part to turbulent drag in shallow seas and, in a much lesser yet significant part, to anelasticity of the lithosphere-asthenosphere. Although the combined effect has well-known consequences, e.g. the lengthening of the day and an increasing Earth-Moon distance, the details of the friction mechanisms by which tidal energy dissipates remain uncertain. In particular, little attention has been paid to the energy losses that occur within the synchronously deforming permeable boundary layer that constitutes the interface between sea water and subsea rock formations. Here, I elaborate an absorption mechanism by which tidal-loading mechanical energy is dissipated via viscous flow of periodically squeezed ultra-thin water-films that are confined to rough-wall natural fractures. Based on the theory of linear viscoelasticity, the absorption is quantified by a frequency-dependent dissipation factor, Q^{-1}, along with its corresponding phase lag, δ. Q^{-1} and δ values are first calculated within the framework of micro-mechanics at the nanoscopic scale, then scaled up to the mesoscopic dimensions of subsea rock formations that are fractured. The results show strong absorption within the semi-diurnal tidal band, peaking round the principal lunar constituent M_2. Very high Q^{-1} values and significant phase lags occur in shallow seas, especially in coastal areas where the marine tides undergo resonance. The tidal energy dissipation contributed via this “squeeze-nanoflow” mechanism is compared with the contributions of other mechanisms thought to operate either in the ocean proper or in the solid Earth proper.

Abstract ID: 36238

Final Number: SE13B-01

Title: River-to-Wetland Surface Water Connectivity in a Cold Region Deltaic Ecosystem

Presenter/First Author: Daniel L Peters, Environment Canada, Victoria, BC

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Co-authors: Olaf Niemann, University of Victoria, Victoria, Canada; Donald J Baird, Enivironment Canada @ Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada

Abstract Body: The Peace-Athabasca Delta (PAD) is a deltaic lake/wetland ecosystem of international importance (Ramsar & World Heritage site). This 6000 km^2, low-relief delta, which formed at the confluence of the Peace, Athabasca and Birch rivers, contains more than 1000 lake/wetland basins with varying degrees of connectivity to the main flow system. Wetland hydroperiod is influenced by occasional ice-jam and open-water inundations that recharge the basins. Prior studies have identified pathways of river-to-wetland floodwater connection as a key knowledge gap, limiting our knowledge of deltaic ecosystem status. To address this gap, surface elevation mapping of approximately 1000 km^2 of the PAD was conducted during the summers of 2012 and 2013 using aerial remote sensing LiDAR. The surveyed areas contain 12 critical wetland monitoring sites where ground-based water level/depth, water quality, and aquatic ecology have been monitored for the past three years. The goal of this presentation is to present our assessment of surface water connectivity for select PAD wetland sites and outline an approach to integrate this newly available physical information into a novel aquatic ecosystem observation system for cold regions deltaic wetlands.

Abstract ID: 35937

Final Number: SE13B-02

Title: Real-time measurements of CO_2 and d^{13}C in volcanic gases on Mt. Etna (Italy)

Presenter/First Author: H.J. Hansjuerg Jost, Thermo Fisher Scientific, Hilterfingen,

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Co-authors: Andrea Luca Rizzo, National Institute of Geophysics and Volcanology, Rome, Italy; Marie-Anne Ancellin, Ecole Nazionale Superieure de Geologie, Vandouvre Les Nancy Cedex, France; Antonio Caracausi, National Institute of Geophysics and Volcanology, Rome, Italy; Peter Stow, Thermo Scientific, , ; Marcello Liotta, Seconda Università degli Studi di Napoli, Caserta, Italy; Marco Liuzzo, Istituto Nazionale di Geofisica e Vulcanologia, Palermo, Italy; Mauro Martelli, National Institute of Geophysics and Volcanology, Rome, Italy; Antonio Paonita, , ,

Published Material: We presented some of this material at the AGU 2014 Fall Meeting

Abstract Body: We present unprecedented data of real-time measurements of concentration and isotope (d^{13}C) composition of CO_2 in fumarolic and plume gases acquired in 2013 and 2014 at Mt. Etna volcano by a laser based Isotope Ratio Infrared Spectrometer (IRIS). We performed about 360 measurements/hour that allowed to extrapolate the d^{13}C of volcanic CO_2. The calculated d^{13}C of Torre del Filosofo (TDF) fumaroles (2,900 m a.s.l.) result between -3.2±0.06‰ and -3.7±0.09‰, comparable to Isotope Ratio Mass Spectrometry (IRMS) measurements of discrete samples collected on the same date. Plume gases collected at more than 1 km from the craters show an extrapolated d^{13}C from -2.2‰ to +1.4‰, partially overlapping crater fumaroles analyzed by IRMS. We also compared Laser with MultiGAS technique in order to evaluate possible relations between d^{13}C and CO_2/SO_2 variations. This approach may represent an important step forward for volcanic monitoring.

Abstract ID: 36873

Final Number: SE13B-04

Title: Laser-based exploration of underwater hydrothermal vents: a multi-sensor payload proof of concept

Presenter/First Author: Pablo Sobron, SETI Institute Mountain View, Mountain View, CA

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Co-authors: Laura M Barge, Jet Propulsion Laboratory, Pasadena, CA; Anupam K Misra, Hawai'i Institute of Geophysics and Planetology, Honolulu, HI; Tayro Acosta-Maeda, Hawai'i Institute of Geophysics and Planetology, Honolulu, HI; Michael J Russell, Jet Propulsion Laboratory, Pasadena, CA; Ken Takai, JAMSTEC, Yokosuka, Japan

Published Material: Partial results (<25%) were presented at the GeoRaman conference in 2014.

Abstract Body: Underwater hydrothermal systems (UHS) are produced by volcanic activity (e.g. black smokers) or directly by water-rock reactions (e.g. serpentinization and production of alkaline vents). Either way, commercially valuable seafloor metallic minerals precipitate from hydrothermal fluid as it interacts with the cooler ambient seawater at or beneath the seafloor, and a new industry is emerging: underwater mining. Since the hydrothermal fluids and mineral precipitates that form in a particular vent are highly specific to the geological setting, new instruments and adaptive exploration concepts that are conducive to analyzing a variety of vent conditions are needed in order to characterize seafloor mineral deposits. In response, we have developed an innovative concept for a robotic payload for UHS exploration. It utilizes high resolution 3D mapping and synergistic laser Raman and laser-induced breakdown spectroscopy (LRS+LIBS) to perform integrated, context-preserving, stand-off, in-situ characterizations of vent fluids and mineral precipitates.

In this work we describe an early-stage prototype and discuss a proof-of-concept demonstration of our payload. The samples are mineral precipitates from the chimney wall of a deep-sea black smoker at the mid-Okinawa Trough. We simulate underwater operation by immersing solid samples in a seawater tank and measuring LRS+LIBS from the outside of the tank. The microimages and the LRS and LIBS spectra show features consistent with sulfides, mainly chalcopyrite, a common metal sulfide mineral in acidic hydrothermal systems. The data obtained so far (1) demonstrate the feasibility of using LRS+LIBS for identifying minerals in black smoker precipitates in-situ and in near real time, and (2) help guide the definition of top-level instrument requirements, concepts of operation, and measurement strategies for the in-situ exploration of UHS in the deep-sea using laser-based robotic payloads.

Abstract ID: 36695

Final Number: SE13B-05

Title: Conditional Random Field for per-line classification of laser point clouds

Presenter/First Author: Gunho Sohn, York University, Toronto, ON

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Co-authors: Chao Luo, , ,

Published Material: A main findings of this presentation was presented at Photgotammetic Computer Vision Symposium in 2015 and published in ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information, II(3):79-86. The presentation will extend it to enabling the proposed Conditional Random Field (CRF) to classify laser point clouds not only in along scannding direction, but also across scanning direction as well. Also, the presentation will demonstrate its application of both static and mobile laser scanning data.

Abstract Body: In recently years, laser scanner rapidly becomes a primary acquisition tool due to its fast acquisition of massive three-dimensional point clouds. For fully utilizing its benefits, developing a robust method to classify many objects of interests from laser point clouds is urgently required. Conditional Random Field (CRF) is a well-known discriminative classifier, which integrates local appearance of the observation with spatial interactions among its neighbouring points in classification process. Typical CRFs employ generic label consistency using short-range dependency only, which often causes locality problem. In this paper, we present a multi-range and asymmetric Conditional Random Field (CRF) (maCRF), which adopts a priori information of scene-layout compatibility addressing long-range dependency. The proposed CRF constructs two graphical models, one for enhancing a local labelling smoothness within short-range (srCRF) and the other for favouring a global and asymmetric regularity of spatial arrangement between different object classes within long-range (lrCRF). This maCRF classifier assumes two graphical models (srCRF and lrCRF) are independent of each other. Final labelling decision was accomplished by probabilistically combining prediction results obtained from two CRF models. We validated maCRF's performance with TLS point clouds acquired from RIEGL LMS-Z390i scanner using cross validation. Experiment results demonstrate that synergetic classification improvement can be achievable by incorporating two CRF models. The presentation will extend it to enabling the proposed Conditional Random Field (CRF) to classify laser point clouds not only in along scannding direction, but also across scanning direction as well. Also, the presentation will demonstrate its application of both static and mobile laser scanning data.

Abstract ID: 36449

Final Number: SE13B-06

Title: Stand-off detection and mapping of mineral and organic compounds using ultraviolet Raman spectroscopy

Presenter/First Author: Evan Eshelman, York University, Toronto, ON

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Co-authors: Michael G Daly, York University, Toronto, ON, Canada; Greg Slater, McMaster University, Hamilton, ON, Canada; Peter Dietrich, MacDonald, Dettwiler and Associates Ltd., Richmond, BC, Canada; Jean-Francois Gravel, Institut national d'optique, Quebec, QC, Canada; Edward Cloutis, University of Winnipeg, Winnipeg, MB, Canada

Published Material: A paper discussing the instrumentation used in this work was published in Planetary and Space Science in 2014:Eshelman, E., Daly, M.G., Slater, G., Dietrich, P., Gravel, J.-F. An ultraviolet Raman wavelength for the in-situ analysis of organic compounds relevant to astrobiology(2014) Planetary and Space Science, 93-94, pp. 65-70.Some of the 2D mapping results on unprepared samples were presented at the Fall 2014 AGU conference in San Francisco:P21D-3955 Analysis of In-Situ Organic and Mineral Compounds Relevant to Martian Astrobiology Using 266 nm Raman Spectroscopy. Evan Eshelman, Michael G Daly, Greg Slater, Peter Dietrich, Jean-Francois Gravel and Edward Cloutis

Abstract Body: Developments in ultraviolet lasers and imaging systems have resulted in the potential for a stand-off ultraviolet Raman instrument that is capable of detecting and identifying low concentrations of mineral and organic compounds in-situ in either terrestrial or planetary settings. An ultraviolet wavelength offers several advantages over visual or infrared excitations, including reduced fluorescence in the Raman window, improved sensitivity due to the increased Raman cross section, and resonance with some organics. A sub-nanosecond laser pulse permits gating of the detector to reject fluorescence, and using an intensified CCD can increase the Raman signal to noise ratio. We present a Raman instrument with an excitation wavelength of 266 nm intended for the detection of organic compounds on Mars, and demonstrate the potential of an ultraviolet Raman system for performing spatial mapping of mineral and organic compounds on a millimeter to centimeter scale. We demonstrate the ability to perform this mapping on a suite of unprepared sedimentary samples containing endoliths from the Canadian Arctic and the Atacama Desert, and show that uneven topography and impurity of the sample do not prevent the ability to obtain spatial maps of the primary mineral and organic components. An ultraviolet Raman instrument such as the one presented is a valuable tool for definitive identification of organics and for determining mineralogy rapidly and non-destructively on unprepared samples in the field or on planetary surfaces. This research was carried out at the Planetary Instrumentation Laboratory at York University, and supported in part by both the Canadian Space Agency (CSA) and by the Natural Sciences and Engineering Research Council of Canada (NSERC).

Abstract ID: 33214

Final Number: SE13B-07

Title: Unfolding 3D Images of Underground Mining Tunnels

Presenter/First Author: PoKong Lai, University of Ottawa, Ottawa,

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Co-authors: Claire Samson, Carleton University, Ottowa, ON, Canada

Abstract Body: Laser imaging of underground tunnels is increasingly used in mining engineering practice. Using the point cloud output of the laser sensor, a three-dimensional (3D) triangular mesh model can be generated. While laser technology has allowed the topology of rock faces to be captured in unprecedented details, 3D mesh models are typically very large and difficult to manipulate which makes the inspection of the results laborious.

We present two different methodologies which "unfold" a 3D mesh model of undeground mining tunnels so that it can be viewed as one connected two-dimensional (2D) drawing. We first examined traditional surface parameterization algorithms, which are often used by artists in computer graphics, to convert an artibary 3D mesh model into a 2D drawing. We found that while these methods were automatic and could provide 2D drawings which have minimal metric distortion (ie: ensuring that area and angles in 3D are conserved in 2D), they are generally not intuitive to interpret. We then explored mesh deformation methods, often used in computer animation, to reshape the 3D mesh to resemble a 3D plane before applying an orthographic projection to produce a 2D drawing. We found that while these methods required user interaction, and introduced a greater amount of metric distortion, they resulted in more intuitive 2D drawings.

To discuss the relative merit of these two methodologies, a large underground mining tunnel was imaged by a laser camera system and a 8.2m wide by 41m long by 6.7m high subsection was selected for analysis. The metric distortion produced by both methodologies was measured and will be presented along with the output 2D drawings.

Abstract ID: 35081

Final Number: SE14A-0347

Title: Utilization of LIDAR for Geomorphological Analysis of Periglacial Features

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Abstract Body: Periglacial features such as polygonal terrain and gullies are common in polar environments of both Earth and Mars. The ability to accurately analyze and measure these features is crucial to understanding the geomorphological processes that shaped that environment. Historically, often the only way to analyze these landscapes was with traditional ground-based or aerial photography. The emergence of LIDAR scans to analyze terrains has led to multiple advancements over traditional photography, including independence from ambient lighting and the ability to record 3D data of the site at multiple angles and viewpoints. Geomorphological changes and features can then be identified and measured at a later date.

Field tests were carried out at the Haughton impact structure located on Devon Island in the Canadian Arctic in 2008, which included multiple LIDAR panoramic scans of polygonal terrain, gullies, and slump features. These point clouds were reanalyzed and incorporated into ArcGIS for analysis and measurement of these periglacial features. A case study was conducted on the polygonal terrain, with analysis of 30 polygons. Polygon perimeters range from 49 to 180 m, with an average perimeter of 96.7 m. Area of the polygons were also calculated, ranging between 129 and 1937 m^2, having an average area of 601 m^2. It was found that the ability to view these features from multiple viewpoints led to the ability to measure features that could not be measured in traditional photographs. Future scans of the same locations could be undertaken to identify changes over time.

The sensitivity of LIDAR to low angle topography makes it an excellent tool for analysis of periglacial features such as polygonal terrain and slump features. Due to the commonality of these features on Earth with those on Mars, we propose that the superiority of LIDAR over traditional photographs for geomorphological analysis makes a strong case for a LIDAR instrument to be included on a future Mars Polar Mission.

Abstract ID: 36594

Final Number: SE14A-0348

Title: Multisensor Data Fusion to Characterize Evolving Wetland Environments: An example from the Peace Delta

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Abstract Body: Wetland environments represent an early warning system for changing climates. Changes in flooding regimes of these wetlands, both in terms of timing and duration, can result from both natural and anthropogenic sources, however the results are the same. Wetlands comprise vegetation assemblages that occupy transitional zones between aquatic and upland environments. As such they are particularly sensitive to changes in hydrological regimes and moisture available for evapotranspiration that are reflective of changes to plant functional types and ecosystem services. This translates to changes to both the vegetation type as well as the morphology. The Peace Delta in northern Alberta represents one such wetland environment where, historically, frequent ice-jam induced flooding has resulted in a unique distribution of vegetation stand structures. Changes in the flow regime can result in changes to the frequency of flooding events. These changes in frequency have also resulted in changes to the vegetation structure and ecosystem services provided. Integrated field observations of historic flood levels and a high resolution airborne remote sensing data collection provides us with the opportunity to examine the vegetation structure within the context of historic flood patterns.

This presentation will describe the application of airborne multisensor (LiDAR and hyperspectral) data collected over the Peace Delta, and the application of these data to wetlands characterization. An area west of Fort Chipewyan covering approximately 300 square kilometres was flown in late August 2012. The sensor payload included a discrete multiple return scanning laser, a small imaging spectrometer (VNIR), and an RGB camera. We used the LiDAR digital elevation model (DEM) to derive a suite of terrain metrics. The vegetation point cloud was processed to correspond to the same grid resolution and extent as the upscaled terrain metrics, and a set of structural metrics biometrics were derived. Hyperspecral data were used to determine species.

This presentation will provide an oversight of the results of the analysis of the vegetation structure as represented by the annual flood levels and related it to changes in the flow regimes of the Peace River.

Abstract ID: 33432

Final Number: SE21A-02

Title: Defining the Iapetan Rifted Margin of Laurentia

Presenter/First Author: William A Thomas, Geological Survey of Alabama, Tuscaloosa, AL

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Published Material: Part of this presentation is a historical review of previously published interpretations, in keeping with the title of the session.

Abstract Body: The first interpretations of the Iapetan rifted margin of Laurentia explained curved salients and recesses of the Paleozoic Appalachian-Ouachita thrust belt as inherited from the shapes of embayments and promontories, respectively, of the late Proterozoic–Cambrian rifted margin. Contrasting interpretations attributed the shape of the rifted margin (1) to transform offsets of the rift or (2) to three-armed radial-rift triple junctions. Neither initially considered palinspastic location of the rifted margin, which is complicated because parts of the rifted margin are translated in Appalachian allochthons, whereas other Appalachian-Ouachita allochthons carried off-shelf sedimentary rocks onto the passive-margin shelf, leaving the rift margin in the footwall. Retrodeformed balanced cross sections (from outcrop geology, drill data, and seismic reflection profiles) support quantitative reconstruction of palinspastic locations of external basement massifs, synrift sedimentary and igneous rocks, passive-margin shelf carbonates and shelf-edge facies, and the rifted margin. The palinspastic reconstructions, gravity and velocity models, distribution of synrift sedimentary and igneous rocks, passive-margin thermal subsidence, and load-driven subsidence of synorogenic foreland basins contribute to distinction between upper-plate and lower-plate rift margins and transform margins of continental crust. Ages of synrift igneous rocks indicate two phases of extension (~775–650 and ~615–530 Ma), the significance of which, as well as implications for rifting processes, remains to be resolved. A few segments of the margin (e.g., the New York promontory) require more subsurface data for confident restoration. Documentation of extent and provenance of accreted exotic (generally Gondwanan) continental terranes will constrain the extent of native Laurentian crust. Expression of the rift and transform margins within the mantle lithoshpere may be resolved by EarthScope velocity data.

Abstract ID: 34385

Final Number: SE21A-03

Title: Shaping of the Appalachian orogen by the breakup of Rodinia and middle-to-late Paleozoic, zippered, transpressional processes: Geologic and geophysical evidence

Presenter/First Author: Robert D Hatcher, University of Tennessee, Knoxville, TN

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Co-authors: J. Wright Horton, , , ; David L. Daniels, , , ; Stephen L. Snyder, , ,

Abstract Body: The Paleozoic Appalachian orogen formed on the Laurentian margin via three orogenies that affected the entire orogen. The Ordovician Taconic orogeny involved arc accretion; the Late Devonian-Early Carboniferous Acadian-Neoacadian orogeny involved accretion of peri-Gondwanan terranes (Gander, Avalon, Meguma); and collison of Gondwana in the Late Carboniferous-Permian Alleghanian orogeny formed supercontinent Pangea. A fourth orogeny, the Late Ordovician to Early Devonian Salinic event, has been documented in the Maritime Appalachians with hints in the central Appalachians. The promontory-embayment shape of the western part of the Appalachian orogen was dictated by the irregular Neoproterozoic margin of Laurentia that formed during supercontinent Rodinia breakup. Much of the Appalachians remain buried beneath sedimentary cover of the Atlantic continental margin, but geologic and geophysical (magnetic and gravity) data locate tectonic boundaries and provide insights into terrane and pluton compositions. These data reveal that the interior (eastern and southern) parts of the orogen were shaped by middle-to-late Paleozoic accretionary-collisional transpressional, rotational processes (zippered), and that peri-Gondwanan terranes make up at least half of the orogen. Middle and late Paleozoic events were dominated by dextral strike-slip as Gondwana collided with Laurentia forming Pangea. Pangea breakup left the Suwanee terrane as a Gondwana remnant. Appalachian structure is truncated to the east by the East Coast magnetic anomaly, which may mark the original suture with Gondwana reactivated as the boundary of Pangea breakup. Despite the dominance of early (north) and late (southern-central) Paleozoic thrusting on the western margin of the Appalachians, strike-slip processes dominate interior parts of the orogen, and non-Laurentian, exotic terranes make up more than half of the orogen.

Abstract ID: 33251

Final Number: SE21A-04

Title: Evolution of the Tyrone arc system during the Grampian (=Taconic) orogeny: field, geochemical, geochronological and isotope (Nd, Sr) constraints

Presenter/First Author: Steven Philip Hollis, CSIRO Earth Science and Resource Engineering Perth, Perth, WA

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Published Material: This presentation details our current understanding of the Tyrone Igneous Complex and its role within the Grampian orogen based on recent PhD work by the lead author. The U-Pb zircon age constraints and geochemical data have been published in (Cooper et al. 2008, 2011 - J. Geol Soc, London; Hollis et al. 2012 - GSA Bulletin; Hollis et al. 2013ab - J. Geol Soc, London; Hollis et al. 2014 - Mineralium Deposita). Unpublished data includes new field constraints, whole rock geochemistry, and isotope (Nd, Sr) analyses. Several U-Pb zircon ages are in preparation from key localities across the complex. This work integrates ~350 whole rock geochemical analyses, 19 U-Pb zircon ages (+preliminary, if available), 26 Sr isotope and 55 Nd isotope constraints.

Abstract Body: The Tyrone Igneous Complex of Northern Ireland records the evolution of a relatively short-lived arc system and its accretion to the Laurentian margin during the Grampian orogeny. The ca. 484-479 Ma Tyrone Plutonic Group forms the structurally lowest levels of the complex and preserves a tectonically dissected suprasubduction ophiolite (εNd_t +4.4 to +7.7; $^{87}Sr/^{86}Sr_i$ 0.7039-0.7106), obducted onto an outboard fragment of micro-continental crust (the Tyrone Central Inlier) prior to ca. 470 Ma. The structurally overlying ca. 475-469 Ma arc-related Tyrone Volcanic Group includes mafic to intermediate lavas, tuffs, rhyolite, banded chert, ironstone and argillaceous sedimentary rocks. Geochemical and isotopic signatures are consistent with its formation in an evolving peri-Laurentian island arc/backarc (εNd_t -4.1 to -13.8) that was contaminated by continental crust and underwent several episodes of extension. Rift-related magmatism is characterized by the presence of (i) Fe-Ti rich eMORB (εNd_t +0.6 to +5.9), island-arc tholeiitic basalt (εNd_t +4.8) and FIV-affinity rhyolite breccias in the ca. 474-475 Ma lower Tyrone Volcanic Group; and (ii) OIB (εNd_t +1.3), alkali basalt (εNd_t +2.4) and FIII-affinity rhyolite in the ca. 473-469 Ma upper Tyrone Volcanic Group. Whereas calc-alkaline lavas and tuffs of the Tyrone Volcanic Group have strongly radiogenic $^{87}Sr/^{86}Sr_i$ values (0.7086-0.7212) between Middle Ordovician seawater and Laurentian continental crust, rift-related basalts display lower ratios (0.7055-0.7110) back towards primitive mantle. All units of the Tyrone Igneous Complex are stitched above the Tyrone Central Inlier by a suite of syn- to post-collisional I-type and arc-related intrusive rocks (ca. 470-464 Ma) which contain inherited Proterozoic zircons and have strongly contaminated isotopic signatures (εNd_t -7.1 to -12.2; $^{87}Sr/^{86}Sr_i$ 0.7120-0.7196). Potential correlations across the British and Irish Caledonides will be discussed.

Abstract ID: 35070

Final Number: SE21A-05

Title: Detrital zircon U-Pb geochronology of the Magog Group, southern Québec Appalachians - tectonic implications.

Presenter/First Author: Morgann Gwenva Perrot, University of Quebec at Montreal, Montreal, QC

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Co-authors: Alain Tremblay, GEOTOP, Montréal, QC, Canada; Jean David, GEOTOP, Montréal, QC, Canada

Abstract Body: In the Southern Quebec Appalachians, the Laurentian continental margin (Humber zone) and adjacent oceanic domain of the Dunnage zone were amalgamated during the Ordovician Taconian orogeny. The Dunnage zone includes ophiolites, overlying synorogenic Ordovician deposits of both the Saint-Daniel Mélange and Magog Group and the remnants of a peri-Laurentian volcanic arc, the Ascot complex.

The Magog Group consists of ~3 km pile of sandstone, felsic volcaniclastic rocks, graphitic slate and sandstone at the base (Frontière, Etchemin and Beauceville formations) overlain by a ~7 km-thick of a turbidites flysch sequence, constituting the St-Victor Formation at the top. The maximum age limit for the Magog Group is currently considered to be Caradocian based on graptolite fauna. This has been proven consistent with a 462 +5/-4 Ma (U-Pb ID-TIMS) from a felsic tuff of the Beauceville Formation, but in obvious contradiction with a detrital zircon U-Pb age of 424 ± 6 Ma recently measured in the St-Victor Formation. A detrital zircon U-Pb geochronology study (LA-HR-ICPMS), focused on the St-Victor Formation, has been therefore initiated in order to better constrain the age and tectonic evolution of the Magog Group. Results were treated according to a Bayesian mixture modeling to highlight different age populations. A feldspar-rich sandstone, directly overlying the Ascot Complex (ca. 460 Ma) and belonging to the base of the St-Victor Formation, yielded ages as young as 431 ± 3 Ma (Wenlockian). Higher in the stratigraphy, a quartz-feldspars sandstone sample contains zircons as young as 419 ±2 Ma (Pridolian). Finally, another sandstone sample from the stratigraphic top of the analyzed sequence yielded a bimodal age distribution, showing prominent populations clustering around ca. 950 Ma and ca. 435 Ma.

These preliminary results suggest a time gap as high as 30 m.y. between the St-Victor Formation and underlying rocks of the lower Magog Group and the Ascot Complex. Combined with current mapping in southern Quebec, this implies the probable occurrence of a major unconformity at the base of the St-Victor, and suggests that a large part of the Magog Group sedimentary sequence has been the result of post-Taconian sedimentation rather than that of a typical forearc sequence as commonly reported in literature.

Abstract ID: 36001

Final Number: SE21A-06

Title: Recognizing the Cambrian Rheic margin in the Kings Mountain terrane of Carolinia

Presenter/First Author: Allen J Dennis, Univ South Carolina Aiken, Aiken, SC

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Published Material: Isotopic data reported at Annual Meeting Geological Society of America, 2012, 2013. Portions of this material presented on Field Trip of Carolina Geological Society, November, 2014. Tectonic model presented at SE Section Geological Society of America, 2015.

Abstract Body: The youngest stratified rocks in Carolinia are within the Blacksburg Formation of the Kings Mountain terrane and the Asbill Pond Formation of the Carolina slate terrane. The 4-5 km thick sedimentary section of the Kings Mountain terrane is interpreted to have been deposited on the lower plate of the rifted Gondwanan Rheic margin, probably adjacent to the Paraguan craton, between 522 – 497 Ma. The Asbill Pond Formation is nominally 1-2 km thick and lies in angular unconformity above the Persimmon Fork and Emory Formations; biostratigraphy of the Asbill Pond Formation indicates it belongs to the *P. atavus* zone (504.5 – 503 Ma) of the Drumian, Series 3, Cambrian. The

Asbill Pond Formation is interpreted to have been deposited on the upper plate rift shoulder of Carolinia. Thus the Kings Mountain terrane and the Asbill Pond Formation are interpreted to been deposited on Carolinian basement on either side of the asymmetric Rheic rift detachment. The present disposition of the Kings Mountain terrane between the Charlotte terrane and the central Piedmont shear zone is an artifact of later terrane dispersal. The Kings Mountain terrane is interpreted to have formed near the North Carolina slate terrane; the epiclastic portion of the Battleground Formation accepted detritus from both the older Hyco-Aaron arc and the younger Uwharrie – Albemarle arc. Additionally the epiclastic section records significant input from Rondonian-San Ignacio (1.55-1.3 Ga) and Sunsas (1.28-0.95 Ga) basement. This interpretation is consistent with 1.551 Ga and 1.229 Ga inheritance reported by Mueller et al (1996) for this part of the North Carolina slate terrane. Above the Jumping Branch Manganiferous Member of the Battleground Formation, the Ediacaran-Cambrian component of the detrital spectrum is lost, and all grains are derived from Amazonian-Paraguan Gondwana. Rheic ridge incision is interpreted to have separated the Kings Mountain terrane from the Gondwanan Paraguan craton.

Abstract ID: 35659

Final Number: SE21A-07

Title: Provenance of Cape Spear Member conglomerates in the Ediacaran Cuckold Formation, Flatrock area, eastern Newfoundland: Implications for Avalonian paleogeography

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Abstract Body: Attempts to constrain Avalonia’s position along the Gondwanan margin during the late Neoproterozoic have been a subject of intense debate since it was first recognized that the eastern flank of the Appalachian orogen is composed of exotic terranes. A consensus has been reached that Avalonia was one of several peri-Gondwanan terranes adjacent to the Amazonian or West African cratons, but its precise location is still controversial. To further test the paleoposition of Avalonia, we conducted new field and detrital zircon U-Pb provenance studies of red-bed fluvial strata within the Cape Spear Member of the Ediacaran Cuckold Formation in eastern Newfoundland. The main objective of the study is to identify Amazonian- or West African-derived detrital zircons in the Cape Spear Member in order to advance the long-standing debate about Avalonia’s position along the Gondwanan margin.

Fieldwork and detrital zircon sampling near the community of Flatrock, 20 km north of St. John’s, focused on a 5 m-thick conglomerate section of the Cape Spear Member with “exotic” clasts of pink quartzite, quartz-sericite schist, and other low-grade metamorphic rocks that have no known source. Clast counts were conducted at five separate stratigraphic levels in the conglomerate section (100 counts each). Locally derived volcanic and plutonic rock clasts comprise 95% of the unit, whereas the exotic clasts occur at a 5% level. Four detrital zircon samples were analyzed with laser ablation (LA-ICP-MS) techniques and include cobble-sized clasts of pink quartzite (85 analyses) and feldspathic sandstone (75 analyses) from the exotic section, a whole-rock conglomerate sample from the exotic section containing clasts and sand matrix (76 analyses), and a whole-rock sample of pebbly sandstone collected 10 m below the base of the exotic section (76 analyses). The new U-Pb results will be compared to published detrital zircon reference frames for the peri-Gondwanan terranes and the Amazonian and West African cratons to test sediment source regions and Avalonian paleogeography.

Abstract ID: 33884

Final Number: SE24A-0349

Title: Far-field effects of Silurian-Early Devonian Appalachian/Franklinian orogenesis: a view from the craton

Presenter/First Author: Nicolas Pinet, Geological Survey of Canada Quebec, Quebec,

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Published Material: An abstract on the same topic has been submitted at the 2015 EGU meeting

Abstract Body: Study of Tethyan orogenic belts indicates that stresses related to plate-interaction affect wide areas, sometimes at considerable distances from mountain fronts. This contrast with eastern and northern North America, where only two regional-scale tectonic features preserved clear evidence of significant Silurian-Early Devonian tectonism: the Hudson Bay Central High (HBCH) and the Boothia uplift/Cornwallis fold belt (BUCF). This contribution makes the hypothesis that intra-plate faulting may contribute to the understanding of Paleozoic plates interaction and geometry by providing a view from the craton on processes that occurred at its margin.

In the Hudson Bay intracratonic basin, the lower part of the sedimentary succession is cut by high-angle faults and overlain by essentially underformed strata. The NNW-trending HBCH is the main structural feature of the basin and extends a minimum length of 500 km. The HBCH includes normal faults characterized by throws up to 500 m that were mainly active during the Silurian - Early Devonian period.

The BUCF is a >700-km long, N-trending feature. In its southern segment (Boothia uplift), it is characterized by an east-dipping reverse fault that puts Precambrian rocks over Paleozoic strata. In its northern segment (Cornwallis fold belt), the Paleozoic succession is involved in open folds and cut by steeply dipping reverse faults. Syn-tectonic sediments constrain the age of structures to the latest Silurian-Early Devonian.

Comparison of the HBCH and BUCF indicates that they are grossly parallel, partly contemporaneous but with different kinematics, suggesting linkages with different segments of the Appalachian/Franklinian orogen. A working hypothesis is proposed in which the HBCH was dynamically linked with the Appalachian orogen located >1400 km to the SE through several grabens. A major change in strike of the developing Franklinian orogen north of the Canadian Arctic islands is proposed and successfully accounts for the orientation and kinematics of the BUCF. In this hypothesis, the nearly perpendicular trends of the BUCF and Franklinian mobile belt were developed in latest Devonian-earliest Carboniferous, well after the formation of the BUCF.

Abstract ID: 34154

Final Number: SE24A-0350

Title: Applications of (U-Th)/He Thermochronology to the St. Lawrence Platform/Humber Zone Sedimentary Basin

Presenter/First Author: Justin Emberley, University of Ottawa, Gatineau,

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Co-authors: David A Schneider, University of Ottawa, Ottawa, ON, Canada

Abstract Body: The St. Lawrence Platform and Humber Zone of the W Appalachians has been cited as a potential hydrocarbon reservoir. Previous vitrinite reflectance studies on the basin determined the degree of thermal maturation yet the timing of the thermal events is not well understood. Through the application of apatite and zircon (U-Th)/He thermochronmetry it is possible to resolve the time/temperature events, as a consequence of burial and exhumation, through a 60-180°C window. Late Cambrian to Late Ordovician siliciclastic samples were collected from exposed outcrops along three parallel transects that extend through the St. Lawrence Platform into the Humber zone. From each sample, 5 apatites and 10 zircons were selected for analysis. Samples collected from the autochthonous platform have not been affected by tectonic burial or displacement during the formation of the Appalachians; thermal maturation is directly proportional to depth of burial by sedimentation and thus stratigraphic age. These sub-horizontal sequences typically have a low degree of thermal maturation (1.0< R_o >2.0) with an increase to the SW, along the long axis of the basin, and to the SE. Moderate subsidence in the SW, due to increasing distance from the rigid basement of the Shield, and a new cycle of sedimentation after the Taconic Orogeny is a likely cause for the increase in maturation. Timing of exhumation that occurred after the formation of the fold belt and renewed sedimentation of the Taconic Orogeny, will be resolved by AHe and ZHe cooling ages. Samples collected east of Logan's Line in the allochthonous Humber Zone, deposited during the Early to Middle Paleozoic, have been tectonically displaced during the Taconic Orogeny. Maturation increases from R_o:1.0 in the northwest to R_o > 4.0 in the southeast, primarily due to synorogenic heating as tectonic overburden increases. New AHe and ZHe data will provide constraints on the timing of low temperature tectonism defined by exhumation of the Taconian.

Abstract ID: 34209

Final Number: SE24A-0351

Title: Rift Flank Uplift and Thermal Evolution of an Intracratonic Rift Basin (Eastern Canada) Determined by Combined Apatite and Zircon (U-Th)/He Thermochronology

Presenter/First Author: Rebecca Hardie, University of Ottawa, Ottawa,

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Co-authors: David A Schneider, University of Ottawa, Ottawa, ON, Canada; James R Metcalf, University of Colorado - Boulder, Boulder, CO; Rebecca Marie Flowers, Univ of Colorado, Boulder, Boulder, CO

Abstract Body: As a significant portion of the world's oil reserves are retrieved from rift systems, a better understanding of the timing of thermal evolution and burial history of these systems will increase the potential for the discovery of hydrocarbon-bearing rifts. The Ottawa Embayment of the St. Lawrence Platform is a reactivated intracratonic rift basin related to the opening of the Iapetus Ocean at ca. 620-570 Ma, followed by the formation of the well-developed continental passive margin. Siliciclastic sediments derived from the adjacent uplifted Neoproterozoic Grenville basement provide the basin fill material. Apatite and zircon (U-Th)/He thermochronology allows for low-temperature analysis across the exposed crystalline rift flank into the synrift sedimentary sequence to resolve the unroofing, burial and subsidence history of the region. Samples were collected along a ~250 km NE-SW transect, oblique to the axis of the rift, from Mont-Tremblant, Québec (~900 m) to the central axis of the Paleozoic rift in the Southern Ontario Lowlands (~300 m). Targets included Neoproterozoic metamorphic rocks of the Grenville Province along the rift flank and basinal Cambro-Ordovician Potsdam Group. Samples from the rift flank yield zircon ages from ca. 650 Ma to ca. 560 Ma and apatite ages from ca. 290 Ma to ca. 190 Ma, with a weak positive correlation between age and grain size. By incorporating (U-Th)/He ages with regional constraints in the thermal modelling program HeFTy, viable temperature time paths for the region can be determined. Through inverse and forward modeling, preliminary rift flank (U-Th)/He ages correspond to post-Grenville cooling with < 4 km of post-Carboniferous burial. The data define slow and long episodes of syn- to post-rift cooling with rates between 0.4 and 0.1 °C/Ma. (U-Th)/He dating of samples along the full-length of the transect will resolve thermal changes in the basin-orogen system and improve our understanding of the rift related history of the region.

Abstract ID: 34963

Final Number: SE24A-0352

Title: Revised Geological and Tectonic Map of the Quebec Appalachians (Southern Sheet) : Lower St. Lawrence and Estrie-Beauce Areas, Canada.

Presenter/First Author: Alain Tremblay, GEOTOP, Montréal, QC

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Co-authors: Morgann Gwenva Perrot, University of Quebec at Montreal, Montreal, QC, Canada; Stéphane de Souza, , , ; Robert Thériault, , ,

Abstract Body: The Quebec Appalachians comprise three major lithotectonic assemblages : the Cambrian–Ordovician Humber and Dunnage zones, and the Upper Ordovician-Middle Devonian cover sequence of the Gaspé Belt. The Humber and Dunnage zones are remnants of Laurentia and adjacent oceanic domain, respectively, and were amalgamated during the Ordovician Taconic orogeny. Together with the Gaspé Belt, these rocks were variably deformed and metamorphosed during the Devonian Acadian orogeny. Since the last two decades, targeted mapping and structural analysis, combined with U-Pb and $^{40}Ar/^{39}Ar$ analyses of selected magmatic and metamorphic rocks, have been critical to constrain the tectonic evolution of the Quebec Appalachians. Since 2010, an extensive program of geological compilation at the 1 : 50,000 map scale has been inititated in collaboration with the *Ministère de l'Énergie et des Ressources naturelles-Québec*. This contribution presents the 1 : 300,000 scale geological map and cross-sections that resulted from compilation and structural re-interpretation. The map covers a surface area of approximately 36,000 km^2. The Humber zone is represented as a fold-and-thrust belt, subdivided into a very low-grade external zone and an upper greenschist to amphibolite facies internal zone. To the SE, it is bounded by the Baie Verte-Brompton Line (BBL), a «late» and composite fault zone that bears components of normal and strike-slip faulting. The Dunnage zone is exposed to the SE of the BBL. It includes a (1) series of well-preserved to dismembered ophiolite massifs, (2) the Saint-Daniel Mélange, (3) the Magog Group, and (4) the Ascot Complex. The Gaspé Belt occurs in a series of synformal outliers in the Dunnage and Humber zones, and, to the SE of the La Guadeloupe fault, occupies the Connecticut Valley–Gaspé trough where it is represented by siliciclastic and volcanic rocks of the Saint-Francis Group and the Frontenac Formation. The revised structural interpretation shown in the map and sections involves the SE-directed tectonic transport of the Taconian crustal wedge of the Humber and Dunnage zones, followed by normal faulting and juxtaposition of the internal Humber zone and Dunnage zone rocks along the BBL-Saint-Joseph fault zone, and the formation of fault-bounded sedimentary basins, such as the Connecticut Valley–Gaspé trough.

Abstract ID: 35027

Final Number: SE24A-0353

Title: A Viable Thermochronometer for Carbonate-Dominated basins? Results of Conodont (U-Th)/He Thermochronology of Anticosti Basin, Eastern Canada

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Published Material: We presented preliminary data at Thermo2014, the international thermochronology conference, and GSA2014. We've added conodont data to that dataset and have new apatite fission track data from the basement that also pertain to the geologic history of Anticosti Island and the St Lawrence Platform throughout.While some of the data is similar to the previous presentations, the work has matured significantly.None of these data have been published in a journal or are yet under review for a publication.

Abstract Body: Apatite and zircon (U-Th)/He thermochronometry (AHe, ZHe) have become increasingly popular in sedimentary basin analysis due to advances in our understanding of thermally controlled diffusion of radiogenic helium. In particular, the AHe system is sensitive to temperatures that correspond to the onset of oil generation, and can provide accurate estimates to the thickness of eroded sedimentary columns. Unfortunately, these methods are of limited use in regions dominated by carbonate sedimentary rocks, as the accessory minerals required for the analyses are not common in the strata. An initial investigation suggested that the chemistry of, and He diffusion in, conodonts is kinetically similar to igneous apatite. Our study resolves to do a first-of-its-kind empirical investigation into the effects of temperature on conodont (U-Th)/He age, sampling a vertical profile in the subsurface of the Lower Paleozoic Anticosti Basin, Eastern Canada. In this study, ten samples were collected from two different boreholes. While sampling primarily targeted conodont-rich lithologies, material for AHe and ZHe thermochronology was also collected where available. Analyses of the crystalline basement (1700 m depth) yield a mean AHe age of 29 ± 2 Ma whereas the Ordovician Mingan sandstone (1520 m depth) record AHe ages between 64-40 Ma. These data, along with apatite fission track analysis and organic thermal maturity parameters are integrated to constrain potential thermal histories for each well. Preliminary conodont (U-Th)/He ages exhibit significant scatter: a few ages (78-26 Ma) are in accord with our existing borehole AHe data. Other age populations (113-97 Ma; 291-195 Ma) are likely associated with partial resetting during the model-derived heating events in the basin. Interestingly, several conodonts yielded ages between 464-425 Ma and have not experienced significant post-depositional He loss. Experiments to assess relationships between the observed age scatter and conodont morphology, structure and chemistry are ongoing. While conodont thermochronometry has great potential, more work is required to understand the complexities of this system.

Abstract ID: 36569

Final Number: SE24A-0354

Title: Early taconian subduction stages recorded by the metamorphic sole of the Mont Albert ophiolite (Quebec, Canada)

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Abstract Body: Metamorphic soles found at the base of obducted ophiolites provide valuable information on the early history of subduction / obduction systems. Metamorphic soles are characterised by rocks originating from the ocean floor (basalts and sediments in variable proportions) metamorphosed up to granulite facies, where the intensity of metamorphism increases to the top of the unit, towards the contact with peridotite. Their mafic and less frequently pelitic lithologies make them sensitive recorders of their pressure-temperature conditions of crystallization and allow radiometric dating. In addition, metamorphic soles have directly witnessed slab dehydration as they underwent similar fluid-producing metamorphic reactions before being accreted to the mantle wedge peridotites (i.e. before “underplating”). The mechanisms of underplating remain uncertain, because of the somewhat obscure link between weakening through fluid production and hardening via garnet crystallization, with direct consequences on the rheology of the plate interface.

In this study, we document metamorphic reactions occurring during the prograde history of the metamorphic sole of the Taconian (ca. 460 Ma) ophiolite from Mont Albert (Quebec, Canada). This metamorphic sole shows variably metamorphosed mafic and pelitic rocks with metamorphic gradients over the scale of 10 metres, with clinopyroxene-garnet-amphibole granulite facies mafic rocks at the contact with the overlying peridotites. Evidences of melting of pelitic lithologies increase towards the contact, and no remains of metapelites have been found within about 20 m from the contact. Fluid channelization and melt migration is evidenced by decimetric dykes and veins. Away from the contact, metamorphism intensity gradually decreases to greenschist facies with abundant hydrated silicates. The aim of the study is to provide constraints (i) on the pressure-temperature conditions of crystallization of observed mineral assemblages, (ii) on the nature of the fluids produced during prograde metamorphism (aqueous versus melt), and (iii) on the composition of these fluids. This will allow a better understanding of the rheological behaviour of subducting slabs in subduction zones and of amphibolites in the lower continental crust.

Abstract ID: 34198

Final Number: SE24A-0355

Title: New Constraints on Cambrian Stratigraphy and Correlations in Avalonia Based on Acritarchs in Atlantic Canada

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Abstract Body: Cambrian sedimentary rocks of Avalonian Nova Scotia (NS), New Brunswick (NB), and Newfoundland (NL) contain generally well preserved acritarchs recovered from the majority of sampled levels. The data provide considerable additional age constraints for the largely siliciclastic successions. The recovery of characteristic acritarchs that are also found in Baltica and other regions offers new possibilities for correlation, especially important for the scarcely fossiliferous Lower Cambrian. Acritarchs of the *Asteridium-Comasphaeridium* Zone, which on Baltica has been suggested to have a first appearance that approximates the base of the Cambrian, have been recovered from the lower part of the Ratcliffe Brook Formation (NB), the MacCodrum Formation (NS), and the Random Formation (NL). The Chapel Island Formation (NL) is dominated by leiosphaerids and *Granomarginata*, also possibly best assigned to the *Asteridium-Comasphaeridum* Zone. Acritarchs of the *Skiagia-Fimbriaglomerella* Zone, which on Baltica has been taken to approximate, or somewhat precede, the first global appearance of trilobites, has been recovered from the upper part of the Ratcliffe Brook Formation, close to the top of the Random Formation (NL), and from the Canoe Brook Formation (NS). In NB the late Early Cambrian *Heliosphaeridium-Skiagia* Zone has been identified from the top part of the Ratcliffe Brook Formation and the lower part of the overlying Hanford Brook Formation; in NS it is found in the upper part of the Canoe Brook Formation. The stratigraphic distribution of acritarch zones suggests alternative correlations among these areas of Atlantic Canada than those traditionally employed. Rich acritarch assemblages also have been recovered from Middle and Upper (Furongian) Cambrian units of NS and southern NB. Of particular note is the recovery of diverse acritarchs from the *Protolenus* Zone of the Hanford Brook Formation, which provides important new means of correlation of this unit, and which places dated ash beds from this unit in a more robust biostratigraphic context.

Abstract ID: 34893

Final Number: SE24A-0357

Title: RECONCILING MUTUALLY INCOMPATIBLE MODELS FOR THE TECTONO-STRATIGRAPHIC ZONATION OF THE VARISCAN OROGEN IN WESTERN EUROPE

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Abstract Body: The Late Paleozoic Variscan orogen in Europe is widely acknowledged to be the result of convergence and collision between Laurussia and Gondwana during closure of the Rheic Ocean. The orogen is classically divided into a number of tectonostratigraphic zones that have a distinctive curvature (Ibero-Armorican Arc, IAA) and record different aspects of the Late Cambrian-Early Ordovician opening of the Rheic Ocean and the migration of terranes from the Gondwanan margin towards Laurussia, as well as the tectonothermal events that accompanied the closure of that ocean and the development of the IAA. Although there is a general consensus that the curvature originated at some stage during the development of the Variscan orogen two models have emerged to explain the distribution of tectonostratigraphic zones:

(1) a consequence of indentation tectonics due to collision with Laurussia by a (Ibero-Aquitanian) promontory of Gondwana during the Devonian;

(2) development of the Cantabrian orocline at ca. 295 Ma at the inner core of the IAA, an interpretation supported by a wealth of paleomagnetic, structural and geochronological data.

These models have been viewed to be mutually incompatible because the former requires curvature along the Gondwanan margin prior to its ca. 400 Ma collision with Laurussia, whereas the latter requires that the tectonostratigraphic zones were linear prior to bending at ca. 295 Ma.

Recent sedimentological and structural data have rekindled the hypothesis that the Cantabrian Orocline is connected to a second orocline to the south (Central Iberian Orocline), highlighting the possibility that inner (Gondwanan) and outer (Laurussian) zones of the Ibero-Armorican arc may be structurally discordant with respect to each other, implying that the geographic limits of orocline formation are presently unclear.

The two models can be simply reconciled if the geography of Gondwana's leading edge was irregular, but the tectono-stratigraphic zones remained approximately linear within the inner zones of the putative Ibero-Aquitanian indenter and (ii) deformation associated with initial collision was largely accommodated by sinistral (SW Iberia) and dextral (Armorican Massif) motion along shear zones on either side of the promontory).

Abstract ID: 35272

Final Number: SE24A-0358

Title: Kinematics of Orocline Related Shortening in the Ponga Unit: Structural Analysis of the Tama Synform and the Rio Monasterio Antiform, Northern Spain

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Abstract Body: The Cantabrian orocline of NW Iberia is interpreted to be a secondary orocline that was formed by the vertical axis rotation caused by N-S shortening of an originally linear, N-S trending Western European Variscan Belt (WEVB). Here we report on a structural study of the WEVB foreland fold and thrust belt from the core region of the Cantabrian orocline. Our goal was to determine what, if any, structures within the fold and thrust belt are attributable to deformation during orocline formation.

The Ponga Unit, a tectonostratigraphic package in the hinge zone of the Cantabrian orocline, is characterized by a sinuous fold interference pattern. We restricted our study to the Rioseco, Laviana and Campo de Caso thrust sheets within the Ponga unit. The thrust sheets are folded forming the Tama synform and Rio Monasterio antiform. We collected over 800 structural data points across these two folds. This data, along with existing geological maps have allowed us to construct detailed quantitative cross-sections both parallel to the axial planes of the folds and perpendicular to the axes of these steeply-plunging folds (down plunge projections). Palinspastic restorations of these cross-sections suggest that 1) the Tama and Rio Monasterio folds post-date and deform the WEVB fold and thrust belt, 2) the folds accommodate north-south shortening that we relate to orocline formation, and 3) that shortening within the orocline hinge region exceeded 60%. WEVB thrust faults are continuous around the younger orocline-related folds, exhibit a stair-step geometry with thrusts climbing up-section to the east, and have related east-verging fault bend folds. Along the axial planes of the orocline-related folds, WEVB fault bend fold axes are perpendicular to the axes of the younger folds, and suggest that the principal compressive stress responsible for orocline formation was perpendicular to the principal compressive stress during WEVB fold and thrust belt formation.

Abstract ID: 35467

Final Number: SE24A-0359

Title:

Flexural accommodation of oroclinal buckling: A structural study of the Cantabrian orocline, NW Iberian Massif

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Published Material: These findings were presented in part at GSA 2014 in Vancouver.

Abstract Body: An 'orocline' is an orogen that expresses plan view curvature either developed over the course of orogen formation (progressive orocline) or subsequent to orogen formation (secondary orocline) by vertical axis buckling in response to a reorientation of regional compressive stress from orogen perpendicular to orogen parallel. An s-shaped pair of coupled oroclines characterizes the Iberian segment of the Western European Variscan belt. The more southerly Central Iberian orocline was only recently documented; the more northerly and well-exposed Cantabrian orocline is one of the best-studied structures of its kind. Structural continuity between the coupled Iberian oroclines suggests that they formed contemporaneously and in the same fashion, however, the nature of the development of the Cantabrian orocline remains a topic of significant debate. Interpretation of the Iberian coupled oroclines as secondary predicts buckling of an originally linear Variscan belt to have been accommodated, at least in part, by flexural shear. Exposures of the Ediacaran Narcea Slates within the so-called Narcea Antiform trace a 150 km long arcuate belt around the 180-degree Cantabrian orocline. In the Western flank of the Narcea Antiform, the Narcea Slates are characterized by a penetrative steep to vertical slaty cleavage (S1) and subparallel 2-km wide reverse shear zones with a penetrative fabric (S2) that are affected by asymmetric meso- to outcrop-scale vertical-axis folds with a dominant vergence toward the oroclinal hinge; i.e. fold sense is dominantly dextral in the southern limb of the Cantabrian orocline and dominantly sinistral in its northern limb. Vertical-axis folds affecting the Narcea Slates are of the appropriate scale and geometry to be parasitic structures developed in response to flexural shear within the limbs of the Cantabrian orocline. A model of formation of the Iberian coupled oroclines by buckling in response to a principle compressive stress oriented at a high angle to orogenic trend is therefore supported.

Abstract ID: 34370

Final Number: SE31A-01

Title: Developing a High Sensitivity Magnetic Gradiometer for Unmanned Aerial Vehicles

Presenter/First Author: Blair Walker, GEM Advanced Magnetometers, Markham, ON

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Abstract Body: It is anticipated that UAV-borne magnetometer systems will replace most ground portable and high resolution airborne magnetometer and magnetic gradiometer surveys. The predicted adoption of UAV-borne magnetic and magnetic gradient systems will only be possible if the data quality is comparable to what is collected with manned systems today.

After assessing a number of UAV vehicles, UASUSA's (Boulder Colorado) Tempest was selected as the platform to carry the ultra-light magnetic gradiometer; the selection was based on the minimal amount of magnetic interference generated by the vehicle, its available payload for a magnetic gradiometer system, its comparable range to a manned helicopter and its affordability.

The customizations to the Tempest included fitting the aircraft with wing tip pods for the GEM Systems' optically pumped potassium vapour magnetometer sensors and relocating servos in the wings that move the aircraft's control surfaces, closer to the fuselage to further improve the noise of the system.

For mineral exploration applications requiring high resolution magnetic measurements, some ancillary software and hardware is required to account for any magnetic interference from the UAV. Those subsystems, which are compact and light weight equivalents of the systems on a manned aircraft, are all components of the GEM Systems UAV gradiometer.

An area near the boundary of the Paleozic Salina and Guelph formations, near Caistorville, Ontario, Canada, was surveyed with the customized unmanned aircraft system at a terrain clearance of 30 m. The survey site was chosen on the basis of its low magnetic gradients. The total magnetic intensity (TMI) and horizontal magnetic gradient data recorded were compared to that obtained during a conventional ground survey.

The study demonstrates that affordable, autonomous vehicles for collecting high resolution magnetic gradient data, are viable replacements for manned vehicle, and can be used in environments that may be too dangerous for a manned vehicle, or too costly / remote for manned vehicles.

Abstract ID: 36513

Final Number: SE31A-02

Title: Assessment of Magnetometers for Under 25kg UAS/RPAS Operations

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Abstract Body: There are currently a number of various magnetometers that are being developed for use with small (under 25kg total payload) Unmanned Aircraft Systems (UAS), or Remotely Piloted Aircraft Systems (RPAS). While it is clear that these systems will eventually become common in the geophysical survey industry, very little work exist that shows the comparison between potential UAS/RPAS compliant systems and the accepted manned aircraft versions that are currently the accepted standard for aeromagnetic surveying.

In this work we show the results of simultaneously flying various new UAS/RPAS compliant and standard manned magnetometers. The UAS/RPAS flights are performed on various fixed- and rotary-wing commercial UAV platforms, while the standard-manned comparison flights are performed on the National Research Council of Canada's (NRC) Convair 580 aeromagnetic research aircraft - the NRC's Convair 580 is the Government of Canada's national aeromagnetic testing aircraft. The measured values from all flights are comparatively analysed with each other and with the specifications of Federally-regulated aeromagnetic surveys.

The present investigation suggests that the quality of the data of potential systems is highly variable with some systems effectively matching the manned versions and others that perform poorly. This association currently, and not surprisingly, is proportional to expense, power requirement and weight of the UAS/RPAS compliant system.

Abstract ID: 34299

Final Number: SE31A-03

Title: Assessing the Capabilities of Unmanned Fixed and Rotary Wing Systems for Geomagnetic Surveying

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Co-authors: Claire Samson, Carleton University, Ottowa, ON, Canada; Alan Wood, , , ; Ian Cook, , , ; Buddy Doyle, , ,

Abstract Body: There is increasing interest in unmanned aircraft systems (UASs) for mineral exploration. UASs have the potential of providing higher resolution data and lower operation cost compared to traditional airborne platforms. However, there have been few studies assessing quantitatively the capabilities of UASs. This contribution presents a theoretical analysis of the UAS capabilities for geomagnetic surveying. The analysis uses: (1) mathematical models describing the magnetic response of geological targets, (2) design parameters from unmanned aircraft systems, such as the precision and accuracy of on-board magnetometers, and (3) realistic noise levels during surveys. Design parameters come from two separate systems currently under development. The first system is a 55kg (with fuel) fixed-wing UAS with a wingspan of 4.95m and a length (tail-to-tip) of 2.74m which is instrumented with two cesium vapour magnetometers in pods on each of the wing tips allowing it to record magnetic gradiometry. The second system is a rotary wing (i.e. helicopter) UAS that can fly as low as 2m above ground level. It is intended to become a cost-effective alternative to magnetic ground survey crew. The performance of these two systems for target identification is assessed for various geological target shapes (i.e. spherical body, vertical dykes, etc.) with a range of target size, depth, and magnetic susceptibilities. Further analysis on the longitudinal gradiometry capabilities of the fixed-wing UAS is performed to determine the minimum separation required between magnetometers to provide reliable data above a specified signal-to-noise ratio. Finally, an analysis focused on the expected data improvements from the enhanced ability of a UAS to closely follow topography (i.e. improved draping) is performed.

Abstract ID: 34025

Final Number: SE31A-04

Title: Development of Purpose-Built Remotely Piloted Aircraft Systems for Airborne Geophysics and Remote Sensing

Presenter/First Author: Jeremy Laliberte, Carleton University, Ottawa,

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Abstract Body: Since 2000, teams of Carleton University undergraduate and graduate students, under the guidance of faculty members and external advisors, have been developing a series of purpose-built remotely piloted aircraft systems (RPAS) for remote sensing and geophysical applications. This development program began with the *Hammerhead* RPAS (2000-2002) developed in collaboration with Transport Canada to support the detection of illegal bilge oil dumping by ships in Canadian waters. Over the two years, a detailed conceptual design and 1/3 scale flying prototype was built and taxi tested.

Next, in 2002, the Carleton team began collaborating with Sander Geophysics Ltd (SGL) to develop a purpose-built geophysics unmanned aircraft. This aircraft, *GeoSurv I* (1000 kg take-off weight), was designed to replace Cessna Caravan-class manned aircraft while carrying a full suite of geophysics instruments including a gravimeter, alpha ray spectrometer and cesium magnetometers. A 1/20 subscale demonstrator for wind tunnel and remote control flight testing was constructed. Next, from 2004-present, *GeoSurv II* (90 kg take-off weight) was designed and tested. A full-scale flight-ready prototype was built and subjected to several rounds of low and high speed taxi testing including a failed attempt at first flight. The *GeoSurv II* is presently undergoing a significant re-design and is being readied for a future flight attempt. From 2009-present the team designed the *Corvus*, a multi-mission small (25 kg take-off weight) remotely piloted aircraft. The *Corvus* aircraft was flown in October 2013 and is now being readied to carry magnetometers for geophysics flight testing starting in Summer 2015.

In this paper, the evolution of the design requirements and lessons learned from lab and field testing will be presented. Additionally, the authors will discuss the challenges of remotely piloted aircraft system design, certification and flight testing based on 15 years of accumulated experience.

Abstract ID: 35675

Final Number: SE31A-05

Title: Terrain Modelling - When to Use LiDAR and When Imagery Will Do

Presenter: Chris Polowick, , ,

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Abstract Body: Organizations waste valuable time, spend unnecessary money and risk lives in performing survey operations that are required to fulfil their corporate purpose, be it mining exploration, oil and gas surveying, forestry management or agriculture operations. For this reason, unmanned aircraft systems have experienced a dramatic increase in popularity. This technology, outfitted with the latest in remote sensing technology can provide an array of data collection capabilities up to survey-grade accuracy. Photogrammetric methods are a proven method of generating a variety of orthorectified imagery, in addition to digital elevation models, but can be limited in accuracy and point density depending on the specific application. These capability gaps have been filled by aerial LiDAR technology, which when coupled with aerial imagery, has excelled to form the basis of remote sensing data for a variety of industries. Although, the large difference in sensor cost has limited the majority of unmanned aircraft to photogrammetric technology. NGF's experience with UAV LiDAR has demonstrated the advanced capabilities for applications where imagery won't do. An analysis is presented of the capabilities and limitations of photogrammetry compared to LiDAR as they apply to real-world applications. This considers several variables such as: terrain profile, point density, vegetation cover, accuracy, time-to-data, budget, in addition to primary feature extraction. Summarized by application and industry, the capabilities for cheaper photogrammetric surveys will be presented while detailing when the advanced capabilities of UAV LiDAR should be employed to not compromise on data quality.

Abstract ID: 36760

Final Number: SE31A-06

Title: UAV-based topographic and vegetation mapping in a northern peatland complex using Structure from Motion (SfM)

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Co-authors: Koreen Millard, Carleton University, Ottawa, ON, Canada; Doug Stiff, , , ; Lindsay Armstrong, , ,

Abstract Body: Vegetation and geomorphology are defining surface characteristics of northern peatland ecosystems that can be used to infer underlying hydrological and ecological processes. In recent years, airborne LiDAR-surveys have greatly enhanced our ability to quantify these surface characteristics with unprecedented precision and accuracy, but costs associated with LiDAR acquisitions are often prohibitive, especially in remote areas. This presentation will report on our ongoing efforts to map surface topography and vegetation in northern peatlands using small, multi-rotor UAV platforms, low cost digital camera equipment and 3D surface generation with Structure from Motion (SfM). Results will be presented from two peatland complexes near Ottawa, ON: Mer Bleu Bog and Alfred Bog. Resolution, precision and accuracy of ground surface elevations and vegetation heights derived from UAV-based SfM will be compared against discrete-return, airborne LiDAR surveys and derivatives at both locations over length-scales ranging from 10 – 100 m, demonstrating remarkable mapping capabilities over these relatively short distances. Limitations are encountered in low dense shrub conditions, along with practical challenges associated with surveying larger areas using small UAV platforms.

Abstract ID: 36421

Final Number: SE31A-07

Title: Unmanned Aerial Vehicle based Remote Sensing for crop disease monitoring and surveillance in Bomet county, Kenya

Presenter/First Author: Osunga MICHAEL Otieno, Regional Centre For Mapping Resource For Development, Kasarani,

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Co-authors: Eunice WANJIRU Kibung`a, Regional Centre for Mapping of Resources for Development, Nairobi, Kenya

Abstract Body: This project intends to develop remote sensing (RS) methods using unmanned aerial vehicle (UAV) for crop disease monitoring and surveillance in Bomet county, Kenya. The crop disease to be monitored is maize lethal necrosis disease (MLND). It has no cure and spreads rapidly through disease vectors .MLND was reported in Kenya in September 2011 in Bomet county. To date it has spread to other counties with negative implications. Maize crops are susceptible to MLND at all growth stages. Once infected the only option left for the farmers is to burn their maize plantations. According to agricultural ministry of Kenya, 2 percent of the national maize harvest was affected in year 2012.

UAV surveys are to be conducted over affected farmlands in Bomet county with intentions to detect early signs of MLND, to detect MLND infestation extent and damage degree and to detect pest and weed infestation level. The overall objective is to prevent MLND from spreading to unaffected maize fields.

Radiometric calibrations and geometric corrections would be applied on the acquired images. Extraction of information will be through band rationing and classification. Multi-spectral image processing would produce indices to be used to study maize crop health whilst classified images would identify crop cover clusters by differentiating the variations in spectral signatures in the image hence distinguish weeds and infected crops. The data contained in indices will be used to create crop health maps to highlight areas that require closer examinations. From classification, spatial distributions of classes in the crop field will be ascertained and be used in generating prescriptions for site-specific pest management. Classification and indices correlation would provide input data to generate prescription data to prevent the spread of MLND. From the findings, farmers in the area will be advised on the best practices to prevent the spread of MLND hence having a positive impact on their livelihoods.

Abstract ID: 33509

Final Number: SE31A-08

Title: Deployment of an unmanned aerial system to assist in mapping an intermittent stream network

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Abstract Body: The recent growth in the capability of unmanned aerial vehicles (UAVs) and systems (UASs) as airborne platforms for collecting environmental data has been very rapid. There are now ample examples in the literature of UASs being deployed to map fine scale vegetation patterns, glacier dynamics, soil moisture, canopy temperatures, turbulent heat fluxes, and river bathymetry. The purported advantages of UASs are their ability to collect spatial data over extensive areas at lower cost, lower risk, higher resolution, and higher frequency than ground surveys or satellite platforms. In this study, whether or not obtaining high resolution UAS imagery was advantageous for identifying an intermittent stream network was determined by comparing it to coarse scale satellite imagery collected for the same purpose. Because UASs that are typically deployed for these purposes have flight distance limitations, and there remains interest in obtaining widespread measurements of intermittent stream network dynamics, it was also determined if the higher resolution UAS imagery was an improvement to GPS acquired ground truth points for classifying an intermittent stream network with the same large scale satellite imagery. The UAS and satellite acquired imagery was derived from a visible spectrum camera capable of 5 cm resolution, and multispectral SPOT-5 with 10 m resolution, respectively. The SPOT-5 imagery with its relatively coarse resolution could not always detect the narrow intermittent stream, which was well resolved in the UAS imagery. When a classified UAS image was applied as a training area for the SPOT-5 image, the identification of the stream network improved. UASs have the potential to revolutionize hydrological research the same way that geographic information systems (GIS) did three decades ago. A final point of the paper will be to provide insight into the advantages and disadvantages of deploying a UAS to evaluate if this technology will live up to its potential.

Abstract ID: 34389

Final Number: SE32A-01

Title: Borehole Gravity Mining Applications Case Studies

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Abstract Body: This presentation reviews the Borehole Gravity technology and shows results from exploration surveys conducted by Abitibi Geophysics. GRAVILOG is a slim-hole gravimeter developed by Scintrex (Nind et al, 2007, First Break v 25). Based on miniaturized CG-5 surface meter technology, it resolves the gravitational field to 1 microgal with a repeatable accuracy of <10 microgals. The primary uses of borehole gravity in mining are detection and estimate of tonnage of mineralization and determination of in-situ apparent density.

Now explorationists can test an electromagnetic anomaly for a coincidental excess mass prior to determining the volume of mineralization. Borehole gravity readings and density determinations are not affected by poor core recovery, washouts, or cementing because measurements have a large radius of exploration and are not affected by the casing. In-situ apparent density is useful for deposit evaluation, grade control, structure, and rock property analysis. In-situ bulk density determinations helped James Mine in Labrador to complete the orebody tonnage estimate in spite of poor core recovery due to strong alteration.

The residual borehole gravity response over a nickel deposit near Sudbury showcases a typical cross-over anomaly. From this one-hole gravity survey a tonnage estimate was made that was close to the geologically derived estimate based on many holes.

A multi-hole gravity survey on Coulon Mines Lens 44 demonstrates excellent correlation of the 3D mass model from an unconstrained Stochastic 3D Inversion (Pejman Shamsipour et al, 2010, Geophysics v 75) compared to a geological model based on drilling. The borehole gravity detects the in-hole and the off-hole excess mass and the 3D unconstrained inversion accurately positions it straddling the geological model.

Borehole gravity data collected in five holes surrounding Hudbay's Lalor Mine show how density variations correlate with lithology and identify a potential new target.

Prudent use of borehole gravity to detect and estimate excess mass of target mineralization early in the exploration cycle can save money and time. Similarly, in-situ density measurements improve information on lithology and grade control. Multi-hole gravity data can be inverted to accurately position the excess mass model in a 3D subsurface space.

Abstract ID: 33786

Final Number: SE32A-02

Title: The Walferdange Underground Laboratory for Geodynamics in Luxembourg

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Abstract Body: The underground laboratory for geodynamics in Walferdange has been established more than 40 years ago. At the origin, it was dedicated to the development and test of instruments mainly used in tidal research and volcanology (gravimeters, titltmeters, strainmeters, water tubes, etc. ...). Since 2000, the activities have been concentrated on gravity. The laboratory was equipped with a superconducting gravimeter, an absolute gravimeter FG5X, two spring relative gravimeters Scintrex and two portable tidal spring gravimeters gPhone. The laboratory already hosted 3 international comparisons of absolute gravimeters. In 2013, for the first time, the international comparison of absolute gravimeters, traditionally organized by the BIPM in Sèvres, took place in Walferdange. Results from the recent developments will be presented: comparisons, calibrations as well as noise characterization of gravimeters. Finally, applications and new instrumental developments will be presented.

Abstract ID: 33802

Final Number: SE32A-03

Title: Using Airborne Gravimetry to Develop a Geoid-based Vertical Datum for the U.S. with the Redefinition of the American Vertical Datum (GRAV-D) Project

Presenter/First Author: Monica Youngman, National Geodetic Survey, Germantown, MD

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Co-authors: Vicki A Childers, NOAA, National Geodetic Survey, Silver Spring, MD; Theresa Damiani, National Geodetic Survey, Silver Spring, MD; Sandra A Preaux, NOAA, Boulder, CO; Simon A Holmes, SGT inc., Greenbelt, MD; Carly Weil, DST, Silver Spring, MD

Abstract Body: The U.S. National Geodetic Survey is nearing 50% completion of airborne gravity data collection through the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project, which was started in 2008 to modernize the vertical datum using a gravimetric geoid accurate to 1 centimeter where possible. With data collected over multiple decades and covering approximately 15.5 million square kilometers when complete, the GRAV-D project continues to face unique challenges to incorporate changing technology and research developments as well as demonstrate the improvements to the geoid. In this presentation we outline the evolution of collection and processing methods as well as results of ground validation and geoid improvement. We also discuss current and future research work, including the effects of kinematic GPS processing, platform motion and off-level corrections, and the potential to use unmanned aerial vehicles.

Abstract ID: 35317

Final Number: SE32A-04

Title: Gravitational Wave Astronomy: Listening To The Universe

Presenter/First Author: Giles Hammond, University of Glasgow, Glasgow,

Presenter/First Author Email: giles.hammond@glasgow.ac.uk

Published Material: 1. C. Bell et al., Experimental results for nulling the effective thermal expansion coefficient of fused silica fibres under a static stress, Classical and Quantum Gravity, 065010, 2014 2. S. Aston, et al., Update on quadruple suspension design for Advanced LIGO, Classical and Quantum Gravity, 235004, 2012 3. K. Tokmakov et al., A study of the fracture mechanisms in pristine fused silica fibres using high speed imaging techniques, Journal of Non-Crystalline Solids, 358, 1699-1709, 2012 4. G.D Hammond et al., Reducing the Suspension Thermal Noise of Advanced Gravitational Wave Detectors, Classical and Quantum Gravity, Vol. 29, 124009, 2012 5. A.V. Cumming et al., Design and development of the advanced LIGO monolithic fused silica suspension, Classical and Quantum Gravity, Vol. 29, 035003, 2012.

Abstract Body: Gravitational wave detectors are the most sensitive length measuring devices in the world. They are broadband long baseline interferometers capable of achieving 10^{-19}m/√Hz at a frequency of 10Hz, and operating up to a few kHz. A worldwide network of 2nd generation detectors is currently under construction/commissioning. This includes the US LIGO detectors with 4km long arms, the 3km VIRGO detector in Italy, GEO-HF in Germany and the KAGRA 3km detector in the Kamioke mine. The goal of these detectors is to measure gravitational waves, tiny ripples in spacetime which are produced by the most extreme environments in

the universe; including supernova, coalescing neutron stars and black holes. This will open a new window on the universe which is complimentary to our current electromagnetic view.

The detectors are limited by a variety of fundamental noise sources including gravity gradient noise, seismic noise, thermal noise and quantum noise. The latter is the effect of the Heisenberg uncertainly principle as applied to the free test masses of the interferometer. In this talk I will provide an overview of the science & sources which are being pursued and some of the technical challenges & hardware development necessary to push the limits of detection sensitivity; this will include the technology to hang 40kg mirrors on fused silica fibres for ultra low thermal noise systems and low scatter optical coatings. Many of these technologies have spin-offs in the field of precision measurement and gravity sensing, including fused silica borehole meters and low frequency MEMS gravimeters. I will further describe the future opportunities in the field, plans for future ground-based and space-based detectors, and the remarkable potential of gravitational wave astronomy.

Abstract ID: 36095

Final Number: SE32A-05

Title: Recent Advances in the FG5 Absolute Gravity Meter, Dynamic Gravity Meters, the Gphone, and Borehole Gravity

Presenter/First Author: Timothy M Niebauer, Micro-g Scintrex, Lafayette, CO

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Co-authors: Andrew Hugill, , , ; Ryan Billson, , , ; Fred Klopping, , , ; Patricia MacQueen, Colorado School of Mines, Golden, CO

Abstract Body: There have been large advances in the gravity meters that are being developed at Micro-g LaCoste, Inc. and Scintrex Ltd. These instruments span applications of absolute gravity, static spring gravity instruments that are useful for looking at low frequency gravity signals, dynamic gravity meters that can be used to measure gravity on an airplane or ship and even drone aircraft. Very small gravity meters are being developed to deploy in very deep vertical or horizontal boreholes for reservoir characterization.

The FG5 absolute gravity meter has recently been upgraded to have a longer dropping length. The additional length of freefall allows the extraction of the gravity and gravity gradient during a single drop. A counterweight has been added to the dropping chambers to greatly reduce the recoil of the dropping chambers. A novel method has been developed to balance the free-fall mass to reduce rotational errors.

Two other instruments derived from the FG5 are being developed that have multiple simultaneous freefall masses in the same vacuum system. These instruments directly measure vertical gravity gradients and higher order gradients can be measure simultaneously.

The gPhone noise has recently been reduced to very low noise level (~0.2microGal/sqrt(Hz)) consistent noise measurements measured by superconducting gravity meters. An interesting new method has been developed that is useful for characterizing instrument noise levels even in the presence of ambient seismic noise without the need to difference gravity meters.

An important advance in dynamic gravity meters that allow the much heavier damped beams to be used with a true force feedback loop to greatly reduce the crosscouplings that limited the performance of these gravity meters in high turbulence. The sensors are also being reduced in size so that they can be used in drone aircraft.

Finally, a new line of ultra-small gravity meter sensors have been developed to deploy in boreholes many miles deep in the earth. The sensors can be leveled in vertical or horizontal boreholes. These instruments will have great utility in reservoir monitoring applications in oil, gas, or water.

Abstract ID: 34646

Final Number: SE32A-06

Title: Gravity and Gravity Gradient Monitoring of Fluid Migration in SAGD Reservoirs: A modeling study

Presenter/First Author: Alexander Braun, Queens University, Kingston, ON

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Co-authors: E Judith Elliott, Queen's University, Kingston, ON, Canada

Abstract Body: Steam assisted Gravity Drainage (SAGD) is a process to mobilize heavy oil or bitumen through steam injection into a reservoir for increased production. Consequences of the injection of steam include a change in the subsurface density distribution, which outlines the fluid migration processes in the reservoir. Monitoring the status and changes of reservoirs is critical for optimizing production as well as mitigating socio-environmental risks associated with developing a reservoir. Time-lapse gravity is a recent approach to measure gravity or gravity gradient over time to infer subsurface mass redistribution. For SAGD reservoir monitoring, major obstacles include the required sub-microGal sensitivity to sense the small density changes as well as the significant noise level originating from other processes in the proximate environment. We develop forward models of two operational SAGD reservoirs and calculate the gravity and gravity gradient signals considering confirmed density effects of 0.05 to 0.25 g/cm^3 in the growing steam chamber. Results outline the importance of measuring gravity gradients for varying baselines in order to exploit its higher spatial focusing ability compared to gravity observations alone. At present, field-deployable superconducting gravimeters are the only relative gravimeters capable of performing such observations at the required sub-microGal level. The forward modeling results enable the development of optimized survey geometry and observation schedule. The models include realistic density distributions as well as randomly distributed variations of reservoir thickness and morphology of geological interfaces. Inversion of simulated gravity gradient data constrained by sedimentology and SAGD operational parameters will be presented.

Abstract ID: 34440

Final Number: SE32A-07

Title: Using Airborne Gravity Data to De-Risk Petroleum Exploration in Frontier Areas: An Example from the Cauca-Patia Basin of Colombia

Presenter/First Author: Malcolm Argyle, Sander Geophysics Ltd., Ottawa, ON

Presenter/First Author Email: argyle@sgl.com

Co-authors: David Westlund, Gran Tierra Energy Inc., Bogota, Colombia

Published Material: A more seismically oriented presentation related to the same project was presented at the CSEG-EAGE Land Seismic Workshop in Banff, Sep. 23-25, 2014.

Abstract Body: The search for petroleum is increasingly focussed on frontier areas, where there is little available subsurface information and exploration risk is high. In addition, these regions have often undergone tectonic activity, leading to complex structures. Acquiring seismic is time consuming and expensive, especially in remote areas, so having reliable information to target seismic line locations becomes critical. Airborne gravity data (usually acquired in conjunction with magnetics) is often useful in this situation, and can be used to target locations for acquiring seismic data, as well as to assist in the processing and interpretation of seismic data.

Gran Tierra Energy (GTE) has been actively exploring in several frontier areas, including the Cauca Patia Basin in Colombia (Figure 1). In 2012, GTE conducted an 8,757 line kilometre helicopter-borne aeromagnetic and gravimetric survey over the Patia sub-basin. The survey was flown and processed by Sander Geophysics Ltd. (SGL), and gravity data were acquired using SGL's airborne gravity system, AIRGrav (Airborne Inertially Referenced Gravimeter).

Results of the airborne survey are excellent, and the potential field data correlates closely with the basin boundaries and other mapped structural features (Figure 1). The potential field data were used along with surface geology to delimit the edges of the sedimentary basin and identify areas likely to result in inherently chaotic seismic data. The potential field data were also used to map areas where higher velocity material has been thrust over the lower velocity sediments, resulting in low velocity seismic zones. Conversely, the data were also used to indicate where lower velocity material is at the surface, in which case seismic imaging issues in these areas are likely the result of structural complexity rather than velocity inversions. Through an iterative analysis, the structural model was re-evaluated, resulting in the generation of a suite of exploration prospects.

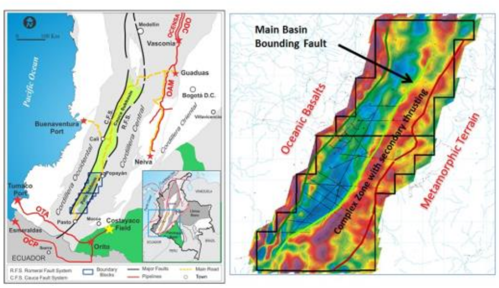

Figure 1. Regional setting (left), and first vertical derivative of the airborne gravity with major structural features (right).

Abstract ID: 34418

Final Number: SE32A-08

Title: Kauring Test Range Airborne Gravity Comparisons using AIRGrav Data Incorporating Measured Horizontal Components

Presenter/First Author: Stefan Elieff, Sander Geophysics Ltd, Ottawa,

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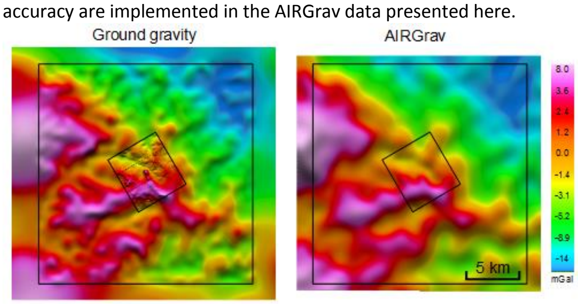
Co-authors: Stephen Ferguson, Sander Geophysics Ltd, Ottawa, ON, Canada

Abstract Body: A Sander Geophysics AIRGrav airborne gravity system was flown over Geoscience Australia's Kauring airborne gravity test site in Western Australia. The test site has been very carefully surveyed with land gravimeters for the purpose of making comparisons between airborne gravimetry and gradiometry results and the ground data. The survey area is divided into a 5 km by 5 km inner “AGG” area and a surrounding 20 km by 20 km “AG” area (see figure). Comparisons with both Geoscience Australia ground data over the “AG” area and airborne gravity gradiometer data acquired by CGG using the Falcon system over the “AGG” area are presented. A series of band pass filters of the vertical gravity and vertical gravity gradient are employed to highlight performance at different wavelengths. While the Falcon system is best suited to the shortest wavelengths present at the Kauring test site, the AIRGrav system is also able to resolve relatively short wavelength features. This is due to noise reduction through the oversampling present with tight line spacing combined with the unique characteristics of the AIRGrav system. Horizontal gravity components (or deflections of the vertical) have been obtained from the AIRGrav system using methods that incorporate the latest Australian geoid model. Improved techniques to combine the horizontal components with the vertical to increase vertical gravity accuracy are implemented in the AIRGrav data presented here.



Abstract ID: 33694

Final Number: SE33A-01

Title: Evolution and structure of Mercury's interior from MESSENGER observations

Presenter/First Author: Nicola Tosi, Technical University Berlin, Berlin,

Presenter/First Author Email: nic.tosi@gmail.com

Published Material: 75% of the talk will be based on two published papers and 25% on new materials that was only presented as a poster at the AGU Fall meeting 2014

Abstract Body: During the past four years, the MESSENGER mission (MErcury Surface, Space Environment, GEochemistry and Ranging) has delivered a wealth of information that has been dramatically advancing the understanding of the geological, chemical, and physical state of Mercury. Taking into account the latest constraints on the interior structure, surface composition, volcanic and tectonic history, we employed numerical models to simulate the thermo-chemical evolution of the planet's interior [1]. Typical evolution scenarios that allow the observational constraints to be satisfied consist of an initial phase of mantle heating accompanied by planetary expansion and the production of a substantial amount of partial melt. The evolution subsequent to 2 Ga is characterised by secular cooling that proceeds approximately at a constant rate and implies that contraction should be still ongoing. Most of the models also predict mantle convection to cease after 3-4 Ga, indicating that Mercury may be no longer dynamically active. In addition, the topography, measured by laser altimetry and the gravity field, obtained from radio-tracking, represent fundamental observations that can be interpreted in terms of the chemical and mechanical structure of the interior. The observed geoid-to-topography ratios at intermediate wavelengths are well explained by the isostatic compensation of the topography associated with lateral variations of the crustal thickness, whose mean value can be estimated to be ~35 km, broadly confirming the predictions of the evolution simulations [2]. Finally, we will show that the degree-2 and 4 of the topography and geoid spectra can be explained in terms of the long-wavelength deformation of the lithosphere resulting from deep thermal anomalies caused by the large latitudinal and longitudinal variations in temperature experienced by Mercury's surface.

[1] Tosi N., M. Grott, A.-C. Plesa and D. Breuer (2013). Thermo-chemical evolution of Mercury's interior. Journal of Geophysical Research - Planets, 118, 2474-2487.
[2] Padovan S., M. Wieczorek, J.-L. Margot, N. Tosi, and S. Solomon (2015). Thickness of the crust of Mercury from geoid-to-topography ratios. Geophysical Research Letters. In press.

Abstract ID: 34035

Final Number: SE33A-02

Title: Early geodynamic evolution of Mars-type planets with core-mantle coupling

Presenter/First Author: Siqi Zhang, Macquarie University, Sydney, NSW

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Co-authors: Craig O'Neill, Macquarie University, Sydney, Australia

Abstract Body: The coupling between the mantle and core is important in understanding the long-term evolution of the Earth and other terrestrial planets. However, most previous models use very simplified treatments for this coupling – eg. a predefined core cooling is often used in mantle dynamic studies. In our mantle dynamics models using the open-source code ASPECT, we developed a parameterized core evolution model which dynamically evolves with core-mantle boundary heat flux. It allows us to model the dynamic evolution of the core and the mantle together.

The question of whether Mars possessed mobile-lid or not still under debate, and the mechanism that generated Mars' early magnetic field is not well determined. We apply ASPECT to the study of the evolution of early Mars. To study the different possible evolutionary paths of early Mars-like planets, we explore a range of parameters such as initial conditions, the existence of surface water, and mantle rheology. We observed different behavior with different model settings; from either stagnant-lid or mobile-lid/episodic mantle convection regimes, and the planetary tectonics can shift from one state to another at certain critical points. In our models, we found that the dynamo activity is strongly related to the convection regime. Models with an early mobile-lid, or which demonstrated a mantle overturn, and which later shifted to a stagnant-lid, are more likely to generate dynamo activity that fits our current understanding of the magnetic history of Mars. And the cessation of mobile-lid tectonics is also likely the cause of the cessation of the dynamo. In the contrary, models that possessed only stagnant-lids throughout their entire evolution seldom produce similar dynamo behavior. From our models, we suggest that early mobile-lid tectonics, or an episodic overturn, is the preferred scenario for producing the early Martian magnetic field.

Abstract ID: 33995

Final Number: SE33A-03

Title: Mantle Viscosity

Presenter/First Author: Scott D King, Virginia Tech, Blacksburg, VA

Presenter/First Author Email: sdk@vt.edu

Abstract Body: One of the least-well constrained properties of the mantle is the viscosity. There are three approaches to constraining mantle viscosity: experimental studies of creep parameters; comparison of viscous flow models with geophysical observations, and guessing. There is actually a long and rich history of the latter approach. Due to the uncertainties of extrapolating from laboratory to geologic conditions, largely the large extrapolation in stress, experimental studies provide constraints on changes in viscosity as a function of temperature and grain-size. Geophysical constraints provide constraints on viscosity integrated over a finite depth interval and are thus non-unique. In this work I will test experimentally derived creep parameters by calculating geoid, dynamic topography, and plate velocities from 3D viscous flow models. The experimental constraints on the effect of pressure have large uncertainties and allow for either an increasing or decreasing in viscosity with depth. The uncertainties in the distribution of water and grain-sizes through out the mantle allow for a wide range of viscosity models.

Abstract ID: 34492

Final Number: SE33A-04

Title: Long Mantle Mixing Times for the early Earth Inferred from Convection Models with Grain-Damage

Presenter/First Author: Bradford J Foley, Carnegie Institution for Science, Washington, DC

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Co-authors: Hanika Rizo, Carnegie Institution for Science, Washington, DC

Abstract Body: The style of tectonics on the Hadean and Archean Earth, particularly whether plate tectonics was in operation or not, is hotly debated, with conflicting lines of evidence coming from geochemistry, petrology, and geodynamics. For example, Hadean zircons show evidence for low temperature, hydrous melting by ~ 4.0 Ga, indicating that some form of crustal recycling, and possibly even subduction, was active on the very early Earth. On the other hand, ^{142}Nd anomalies recorded in 3.8 to 3.4 Ga rocks from southwest Greenland and 2.7 Ga rocks from the Superior Province (Canada) indicate that chemically heterogeneous reservoirs, formed during the first ~ 100 million years of Earths' history, survived their remixing into the mantle for over 1 Gyr. Such a long mantle mixing time is difficult to explain with a traditional model of plate tectonics, where plate speeds increase significantly in the past due to a hotter mantle. However, a new model for generating plate tectonics from mantle convection based on grainsize reduction (called grain-damage) proposes that plate speeds may have decreased with increasing mantle temperature. Higher mantle temperatures lead to higher grain-growth rates that inhibit the formation of weak lithospheric shear zones. As a result, plate boundaries are more viscous and provide a stronger resistance to plate motions, and thus mantle mixing times may still be long even for Hadean or Archean mantle temperatures. We use new numerical models of convection with grain-damage to constrain mantle mixing times for the early Earth with the effects of grainsize variation included. We find that mantle mixing times remain long as mantle temperature increases because of faster grain-growth rates in the mantle and lithosphere. Therefore the preservation of chemical heterogeneities for over 1 Gyr in the Hadean-Archean mantle is not inconsistent with the operation of plate tectonics at this time, and geodynamic models of early Earth plate tectonics can be reconciled with geochemical observations.

Abstract ID: 33974

Final Number: SE33A-05

Title: The Influence of Subduction and Mantle Rheology on the Position of Large Igneous Provinces Following Supercontinent Formation

Presenter: Philip J Heron, University of Toronto, Toronto, ON

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First Author: Julian Philip Lowman, University of Toronto, Toronto, ON

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First Author Student?: No

Co-authors: Claudia Stein, University of Munster, Munster, Germany

Published Material: The majority of this work was presented at the 2014 Fall AGU and much of this work is currently included in a paper under review for JGR.

Abstract Body: Several mantle convection studies analyzing the effects of supercontinent formation and dispersal show that the genesis of subcontinental plumes results from the formation of subduction zones at the edges of the supercontinent, rather than from the effect of continental thermal insulation or thermo-chemical piles. However, the influence of subduction zone location on the position of subcontinental plumes has received little attention. This study analyzes 2D and 3D numerical models of supercontinent formation (in an isochemical mantle) to assess the role of subduction and mantle viscosity contrast in the generation of sub-continental mantle plumes. We find that once a critical supercontinent width is reached, plumes do not form under the center of a supercontinent. In studies featuring a relatively low viscosity lower mantle, the surface plume positions become locked at a distance 2000-3000km from the continental margins. The broad downwellings of simulations that feature a lower mantle viscosity 100 times greater than the upper mantle viscosity generate longer wavelength perturbations in the basal thermal boundary layer, forming plumes at a greater distance from the continental margin subduction. For all mantle viscosity profiles, sub-continental plumes show dependence on the location of supercontinent margin subduction. Furthermore, we analyze how subduction due to a dispersing supercontinent changes mantle dynamics and offer some discussion on the pattern of large igneous provinces post-Pangea breakup. As theories differ on the role of chemical piles in plume formation, it is significant that our isochemical models show that the formation of subduction zones at the margins of a supercontinent has a profound effect on subcontinental mantle dynamics. Our results may help to explain what determined the eruption sites of past (and future) large igneous provinces.

Abstract ID: 35152

Final Number: SE33A-06

Title: Seismic and Geodynamic Constraints on Lower-Mantle LSVP: Implications for Mantle Upwellings

Presenter/First Author: Alessandro M Forte, University of Quebec at Montreal UQAM, Montreal, QC

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Co-authors: Petar Glisovic, Université du Québec à Montréal, Montreal, QC, Canada; David B Rowley, University of Chicago, Chicago, IL; Nathan A Simmons, Lawrence Livermore National Laboratory, Livermore, CA; Stephen P Grand, University of Texas, Austin, TX; Chang Lu, University of Texas at Austin, Austin, TX

Published Material: Some preliminary results were presented in an oral presentation at the 2014 Fall Meeting of the AGU in San Francisco.

Abstract Body: Past efforts to obtain direct constraints on the composition and dynamics of so-called Large Shear Velocity Provinces (LSVP) in the lower mantle have used tomography-based mantle flow models. Such modelling requires additional assumptions on the relationship between seismic anomalies and density and on mantle viscosity, thus compounding the uncertainties already present in the global tomography models. Here we explore the range of these uncertainties and we evaluate the combined tomographic and geodynamic evidence for compositionally distinct material in the lower-mantle LSVP. We consider a suite of published tomography models, differing mantle viscosity inferences and a range of thermally-derived conversions of seismic velocity to density perturbations, yielding nearly 100 distinct models of mantle flow. We evaluate the geodynamic plausibility of each model by directly comparing their predictions of convection-related observables against the data. We find it is difficult to obtain a satisfactory fit to the combined set of surface geodynamic data (especially the global, long-wavelength gravity anomalies) and space-geodetic inferences of excess CMB flattening, with a purely thermal interpretation of lower-mantle heterogeneity. In contrast, the introduction of compositionally-distinct material in the central portions of the LSVP yields a notably improved fit to the gravity anomaly and CMB ellipticity data. We evaluate the dynamical implications of this deeply-rooted compositional heterogeneity by calculating the 3-D convective flow in the lower mantle, using a subset of the models that yield the best fits to the geodynamic data. The flow predictions reveal two dominant upwellings in the Pacific lower-mantle: below the East Pacific Rise (EPR) and under the Caroline Islands in the Western Pacific. The EPR "plume" has a special significance because of its obvious connection with the fastest spreading ridge on Earth today. Under the African plate the two dominant lower-mantle upwellings are below the East-African Ridge and the Cape Verde Islands. A separate large-scale upwelling is also found at high latitude under the North Atlantic. In summary, this analysis of the most robustly constrained lower-mantle upwellings reveals a constellation of five active large-scale plumes.

Abstract ID: 34214

Final Number: SE33A-07

Title: Constraining the Lithosphere-Asthenosphere Coupling from Geodynamical Modeling Based on Tomography Models over the North American continent

Presenter/First Author: Claudia Maria Adam, Virginia Polytechnic Institute and State University, Blacksburg, VA

Presenter/First Author Email: claudia.m.adam@gmail.com

Co-authors: Scott D King, Virginia Polytech State University, Blacksburg, VA; Mark J Caddick, Virginia Tech, Blacksburg, VA

Abstract Body: Understanding the interaction between the lithosphere and asthenosphere is one of the most fundamental problems in geodynamics, and coupling is especially complex in the continental context. We take advantage of major imaging improvements brought through the set up of the mobile EarthScope/USArray, to quantify this interaction. We couple the DNA13 tomography model with thermodynamic calculations to derive realistic density and temperature anomalies. We then compute instantaneous mantle flow in a 3D spherical geometry with realistic temperature and pressure dependent rheology, and derive the lithospheric stresses and the induced tectonic regimes. Our model can account for several complex seismicity patterns.

For example, the San Andreas Fault systems divide into three segments, each with different characteristics. Along the southernmost segment the deformation is transtensional, while the central and northern parts are in transpression. Our model reproduces this transition. We find radial extension between latitudes 30 and 35^{o}S, and compression between latitudes 35 and 39^{o}N, which may be related to a downwelling flow created by lithospheric drip. Our modeled stresses also reproduce the main characteristics of the surface deformation observed along the Yellowstone–Snake River Plain volcanic region. We predict extension over the tectonic parabola of deformation, as observed in focal mechanism and strain-rate tensors derived from GPS measurements. We also predict an extensional regime parallel to the volcanic track. Such a regime will develop faults perpendicular to the track direction, i.e. along the NW-SE direction, consistent with the direction of the Pleistocene-Quaternary major faults. In the New Madrid seismic zone, we retrieve the thrust regimes with a P-axis orientation along the NE-SW direction. This suggests that at least a part of the active seismicity is generated by the present-day state of the mantle, not to older re-adjustment processes.

Abstract ID: 34551

Final Number: SE33A-08

Title: The Effects of Internal Heating Rate, Rayleigh Number and Plate Representation on the Preponderance of Couette and Poisseuille Flows in the Asthenosphere

Presenter: Christine Shiels, University of Saskatchewan, Saskatoon, SK

Presenter Email: christine.shiels@usask.ca

First Author: Samuel L Butler, University of Saskatchewan, Saskatoon, SK

First Author Email: sam.butler@usask.ca

First Author Student?: No

Published Material: These findings were submitted for publication in Physics of the Earth and Planetary Interiors in November, 2014.

Abstract Body: It has recently been shown that mantle convection models with high viscosity surface plates and a low viscosity asthenosphere display two distinct flow types in the asthenosphere depending on the mobility of the surface plates. When plates are highly mobile, the flow in the asthenosphere is similar to a Couette flow and it is driven by the surface plate. When surface plates are sluggish, the asthenospheric flow is similar to a Poisseuille flow and is driven by lateral pressure gradients. When a low viscosity asthenosphere is present, large aspect ratio convection cells are found to arise and, contrary to the case with no asthenosphere, the surface heat flux is found to increase with increasing aspect ratio when the plates are sluggish. The difference in the flow type in the asthenosphere may thus be important for understanding Earth's thermal state and for understanding the pattern of seismic anisotropy in the upper mantle. In this study, we examine the effects of internal heating rate, mantle Rayleigh number and the representation of surface plates on the nature of the flow in the asthenosphere and on the dependence of surface heat flow with aspect ratio. We find that the flow type in the asthenosphere is fairly insensitive to the internal heating rate and Rayleigh number, however, in models with lower internal heating rates, the surface heat flow does not increase substantially with aspect ratio. However, when a force balance representation of surface plates is used, the flow regime in the asthenosphere is found to be insensitive to the plate aspect ratio and the surface heat flux decreases with convection cell aspect ratio.

Abstract ID: 34580

Final Number: SE34A-0331

Title: Study of the Earth's Interior using Measurements of Sound Velocities in Minerals by Ultrasonic Interferometry Robert C. Liebermann*[1,2,], Xuebing Wang[1], Ting Chen[1], Yongtao Zou[2], Baosheng Li[1,2] [1]*Department of Geosciences, Stony Brook University, Stony Brook, NY USA* [2]*Mineral Physics Institute, Stony Brook University, Stony Brook, NY USA*

Presenter/First Author: Robert C Liebermann, Stony Brook University, Stony Brook, NY

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Published Material: 3% published in PEPI in 2014

Abstract Body: This paper reviews the progress of the technology of ultrasonic interferometry from the early 1950s to the present day. During this period of more than 60 years, sound wave velocity measurements have been increased from pressures less than 1 GPa and temperatures less than 800K to conditions above 25 GPa and temperatures of 1800K. This technique is complimentary to other direct methods to measure sound velocities (such as Brillouin and impulsive stimulated scattering) as well as indirect methods (e.g., resonance ultrasound spectroscopy, static or shock compression, inelastic X-ray scattering). Newly developed pressure calibration methods and data analysis procedures using a finite strain approach are described and applied to major mantle minerals for the implication for the composition of the Earth's mantle. The state-of-the-art ultrasonic experiments performed in conjunction with synchrotron X-radiation can achieve simultaneous measurements of the elastic bulk and shear moduli and their pressure and temperature derivatives with direct determination of pressure. Recent examples of such studies are presented for a synthetic KLB-1 peridotite and polycrystalline SiO_2-coesite and the current status and outlook/challenges for future experiments are summarized.

This research is supported by the U. S. National Science Foundation and Department of Energy.

Abstract ID: 34571

Final Number: SE34A-0332

Title: Large-Volume, High-Pressure Research at GSECARS Beamlines, Advanced Photon Source

Presenter/First Author: Tony Yu, University of Chicago, Chicago, IL

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Co-authors: Yanbin Wang, The University of Chicago, Argonne, IL; Julien Gasc, University of Chicago, Argonne, IL

Abstract Body: The development of synchrotron-based large-volume high pressure (LVP) techniques for studying earth-related materials under extreme pressure and temperature (PT) conditions has been an ongoing effort at the GeoSoilEnviroCARS (GSECARS) of the Advanced Photon Source (APS). Over the years, these developmental efforts have enabled us to conduct coordinated studies on earth materials in both the solid and liquid states under high PT conditions. In this presentation we will show, with the following examples, how state-of-the-art techniques were used in our recent scientific studies: (1) high PT ultrasonic velocity measurements, (2) rheological properties of earth materials at high pressure and temperature, using the deformation DIA (D-DIA), (3) acoustic emission recording coupled with D-DIA for monitoring ductile vs. brittle behavior and reaction progress in rock deformation studies, (4) high pressure 3D imaging of composite materials using the high-pressure x-ray tomographic microscope (HPXTM), and (5) structure studies of non-crystalline materials using a Paris-Edinburgh Press (PEP) combined with a multi-channel collimator (MCC). These techniques have the potential to provide the community with a complete suite of tools for structure, density, elasticity and viscosity measurements of earth materials.

Abstract ID: 33481

Final Number: SE34A-0333

Title: Elastic and Inelastic Properties under Simulated Earth's Mantle Conditions in LVPs in Conjunction with Synchrotron Radiation

Presenter/First Author: Hans J Mueller, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam,

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Co-authors: Joern Lauterjung, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany; Christian Lathe, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany

Abstract Body: The interpretation of highly resolved seismic data from Earth=s deep interior require measurements of the physical properties of Earth's materials under experimental simulated Earth's mantle conditions. More than a decade ago seismic tomography clearly showed subduction of crustal material can reach the core mantle boundary under specific circumstances. That means there is no longer space for the assumption deep mantle rocks might be much less complex than deep crustal rocks known from exhumation processes. Viscosity data of melts measured under in situ high pressure conditions are crucial for the understanding of Earth's lower mantle and the interior of terrestrial and extrasolar Super-Earth planets. Consequently in situ data of the elastic and inelastic properties of complex Earth's materials are of extraordinary importance for the interpreation of geophysical data from great depths of planets. Recent large volume presses provide sample volumes 3 to 7 orders of magnitude bigger than in diamond anvil cells far beyond Earth's transition zone conditions. The sample size of several cubic millimeters allows elastic wave frequencies in the low to medium MHz range. Ultrasonic interferometry necessarily requires in situ sample deformation measurement by X-radiography. Time-resolved X-radiography makes in situ falling sphere viscosimetry and even the measurement of elastic and inelastic properties in the seismic frequency range by using the recent deformation technique achievable. This way current geophysical high pressure research is more and more bridging the gap between indoor and outdoor seismology. The paper presents recent techniques of geophysical high pressure LVP research and their results.

Abstract ID: 34673

Final Number: SE34A-0334

Title: Investigating the Possibility of Invariance in Electrical Resistivity in Transition Metals along their Pressure Dependent Melting Boundary

Presenter/First Author: Innocent Chinwe Ezenwa, University of Western Ontario, London,

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Co-authors: Richard Secco, University of Western Ontario, London, ON, Canada

Abstract Body: Understanding core cooling through heat conduction and modelling the geodynamo requires knowledge of the thermal and electrical conductivities of relevant liquid Fe alloys at high pressures. Fortunately, the electronic component of the thermal conductivity of metals, which dominates their conductive heat transport, can be calculated from the electrical conductivity using the Wiedemann-Franz law. Measurement of physical properties at core pressures and temperatures (P-T) are challenging which motivates an alternative approach. We take advantage of the fact that the interface between the solid inner core and the liquid outer core is on the high pressure melting boundary of the core constituents. Attempts to evaluate a theory that predicts the electrical resistivity of a metal is constant on its P-dependent melting boundary is on-going using a large volume press up to 5 GPa. The evaluation is being made on transition metals Cu, Zn and Ni which offer comparison of the roles played by filled and partially-filled 3d bands in the electrical resistivity. Using a four-wire resistivity method, experiments are being conducted to provide a possible way to access core conductivity values at low, relative to core, P and T. The aim is to apply electrical conductivity measurements on Fe at low P and T to the inner core boundary in order to study the thermal regime of the core.

Abstract ID: 35334

Final Number: SE34A-0335

Title: Detection of a Pressure-Induced Liquid ⇌ Solid Phase Transformation by Measuring Sound Velocity in a Multi-Anvil Apparatus

Presenter/First Author: Timothy Officer, University of Western Ontario, London, ON

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Co-authors: Richard Secco, University of Western Ontario, London, ON, Canada

Published Material: A samll portion (~20%) of this presentation was presented at the 2013 AGU fall meeting. These findings are currently under review.

Abstract Body: A technique for detecting and measuring phase transitions in a multi-anvil apparatus by measuring the change in longitudinal sound velocity as a function of pressure is reported. The system measures the time for pulsed ultrasonic signals to travel through a high pressure assembly with a sample in the center. Upon phase change from liquid to solid, the sound velocity shows an abrupt increase due to the intrinsic increase of velocity in the sample and a reduced delay between the triggering of an amplitude threshold and the arrival of the waveform. As a proof of concept, results are shown for Hg as it undergoes pressure-induced liquid ⇌ solid transitions at room temperature.

Abstract ID: 33596

Final Number: SE43A-01

Title: Botswana's Nationwide Tie Line Survey and New Magnetic Compilation

Presenter/First Author: Stephen Reford, Paterson, Grant & Watson Limited, Toronto, ON

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Co-authors: Mogomotsi Nyepetsi, Department of Geological Survey, Gaborone, Botswana; Gomotsang Tshoso, , , ; Mojaboswa Koketso, , , ; Billy Steenkamp, , , ; Abri Crous, , ,

Published Material: 13th SAGA Biennial Conference and Exhibition - 2013

Abstract Body: The Department of Geological Survey (DGS) of Botswana, over a period spanning the late eighties through to early 2000s, acquired high-resolution aeromagnetic surveys over most of the country except for the southwest (Nossop - Ncojane Basin) area. These surveys were mostly conducted at survey specifications of 250 m line spacing and 80 m mean terrain clearance. The line direction for each survey block depended on the dominant strike of the geology. Additional coverage of aeromagnetic survey data was provided by private exploration companies, in places, at higher resolution.

The compilation of the above individual, separate aeromagnetic surveys into one seamless magnetic grid and the long-term endeavour to produce a country-wide high resolution magnetic map prompted DGS to conduct a fixed-wing tie line magnetic survey over the entire country and then merge all existing high resolution aeromagnetic data. The country wide Tie Line Survey serves as a reference datum for past and for future surveys and preserves a full magnetic spectrum magnetic anomaly map of Botswana. Most institutions have opted for the use of satellite magnetic data and/or occasional/sparse low altitude magnetic traverses in an attempt to define a datum for merging multiple surveys to generate a single seamless compilation. However, near-earth satellite magnetic data regrettably do not have the spatial resolution and consequently, the long wavelength components of the magnetic anomaly map still suffer from artefacts.

DGS has realized its first objective of constructing a nationwide magnetic datum through the acquisition of a state-of-the-art tie line survey, incorporating careful compilation of the data to account for variations in the geomagnetic field over the course of the survey. After compilation of the Tie Line Survey, some 70 higher resolution magnetic surveys were recompiled, most acquired by DGS supplemented by some from industry. They were then levelled to the magnetic datum provided by the Tie Line Survey, from which a new nationwide grid of total magnetic intensity at 50 m resolution was prepared. These data and enhanced nationwide magnetic grids were released by DGS in 2012. The Tie Line Survey, separate aeromagnetic surveys and resultant magnetic compilation are shown in Figures 1 through 5.

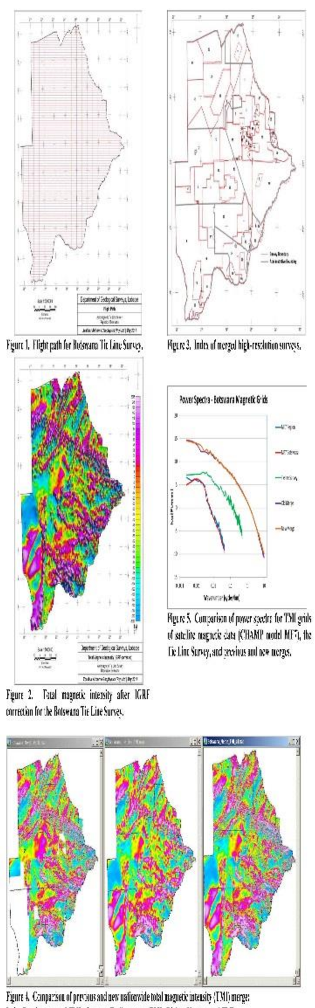

Figure 1. Flight path for Botswana Tie Line Survey. Figure 3. Index of merged high-resolution surveys.

Figure 2. Total magnetic intensity after IGRF correction for the Botswana Tie Line Survey. Figure 5. Comparison of power spectra for TMI grids of satellite magnetic data (CHAMP model MF7), the Tie Line Survey, and previous and new merges.

Figure 4. Comparison of previous and new nationwide total magnetic intensity (TMI) merge: Left – Previous merged TMI, Centre – Tie line survey TMI, Right – New merged TMI.

Abstract ID: 34680

Final Number: SE43A-02

Title: Removing barriers to accessing Geological Survey of Queensland (GSQ) survey data - a case study

Presenter/First Author: Kenneth John Howieson, Geosoft Inc., Toronto,

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Co-authors: Henry Wang, Geosoft Inc., Toronto, ON, Canada; Mark Thornton, Geological Survey of Queensland, Brisbane, Australia

Abstract Body: The Geological Survey of Queensland (GSQ) provides geoscience and resource information to improve the understanding of the geology and mineral and energy resource potential of Queensland, and promotes the geoscientific data and exploration potential to attract investment. GSQ has under its management a wide range of data types including geophysical data (including airborne magnetic, radiometric, electromagnetic and gravity, deep seismic, 2D and 3D seismic survey data, magnetotellurics), exploration geochemistry data, digital geological mapping data, mineral occurrence and geological observation data, wireline log data, hyperspectral imagery and 3D models. A big challenge facing GSQ was how to get this data into the hands of exploration companies in a cost effective manner. Explorers had limited ability to search and find what data was available from GSQ. Requests for data were then handled manually within the GSQ, which took time and resources to find, clean and deliver datasets. This paper will examine how the GSQ implemented the new Queensland Digital Exploration (QDEX) Data system, enabling customers to search for and download large spatial datasets via a simple web interface. It also provides a data management solution for the GSQ data managers to index and catalog the many different forms of exploration data held within the GSQ.

The case study will review the drivers for the new system, the challenges faced and lessons learned, during the implementation.

Abstract ID: 34940

Final Number: SE43A-03

Title: A Country-wide Airborne Geophysical Survey of Malawi

Presenter/First Author: Martin Bates, , Ottawa,

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Co-authors: Luise Sander, , ,

Abstract Body: In 2013, the Government of Malawi organized a country-wide airborne geophysical survey to unveil “the true mineral potential of Malawi”. The World Bank and European Union funded the survey with the goal of attracting more foreign mining sector investors to the country. The project was preceded by a large socialization campaign conducted by the staff of the Malawi Mining Governance and Growth Support Project.

Sander Geophysics Limited (SGL) was contracted to conduct a fixed-wing high resolution aeromagnetic, gamma-ray spectrometric, and gravimetric survey. Three SGL owned Cessna Grand Caravans were outfitted with magnetic and radiometric survey systems and one of them was also equipped with SGL's Airborne Inertially Referenced Gravimeter (AIRGrav) system. The survey included the acquisition of magnetic and radiometric data throughout the entire country. Gravity data were acquired over three separate blocks of particular interest to the Government of Malawi. A total of 442,933 line kilometres of magnetic and radiometric data and a total of 14,546 line kilometres of gravity data were acquired. Three infill blocks were flown to provide better radiometric data resolution. Survey operations were conducted from Lilongwe, Blantyre and Karonga from

September 23rd, 2013 to July 28th, 2014, and involved 51 members of SGL's staff.

Final products include digital data and a total of 1,100 maps at scales 1:100,000 to 1:250,000, consisting of 22 different map types. Training for geoscientists from the Malawi Ministry of Mines was conducted in-country and at SGL's head office in Ottawa.

The presentation will include a description of the project and preliminary results, logistical hurdles encountered in performing such a large project, the training component of the project and SGL's involvement in the socialization campaign.

Abstract ID: 35193

Final Number: SE43A-04

Title: ONTARIO AIRBORNE GEOPHYSICS – MAKING THE MOST OF RESOURCES

Presenter/First Author: Desmond Rainsford, Ontario Geological Survey, Sudbury, ON

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Co-authors: Saurav Biswas, Ontario Geological Survey, Sudbury, Canada

Published Material: The Ontario Geological Survey (OGS) publishes all airborne geophysical data that it acquires. Some aspects of this talk have been previously presented to KEGS, Laurentian University, Northwest Ontario Mines and Minerals Symposia, Northeast Ontario Mines and Minerals Symposia, Ontario Exploration Geoscience Symposia and Summaries of Fieldwork and Other Activities published annually by the OGS. These findings are not under review and are not published in a scientific journal.

Abstract Body: Federal aeromagnetic surveying of the province began in 1947 and coverage of Ontario, at 800m line spacing, was completed in the 1987. Beginning in 1975 the Ontario Geological Survey (OGS) has been acquiring high resolution airborne geophysical data throughout the province. The objectives of this work are to improve the understanding of Ontario geology by assisting OGS mapping efforts, to promote mineral exploration and to provide geoscience data to aid in land use planning. Owing to the large landmass to be covered and limited financial resources, several program models have been used to acquire data. These include internal funding, federal – provincial collaborations, regional initiatives, government – industry partnerships and purchase of existing proprietary data. Through these processes, the OGS has been able to acquire high quality airborne geophysical data over large parts of the province. This paper discusses the benefits and limitations of each of these methods. The acquisition of new data is on-going and consultations with stakeholders have shown that there is continued high demand for the results of these surveys. To manage this, the OGS has developed processes to select and prioritize new areas to be surveyed. Finally we will discuss quality control, how the data are distributed, how the data are used and the work that remains to be done.

Abstract ID: 34412

Final Number: SE44A-0336

Title: The Effect of Lower Mantle Viscosity on Surface Mobility in 3D Spherical Shell Convection Models

Presenter/First Author: Sean Michael Langemeyer, University of Toronto, Toronto, ON

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Co-authors: Julian Philip Lowman, University of Toronto, Toronto, ON, Canada; Paul J Tackley, ETH Zurich, Zurich, Switzerland

Abstract Body: Identification of the conditions that allow for ongoing surface mobility in a mantle convection model featuring a temperature and stress-dependent rheology has received considerable attention for over a decade. The importance of discovered trends that appear to increase the likelihood of obtaining a stagnant-lid mode of convection, such as increasing internal heating rates, higher yield stresses, and large planetary cores, is still not fully understood due to the various degrees of feedback that exist with complex rheologies and mixed mode heating. Specifically, allowing for new variables in increasingly complex models can reset previously identified thresholds for transitions between mobile and stagnant-lid regimes. Here we investigate, through the use of 3D spherical shell models, the effect of temperature dependent viscosity and heating mode on surface mobility in cases varying the radial viscosity profile of the mantle. The influence of lower mantle viscosity on surface mobility is explored by considering the viscosity contrast occurring across the 670km depth phase boundary. Additionally, we look at the effects of plastic yielding on the mobility of the surface with the use of both constant and depth dependent yield stresses in cases with different radial viscosity profiles. The planetary bodies to be modelled feature Earth-like core size relative to radius and feature a variety of heating modes including, purely basally heated models, internally heated models and mixed heating models.

Abstract ID: 35645

Final Number: SE44A-0337

Title: The Feedback Between Continents and Compositional Anomalies in the Deep Mantle

Presenter: Julian Philip Lowman, University of Toronto, Toronto, ON

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First Author Student?: No

Published Material: Part of this presentation was shown at the AGU Fall Meeting 2014.

Abstract Body: Findings from global seismic tomography studies suggest that the deep mantle may harbor a pair of broad, steep-sided, relatively dense compositionally anomalous provinces. The longevity and stability of these Large Low Shear-Wave Velocity Provinces (LLSVPs) has received considerable interest but their possible influence on surface motion has drawn lesser attention. Recent work using numerical mantle convection models investigated the feedback between oceanic plate motion and high density compositional anomalies. It was found that surface mobility is affected by the presence of compositional anomalies such that critical density contrasts and volumes of the enriched material produce a transition to stagnant-lid convection. For lesser volumes and density contrast (for example, volumes that are representative of the concentrations in the Earth's mantle) the presence of the compositional anomalies affects mean plate velocity and size when compared to the characteristics of systems in which the enriched material is absent. In addition, numerous studies and lines of evidence in the geologic record suggest that the presence of the density anomalies plays a role in determining the location of mantle upwellings, which in turn influence surface dynamics. We present the results from a study implementing a two-dimensional mantle convection model featuring an anomalously

dense component and distinct continental and oceanic lithosphere. The mass, momentum, and energy equations are solved using a hybrid spectral-finite difference code. Lagrangian tracers are used to track composition. Tectonic plates are modeled using a force-balance method and plate boundary locations evolve in response to interior stresses, plate velocity, age and lithospheric chemistry (i.e., oceanic versus continental). We examine the influence of continents on compositional anomaly morphology and longevity and the influence of compositional anomalies on continental size, mobility and aggregation.

Abstract ID: 35688

Final Number: SE44A-0338

Title: Modeling the Formation of Porosity Bands in a Mid-Ocean Ridge Corner Flow

Presenter: David Gebhardt, University of Saskatchewan, Saskatoon, SK

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First Author: Samuel L Butler, University of Saskatchewan, Saskatoon, SK

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First Author Student?: No

Published Material: Some of the material was presented at the Geological Society of America, 2014 conference.

Abstract Body: Porosity bands are the regions of contrasting high and low porosity that form when an external shear is imposed on a system of partial melt that has a matrix viscosity that decreases with increasing porosity. Previous laboratory experiments have been conducted using simple and torsional shear geometries while previous numerical and theoretical studies have employed simple shear, pure shear and torsional shear geometries. Additionally, mid-ocean ridges present a mass discrepancy between the mass of the new oceanic crust at the top of the ridge axis and the mass of the melt material rising vertically along the ridge axis. This implies the need for lateral melt channelling in order to achieve mass balance. In this contribution we make use of the velocity field derived for a mid-ocean ridge to impose a shear on a partial melt system in a numerical model so as to evaluate the suitability of porosity band formation as a mechanism for channelling melt beneath mid-ocean ridges; this is done for both slow and fast spreading ridges with a variety of strain-rate dependencies for the melt matrix viscosity.

SEDIMENTARY GEOLOGY AND PALEOBIOLOGY

Abstract ID: 36791

Final Number: SG11A-01

Title: Organomineralizing cryptic communities as an element of carbonate mound formation

Presenter/First Author: Stephanie Nathalie Larmagnat, Laval University, Quebec,

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Co-authors: Fritz Neuweiler, Laval University, Quebec City, QC, Canada

Published Material: Parts of the content of this presentation will appear in the 2015 February issue of the journal PALAIOS.

Abstract Body: Late Ordovician bryozoan carbonate mounds exposed in the upper part of the Deschambault Formation (Trenton Group, Montmorency Falls, Quebec) are local features within a well bedded sequence of bryozoan-rich carbonate sedimentary rocks. An array of taphonomic filter mechanisms was at work to produce subtle changes in rock texture and microfacies hence controlling early diagenesis and buildup formation. These mechanisms encompass bioerosion, mechanical fragmentation, transport, automicrite formation and marine cementation. Growth cavities between bryozoan colonies were filled with up to four generations of muds, one authigenic and locally up to three infiltrated muds. Stable isotope signature of all microcrystalline indicates that precipitation occurred in equilibrium with marine water. The distribution pattern of rare earth elements is consistent with an oxic marine environment. Intriguingly, the variation of bryozoan zooecium size between mound core, mound flank and off-mound sediments does not support the assumption that bryozoan growth rate was higher in the core of the mound. Instead centimeter-size patches of automicrite with scalloped outer margins are present in mound core facies and are thought to have reinforce the bryozoan colonies. The automicrite together with the first stage of infiltrated mud contains clusters of microsparitic microtubules. The interpretation of these microtubules remains a subject of discussion; they might represent the remnants of non-spicular, keratosan sponges or Wedl-type tunnels associated with the assimilatory action of marine fungi. Irrespective of their specific biological origin, organomineralizing cryptobionts and the subsequent formation of ephemeral substrates might have induced stabilization and fixation of the bryozoan skeletons, and favour local mound formation.

Abstract ID: 36606

Final Number: SG11A-02

Title: Cnidarian Medusae (Jellyfish): the Ultimate Taphonomic Proxies

Presenter/First Author: Graham Young, Organization Not Listed, Winnipeg, MB

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Co-authors: James Hagadorn, Denver Museum of Nature and Science, Denver, CO

Published Material: My colleague made a presentation of this work in progress at the international Taphos meeting last year.

Abstract Body: Cnidarian medusae have very low preservation potential. They have almost no hard tissues and usually decay or are scavenged after death. They have been around for at least ~550 Ma, yet even in the hundreds of known *Konservat-Lagerstätten*, Cnidaria and their medusae are the least common major metazoan phylum. Despite frequent taphonomic opportunities for preservation, they are known from just a dozen fossil deposits. Thus, their presence in ancient deposits signals anomalous conditions.

Medusae thrive in many environments, yet are only preserved in three types of depositional settings. They are most abundant in strata from tidal sand- and mud-flats, where their deposition at the strandline provides a precise shoreline indicator. Medusae are also preserved in lagoonal mudstones, where they indicate fluctuating salinity or salinity stratification, rapid burial in fine mud, and/or the presence of anaerobic bottom waters. Fossil medusae are rare in shales representing deeper water settings, where they signal rapid burial often associated with bacterial fermentation and mineralization.

Over Phanerozoic time, taphonomic windows that permitted preservation of medusae have shrunk or shut entirely. Strandline deposits are restricted to the early Paleozoic, before metazoans began eating buried carcasses or disrupting microbial mats that bioimmured soft tissue. Preservation of medusae in deeper marine settings disappears by the end-Paleozoic, possibly owing to colonization of basin bottoms by bioturbating organisms. All Mesozoic and Cenozoic fossil medusae are in lagoonal settings, where metazoan activity and microbial degradation were retarded by fluctuating salinity or oxygen, where fine sediment facilitated burial of carcasses, and where microbially-mediated mineralization was fostered.

The present is often a key to the past, but are medusae being preserved anywhere on earth today?

Abstract ID: 33421

Final Number: SG11A-03

Title: *Halysis* Høeg, 1932 (Early Ordovician-Middle Devonian): calcification history and role in mound formation.

Presenter/First Author: Yuefeng Shen, Laval University, Quebec, QC

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Co-authors: Fritz Neuweiler, Laval University, Quebec City, QC, Canada

Published Material: A part of the results was under review as a manuscript by the journal of PALAIOS, Dec, 2014.

Abstract Body: *Halysis* Høeg, 1932 is a calcareous microproblematicum which occurs in abundance in Ordovician fine-grained, reddish carbonate mounds rich in spar-cemented cavities (Tarim Basin, NW China). *Halysis* consists of laterally branching tubes arranged to form a U-shaped skeleton punctually attached to a soft substrate. The skeleton consists of an inner and an outer layer of microcrystalline calcite, and a central layer of imbricated, radially arranged calcite tablets. An affinity of *Halysis* with extant calcareous green algae (Bryopsidales, Udoteaceae) is likely. A literature review of the skeletal robustness of *Halysis* (quantified by size, tube number, wall thickness) concludes for a sudden appearance of most robust growth forms in the Early Ordovician. *Halysis* might have acquired its skeleton *de novo* from a soft-bodied ancestor and by consequence might represent an example of a green alga which obtained its mineralogy (low magnesian calcite) in accord with the ambient sea-water chemistry (calcite sea). In the aftermath, there is a continuous decline of skeletal robustness spanning the Ordovician and Silurian. During the Devonian, the trend is reversed before extinction occurred in the Givetian. Strongly calcified *Halysis* contributes to Ordovician mound formation by creating a significant volume of shelter cavities. The mound sediments consist of algal pellet packstones and grainstones which contain unsupported voids. These voids are similar to those produced from experimental sediment-laden flows operating at the limit of their capacity thereby implying vast areas of highly mobile algal pellet sediments (carbonate silt) in inner carbonate ramp settings (highly productive, high energy). Shelter cavities and unsupported voids together make up about 10% of the total rock volume thereby reducing accommodation space in enough quantity to explain hydrodynamic mound formation.

Abstract ID: 36637

Final Number: SG11A-04

Title: Factors leading to the development of a Precambrian quartz arenite: the Paleoproterozoic Bar River Formation, Huronian Supergroup

Presenter/First Author: Rohan David John Aranha, University of Western Ontario, London,

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Co-authors: Patricia L Corcoran, , , ; Fred J Longstaffe, University of Western Ontario, London, ON, Canada

Abstract Body: The Bar River Formation is the youngest unit of the 2.45-2.2 Ga Huronian Supergroup and represents the final pulse of sediment deposition before the Great Stratigraphic Gap. The formation is quartz arenite-dominated and contains abundant planar and trough crossbeds, ripple marks, herringbone crossbeds, and dessication features, which are consistent with deposition on a tidal flat. Recently recognized microbial mat destruction features in the Flack Lake area also support a tide-influenced environment. These mat features include filled sand cracks, petee ridges and patchy ripples. Combined with the quartz-rich nature of the formation, the tide-influenced depositional environment is consistent with development along a passive margin. Paleocurrent analysis of the Bar River Formation at Flack Lake reveals a polymodal trend. The two strongest trends point ESE and SSE, indicating the main flow directions, and point to a sediment source NW of the present-day Flack Lake region. Increasing complexity of paleocurrents up-section reveals a possible aeolian influence, which is supported by the presence of large-scale cross-beds (1.5 m sets). Samples of fine-grained sandstone plot within the passive continental margin field on the Th-Sc-Zr/10 ternary plot, which further supports deposition along a continental shelf. The quartz-rich nature of the formation can therefore be attributed to wave and tide reworking in the depositional environment. A previous investigation of the Bar River Formation east of Manitoulin Island produced ZTR (zircon-tourmaline-rutile index) values between 70-100, which indicates a substantial recycling component. This is further supported by the logZr/Sc vs logTh/Sc diagram where the samples plot in the sediment recycling field. Chemical weathering of the source rock is indicated by CIA values of 74-83. The combined results suggest that the composition of the Bar River Formation detritus was controlled by transport and climatic effects.

Abstract ID: 33465

Final Number: SG11A-05

Title: Source rock analysis of the Agbada shales of Niger Delta basin, Nigeria, using well log data and Attribute analysis

Presenter/First Author: Ahmad Adeola Adeniji, , Lagos,

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Co-authors: John Ramon Onayemi, University of Lagos, Oshodi, Nigeria

Published Material: Society of Exploration Geophysicists 83rd Annual Meeting

Abstract Body: The Agbada Formation is a parallic sequence of the Niger delta basin, composed of sand-shale intercalation. Sands in the Agbada formation are known to be the major reservoir rocks in the area. The research work aimed at employing geophysical approach to carry out a study on the shale lithologies of the Agbada Formation in the Niger Delta basin to prove whether they have mature
source rock potential or their major responsibility is to seal the reservoirs, which has been the major argument among researchers.
Two separate fields; 'LAG' and 'JAY' located in the basin were studied. Seismic and Well log data of 10 wells from the studied areas were used and the interpretation was carried out with Schlumberger's Petrel 2012 software package, using gamma ray log to differentiate between the sand and shale lithologies. Overlay of sonic log and resistivity log was used to identify kerogen rich zones, and overlay of sonic log and derived pseudo-sonic log (derived from the cross-plot LogR and sonic log) was used to test for maturity of the potential source rock zones, Seismic attribute (RMS Amplitude) was used to check for generated hydrocarbon in the shales as part of the property of mature source rock is to contain hydrocarbon about to be migrated.

Four major shales were studied and their petrophysical analysis revealed that two of the shales were kerogen-rich source rocks, while the others were kerogen-defficient, Attribute analysis showed the absence of generated hydrocarbon. The sonic-pseudosonic overlay and attribute analysis revealed that none of the studied shales is a matured source rock. This work has been able to prove that Agbada shales are not matured source rocks, but rather sealing the reservoir.

Abstract ID: 35603

Final Number: SG11A-06

Title: Upscaling permeability in bioturbated, heterogeneous tight reservoir rock using the K_{eq} approach

Presenter/First Author: Amy Hsieh, Simon Fraser University, Burnaby,

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Co-authors: Diana M Allen, Simon Fraser University, Burnaby, BC, Canada; James A MacEachern, , ,

Abstract Body: There is considerable interest in recovering hydrocarbons from marginal reservoirs using horizontal drilling techniques and hydraulic fracturing. In such reservoirs, subtle changes in the distribution of sedimentary media such as generated by bioturbation can greatly affect the porosity and permeability distribution of the facies. While burrow-affected permeability trends in reservoirs must be considered in order to properly define reservoir flow characteristics, the marked variability generated at the bed/bedset scale makes such bioturbated media difficult to model. This paper attempts to simplify the variability in K at the bed/bedset scale by estimating an upscaled composite K_{eq} that represents the thickness-weighted sum of K at the bed/bedset scale. Using plug permeability data measured at the bed/bedset scale, K_{eq} is calculated using expressions for layered media in both the vertical (K_z) and horizontal (K_{xy}) directions for hydrofacies (HF) at the composite scale. Numerical block models are then generated using MODFLOW for both the bed/bedset HFs and the composite HFs. Vertical and horizontal flows are simulated by assigning prescribed hydraulic gradients in the vertical and horizontal directions, respectively, in each representation of K. The volumetric flows (Q in m^3/s) in each direction are compared to verify the representativeness of using K_{eq}. The results show that the horizontal and vertical Q for the bed/bedset simulations and the upscaled composite simulations differ by less than ±5%. This technique can potentially be used as a conceptual framework for upscaling K, where there is high variability in K at the bed/bedset scale.

Abstract ID: 35851

Final Number: SG11A-07

Title: Integrated Geomechanical, Geological, and Geophysical Investigations of the Cretaceous Pierre Shale

Presenter/First Author: Bill Roggenthen, South Dakota School of Mines and Technology, Rapid City, SD

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Abstract Body: The Pierre Shale, a thick Late Cretaceous shale sequence, has one of the largest outcrop areas in the world. The geomechanical and geochemical characteristics of the outcrops have been studied extensively due to the large outcrop area and its importance for civil construction. However, the properties of the Pierre Shale in outcrop and in the subsurface differ greatly due to chemical and mechanical weathering processes of these poorly indurated and often smectitic shales. An ongoing, integrated study is being conducted to investigate geomechanical, chemical, paleontological, and petrophysical properties of the shale in the deep subsurface. Two continuous core drilling sites, located 75 km apart on the eastern side of the Cretaceous Seaway in central South Dakota, have recovered 150 m and 170 m of core from the lower Cretaceous (Campanian). The primary purpose of the coring was to recover unaltered sample to perform long-term creep testing (approximately 1 month) which will assist in the development of a constitutive model for time-dependent deformation of shale. In addition to the geomechanical study of the shale, the ongoing investigations associated with the coring activity include studies of shale microscopic textures (micro-CT and SEM), oxygen isotope stratigraphy, correlation between petrophysics and cores, and micropaleontology. Of stratigraphic interest, both of these drill holes have captured notably dissimilar samples from the Crow Creek Member, which has been ascribed to being derived from tsunamite deposits associated with the Manson Meteorite Impact in Iowa at ~74 Ma. Potential applications for the geologic unit that are being investigated include its use as a storage medium and evaluation of its potential as a source rock for hydrocarbon generation. Numerical modeling has been performed that provide a basis for a preliminary design for a shale-hosted underground research laboratory.

Abstract ID: 35273

Final Number: SG14A-0360

Title: Correlation Between Zooclast Reflectance and Rock-Eval T_{max} in the Upper Ordovician Cape Phillips Formation, Nunavut

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Abstract Body: Determination of thermal maturity is an important step in the establishment of a basin model and in the reconstruction of the basins thermal history. The reflectance of certain zooclasts has been demonstrated to correlate with the maximum thermal maturity (T_{max}) of the organic material in the rock (kerogen). Quantification of this relationship has however remained difficult. This study examines the correlation between the reflectance of Graptolites and Chitinozoans and the T_{max} parameter obtained using Rock-Eval Pyrolysis in order to evaluate the suitability of zooclast reflectance as a tool in thermal maturity studies and quantify the correlations between these datasets. Forty-nine samples from the Upper Ordovician Cape Phillips Formation of Nunavut, Canada were powdered for Rock-Eval testing, and prepared into slides for measurement of reflectance. Rock-Eval is an established, reliable method of obtaining thermal maturity data (converted to VR_{eqv} using VR_{eqv}=0.018*T_{max}-7.16) and will be used as a baseline to examine the suitability of zooclast reflectance. Reflectance was measured approximately 100 times per sample across as many individual specimens as possible. Eighteen samples were eliminated due to unreliable results caused by low total organic carbon or lack of zooclasts. Preliminary statistical evaluation shows a reasonable correlation within a prediction interval and an R^2 value of 0.49 for Chitinozoans and 0.57 for Graptolites compared to T_{max} values. Results suggest that zooclast reflectance could be reliably used as a tool in thermal maturity studies. Study is currently ongoing, and future work will focus on developing a conversion factor for the zooclast reflectance to VR_{eqv} (industry standard), and comparing previously published conversions of Graptolite and Chitinozoan reflectance.

Abstract ID: 35153

Final Number: SG14A-0362

Title: Seismic Stratigraphic Analysis of the Messinian Evaporite Deposits and Their Temporal and Spatial Distribution in the Western Cyprus Arc, Northeastern Mediterranean

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Abstract Body: At the end of the Miocene (~ 6 Ma), progressive closure of the straits connecting the Mediterranean Sea with the Atlantic Ocean triggered the desiccation of the Mediterranean Sea. This caused significant amounts of evaporation in a relatively brief period of ~0.63 My, and is known as the Messinian Salinity Crisis (MSC). The sea level drop during the MSC represents the most striking environmental change in the Cenozoic history of the Mediterranean Sea. During this event, rapid sea level drop resulted in an increased salinity and in the deposition of evaporites within shallow water marginal basins (today located onshore and isolated from the offshore deep basin), followed by massive erosion at the continental margins and deposition of thick Messinian Evaporite succession in the deep Mediterranean basins. This paper describes temporal and spatial seismic facies variations across the southern Antalya Basin, Anaxagoras Mountains and the Florence Rise in the eastern Mediterranean Sea. Interpretation of new high resolution seismic reflection data collected from the western Cyprus Arc (Eastern Mediterranean) has revealed the complex depositional and structural setting of the basinwide late Miocene (Messinian) evaporites. Isochron maps and seismic cross-sections are correlated with borehole information from DSDP Leg XLII Sites 375 and 376 and the onland Aksu-1, Manavgat-1 and Manavgat-2 wells, as well as successions in the eastern Mediterranean, and these data are used to describe the spatial variations of the evaporite architecture in the study area. The late Miocene (Messinian) and early Pliocene evaporite successions are divided into four seismic stratigraphic subunits, and a thorough acoustic and thus proxy sedimentary description of these subunits is used to place these subunits into a chronostratigraphic framework.

Abstract ID: 34922

Final Number: SG14A-0363

Title: Mid-Miocene Vegetation and Climate Development on the Atlantic Coastal Plain (IODP Expedition 313)

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Abstract Body: Among other goals, IODP Expedition 313 aims at assessing sea-level changes and ecosystem and climate dynamics during the Oligocene and Miocene. We have investigated the palynology of sediment cores from IODP Site M0027, 45 km off the present-day coast of New Jersey. We have focused on pollen studies for the second half of the Mid-Miocene Climatic Optimum (MMCO) and the subsequent transition to globally cooler conditions (ca. 15 to 13 million years before present) in order to examine if the global climatic trends are reflected in ecosystems in the hinterland of the New Jersey shelf. Transport-caused bias of the pollen assemblages was identified via analysis of the terrestrial/marine palynomorph ratio. Palynomorphs were analyzed via both light and scanning electron microscopy and showed good preservation.

Generally, pollen assemblages were not very diverse in the time interval analyzed. Most abundant taxa through all samples were *Quercus* (oak) and *Carya* (hickory). Pollen grains of *Fagus* (beech) were also frequent in most samples, while pollen grains of typical wetland elements like Cyperaceae, *Taxodium* (cypress), *Nyssa* (tupelo tree) were rarer. Taxa like Sapotaceae, Symplocaceae, Arecaceae (palm trees), Buxaceae, and *Alangium*, which today grow in the tropics and subtropics and thus indicate particularly warm climate conditions, were only sporadically found. However, these taxa indicate warmer phases during the second half of the MMCO. Herbal pollen was generally infrequent, but members of the Asteraceae, Apiaceae, and Ericaceae families, together with infrequent occurences of Poaceae pollen indicate the presence of areas with open vegetation.

The Mid-Miocene pollen assemblages reflect ecosystem conditions in the hinterland of the New Jersey shelf which were reminiscent of Oligocene and early Miocene conditions analyzed in previous studies. Frequent occurrences of conifer pollen (*Pinus*, *Picea*, *Abies*, *Sciadopitys*, and *Tsuga canadensis*) indicate that conifer forests prevailed in higher altitudes during the MMCO, while the lowlands were probably dominated by deciduous woodland. We assume that a Miocene uplift of the Appalachian Mountains as postulated by other authors led to a spread of mountainous taxa in the middle Miocene and thus to an increase of related pollen taxa in the palynological record.

Abstract ID: 35521

Final Number: SG14A-0364

Title: Paleoenvironmental records from alaskan Late Pleistocene yedoma permafrost : A case study from the Itkillik river

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Published Material: Same pollen diagram and sedimentologic raw data presented at Arctic Change because the paleoclimatic recontruction (Modern Analog Technique) that I want to introduce at the Joint Assembly conference 2015 are based on these.

Abstract Body: The cold-arid climate associated with the late Pleistocene environment of unglaciated Beringia was favorable to active sedimentation processes and accumulation of ground ice leading to the formation of a relic form of ice-rich syngenetic permafrost, termed yedoma. These periglacial features provide interesting snapshots of well-preserved old terrestrial paleoenvironmental data (80-12kyr BP). The Itkillik river yedoma exposure (400m x 30-35m) is located in northern Alaska at the border of the Arctic Coastal Plain and the Arctic Foothills. This yedoma provides new information about the extent and temporal dynamics of the former tundra-steppe biome which acted as refugium for plant species and the megafauna during the Pleistocene. Paleoecological records from the site is mainly associated to late and middle Wisconsinan (~10-+43,5kyr BP). Pollen analysis and reconstruction of paleoclimatic parameters (modern

analogue technique) reveal a tundra-steppe environment dominated by herbaceous community. We observed that vegetation was dominated by *Cyperaceae* during warmer periods (middle Wisconsinan (~27-+43,5kyr BP) and Holocene (-15kyr BP)). Summer temperature reconstructed were warmer, near the modern value (8.6 °C), and correlated to δ18O deviations. The total carbon (TC) was slightly higher (+3%) compare to colder episodes and more represented by organic carbon. The volumetric ice content was also higher (average 75%), potentially linked to climatic conditions promoting peat layers formation and segregation of ice during synegenetic development of the permafrost. In contrast, during cold and dry periods (late (~10-27kyr BP) and early (+45kyr BP) Wisconsinan)), the vegetation was mainly represented by *Poaceae* and a higher diversity of minor herbs and forbs. TC was low and mostly represented by inorganic carbon (average 84%). Volumetric ice content values were lower likely due to an increase of eolian sedimentation accelerating more than than twice syngenetic surface elevation during this period.

Abstract ID: 33240

Final Number: SG14A-0365

Title: What was happening when earthquake suddenly deformed the sediments earth in Liwa region, Sumatera, Indonesia?

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Abstract Body: Liwa is a place where the Sumatra Fault crosses this area and produced some devastating earthquakes occurred in 1933, 1984 and 2005. Geological evidences produced by the earthquake could be easily observed immediately after the event, but will quickly disappear after a few days. Therefore the investigation of the earthquake should not wait until a few days, but it should be done immediately after the incident. Very few traces of the earthquake stored properly in the affected areas. The geological evidences were found and show the events that occur suddenly due to an earthquake in Liwa region in a channel of a stream offset, the material which is deposited in a channel. The position of this evidence is on one of the offset of the river in the southwest of the fault. The appearance of the outcrop, shows a discontinuity located at the lower part of the outcrop, while filler material which has relatively young sedimentary structures, seen filling the channel. We suspect that when the earthquake occured, there was an abrupt mass movement and bring materials slide into the channel. To prove these evidences, the grain size analysis and sediments age determination using carbon dating are performed in this research.

Keywords: Liwa, paleo channel, filling material, grain size analysis, carbon dating.

Abstract ID: 34061

Final Number: SG14A-0367

Title: Late Holocene Wood and Vertebrates from Gravels Near Fort Saskatchewan, Alberta

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Co-authors: Christopher N. Jass, , ,

Published Material: Initial version of this research presented (poster) at Alberta Palaeontological Society 17th Annual Symposium in Calgary in 2013

Abstract Body: Gravels in central Alberta are a major source of late Quaternary fossils, which are often found during active gravel mining operations. Most are of pre-last glacial age (20,000 – 40,000 YBP). Plant macroremains are found less frequently than vertebrate remains but are known from several localities. Here we describe plant and vertebrate remains from a new locality along the North Saskatchewan River valley between Edmonton and Fort Saskatchewan. The remains were recovered from an active gravel operation situated on a low terrace about 10 m above present river level. We were alerted to the fossils by the operator and, thanks to an excellent working relationship, were enabled to visit the pit and examine the context. We collected in-situ wood exposed in a thin layer about 4 m below the present surface. Wood fragments were well-worn, rounded, and aligned roughly west-east, consistent with fluvial transport. The layer was underlain by cross-bedded sands and matrix-supported gravel, containing Shield clasts indicative of a postglacial maximum age. The upper part of the deposit was mostly fine sands, with some cross-bedding. Seven wood specimens were analyzed and were identified as conifer. Skeletal remains of elk (*Cervus elaphus*) and bison (*Bison bison*) were also recovered from the site, though none were clearly from primary context. Elk remains consist of a partial cranium whereas bison remains include both cranial and post-cranial elements. Two AMS dates on samples from cranial remains of elk and bison and three from samples of wood show a tight grouping of 500 – 900 ^{14}C YBP (about 570 – 800 cal YBP). The thick sedimentary deposits and radiocarbon data indicate considerable late Holocene fluvial deposition by the North Saskatchewan River.

Abstract ID: 33341

Final Number: SG14B-0368

Title: Preliminary assessment of Nevado del Ruiz geothermal potential from laboratory measurements of thermal properties

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Abstract Body: This study aims to evaluate the geothermal potential of Nevado del Ruiz volcano, in Colombia, through determination of thermal properties of rock samples collected in the field. The Nevado del Ruiz is a stratovolcano located in Los Nevados Colombian Natural National Park between the limits of Caldas and Tolima departments. Exploitation of geothermal resources could help to supply the local energy needs, particularly for agriculture based mainly on coffee crops.

Geothermal research in this region began in 1968 with a geothermal regional reconnaissance study. In 1983, a prefeasibility study located a promising area on the South Western side of Nevado del Ruiz, due to the presence of various active volcanoes (Santa Isabel, El Cisne and Ruiz) and the existence of fumaroles having a temperature up to 83 °C. At the end of 1990s, the geothermal potential of the Ruiz complex was estimated to 50 MWe.

Recent researches concerned hydrothermal alteration, kinematic characteristics of westward faults, geochemical and thermal evolution, and rock resistivity profiles. Other studies shown that faults may act as preferential flow paths for geothermal fluids. Nevertheless, there are no

published studies about rock thermal properties, which can improve resource assessment.

Therefore, this work focuses on the evaluation of thermal properties of 62 rocks samples collected in surface outcrops. Thermal conductivity and specific heat will be measured using a needle probe and a calorimeter, allowing the calculation of thermal diffusivity. These thermal properties coupled to geothermal gradient values will lead to estimation of heat flow, extrapolation of temperature at depth and improvement of the geothermal resources assessment.

This work represents a first step towards the construction of a simple conceptual model for the geothermal reservoir of Nevado del Ruiz volcano.

Abstract ID: 33500

Final Number: SG14B-0369

Title: Mapping the geoexchange potential of the St. Lawrence Lowlands from thermal conductivity measurements of rock samples

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Abstract Body: The objective of this project was to determine the geothermal heating and cooling potential of the St. Lawrence Lowlands sedimentary basin. This region encloses major cities such as Montreal and Quebec City and is the most important market for ground source heat pumps in the province of Quebec because of the population density. Tables and maps were developed from a thermostratigraphic assessment of rock samples to illustrate the geothermal potential associated to vertical closed-loop systems.

Sizing calculations were first performed for 45 locations to evaluate the drilling length needed for the installation of a ground heat exchanger at a typical home. The building design parameters were kept constant for each location and the subsurface properties were varied according to laboratory measurements of samples collected in surface outcrops. The subsurface thermal conductivity was measured with a needle probe and the subsurface heat capacity was calculated according to the mineralogy estimated with thin section descriptions. Thus, for all rock samples, sizing calculations revealed that bore length should vary between 101 and 213 m.

Thermostratigraphic classifications of the geological units were subsequently created according to their geothermal potential (high, medium or low) based on drilling depth. Results highlight high potential for units such as Theresa, Covey Hill and Cairnside formations having depth of drilling varying from 101 to 129 m and thermal conductivity ranging from 4 to 6,9 W/mK.

Thermal conductivity measurements and sizing calculations were finally mapped using ArcGIS software. Two separate maps showing results with points over the surface distribution of the geological units were designed to simplify visualization. The maps shows that thermostratigraphic units with high geothermal potential are mostly found in the western part of the sedimentary basin.

Abstract ID: 36012

Final Number: SG21A-01

Title: Measuring terrestrial Precambrian atmospheric oxygen levels: An isotopic approach

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Published Material: Part (<50%) of the Cr isotope data have been presented at the 2014 AGU Fall Meeting.

Abstract Body: The history of atmospheric oxygen levels through Earth history has been the topic of intense interest since at least the 1960s (Cloud, 1968). By 2000, a two-step model had become strongly established in Precambrian research in which oxygen is hypothesized to have remained relatively constant except for large, geologically rapid, unidirectional increases in O_2 in the early Paleoproterozoic (the “Great Oxidation Event”) and the Neoproterozoic. Work in the last decade has begun to add detail to this simple view, discriminating between different O_2 levels rather than simply assessing its presence or absence (e.g., Lyons et al., 2014). While typically less common or complete than marine records, terrestrial records such as paleosols form in direct contact with the atmosphere and thus provide direct records of atmospheric composition (e.g., Rye and Holland, 1998).

Uranium and chromium are redox-sensitive isotope systems that are thought to behave relatively simply in terrestrial soils. Uranium fractionation occurs at O_2 levels above ~10^{-5} times present atmospheric levels (PAL) (Partin et al., 2013), while chromium responds above ~10^{-3} PAL (Crowe et al., 2013). Here we present paired U and Cr isotope measurements on a set of globally distributed paleosols that span the time interval from Mesoarchean (≥3.0 Ga) to Mesoproterozoic (1.1 Ga). These paleosols are considered to have excellent preservation based on textural, mineralogical, and chemical examination. By pairing these two isotope systems, we construct a quantitatively constrained history of oxygen levels, rather than simply assessing “almost none” versus “more than almost none.” The record shows, perhaps surprisingly, that O_2 levels remained below ~10^{-5} PAL until at least 2.45 Ga, just before the GOE. However, other records (e.g., Anbar et al., 2007; Crowe et al., 2013) suggest that higher levels of O_2 were present at least locally prior to the GOE for perhaps several hundred million years. Reconciling these results with the rapid mixing time of the atmosphere will be a future challenge, and will inform our understanding of the critical transitions in Earth history occurring during the late Archean and Proterozoic, including the Huronian glaciation, the expansion of oxidative photosynthesis, and the appearance of eukaryotes.

Abstract ID: 35951

Final Number: SG21A-02

Title: Hyperventilation During the Paleoproterozoic – Evidence for Extensive Oxidation of Terrestrial Surfaces in Fennoscandia

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Co-authors: Lee Robert Kump, Pennsylvania State Univ, University Park, PA; Weiqiang Li, Univ. of Wisconsin - Madison, Madison, WI; Clark Johnson, University of Wisconsin Madison, Madison, WI; Ronny Schoenberg, University of Tübingen, Tübingen, Germany; Victor Melezhik, , , ; Eero Hanski, , ,

Published Material: The major element chemistry used to identify the altered volcanic rocks as a weathering profile was presented at the 2014 Goldschmidt conference.

Abstract Body: The *ca.* 2.06 Ga Kuetsjärvi Volcanic Formation (KVF) is a subaerially erupted volcanic sequence in Fennoscandia that displays an anomalously elevated ratio of oxidized to total iron ($Fe^{3+}/\sum Fe$) compared to those of typical volcanic rocks. To date, two hypotheses have been put forth to explain the oxidized nature of KVF: 1) eruption from a highly oxidized magma source region, or 2) oxidation during terrestrial exposure by oxygen-charged groundwaters in the wake of the proposed atmospheric oxygen 'overshoot' 2.2 Ga ago.

Petrographic observations from Fennoscandia Arctic Russia – Drilling Early Earth Project (FAR–DEEP) Cores 7A and 8B suggest that the KVF's elevated $Fe^{3+}/\sum Fe$ ratios result from post-crystallization hematization of the rocks. We propose that oxidation of the KVF was initiated at the erosional contact marking the top of the KVF, and progressed downward through interactions between the bedrock and oxidizing groundwaters exploiting the oldest fracture sets prior to regional metamorphism. This interpretation is supported by the strong correlation between the measured $Fe^{3+}/\sum Fe$ ratios and the calculated chemical index of alteration of the altered rocks, and the presence of anomalously oxidized KVF clasts within the overlying conglomerate whose matrix does not exhibit any signs of pervasive oxidation. Detailed U–Th–Pb isotope work indicates that the precipitation of the secondary Fe–oxides occurred after the initial crystallization, but prior to regional metamorphism. Iron appears to have undergone limited mobility as indicated by our detailed Fe–isotope work. Conversely, our preliminary Cr–isotope data indicate that Cr may have been transported laterally during weathering. Altogether, these observations and data support that the oxidation of the KVF resulted from interaction with highly oxidizing groundwaters between *ca.* 2.06 and 1.75 Ga ago.

Abstract ID: 35805

Final Number: SG21A-03

Title: A Theory of Archean Oxygen Stability

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Co-authors: Thomas Laakso, Harvard University, Cambridge, MA

Abstract Body: Though much attention has been given to the Great Oxidation Event of ~2.4 Ga, there is still no mechanistic model for what controls the steady-state levels of atmospheric O_2 in the late Archean or the early Proterozoic. Here we discuss the major controls on pO_2 during various stages of the Archean, using a simple model that describes the biogeochemical of oxygen, hydrogen, carbon, iron, sulfur and phosphorus in the ocean and atmosphere. In the prebiotic era, the redox balance was dominated by the input of reduced species derived from the mantle and from water-crust interactions, compensated by the escape of hydrogen to space. Based on a simple energy balance model of the thermosphere, we find the escape rate may have been slower than the diffusion-limited rate often assumed, leading to elevated hydrogen concentrations. The appearance of chemoautotrophic life altered this balance by adding an additional sink for hydrogen, drawing down the concentration of H_2-bearing species in the atmosphere. In our model the drop in hydrogen concentrations can be as large as several orders of magnitude, with a similarly large increase in pO_2 due to slowed reaction rates between atmospheric reductants and photochemically-derived oxygen. Such large changes in the composition of the atmosphere may have implications for detecting the origin of life, at least as a geochemically significant force, in the rock record. Our model results show that an atmosphere with pO_2 of 10^{-10} PAL would have been stable even after the evolution of oxygenic photosynthesis, provided that the rates of outgassing and serpentinization were sufficiently large in the Archean relative to the organic carbon burial, which was likely limited by alternative sinks for phosphorous.

Abstract ID: 35875

Final Number: SG21A-04

Title: Alkalinity, Snowball Glaciations, and the Great Oxidation Event

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Abstract Body: The cause of the rapid rise in atmospheric oxygen at 2.4 Ga remains controversial. Using a model of biogeochemical cycling , we identify a new positive feedback that greatly increases the rate at which pO_2 rises across the GOE compared to simpler models. Increasing pO_2 strips ferrous iron from the oceans, reducing alkalinity and the precipitation of calcium carbonate. This is supplemented by sulfide oxidation, which also leads to a reduced flux of alkalinity. To compensate, pCO_2 rises, leading to additional silicate weathering and alkalinity production. This also increases the release of phosphate via apatite weathering, which must be balanced by increased organic carbon burial and further production of oxygen. We show that this positive feedback leads to multiple equilibria in pO_2. In an otherwise steady state, low-oxygen Archean with oxygenic photosynthesis, a transient increase in pCO_2 leads to increased oxygen production via the alkalinity feedback. If this pulse is sufficiently large, the ratio of oxygen to production to electron outgassing can pass the critical threshold without any change in mantle processes, and a permanent transition to high oxygen occurs. Otherwise, the pulse of oxygen is overwhelmed by reductants from the mantle, and pO_2 decays back to its Archean values. These dynamics may explain why the GOE appears to be associated with one of the Paleoproterozoic Snowball events.

Abstract ID: 36112

Final Number: SG21A-05

Title: Multiple Sulfur Isotopes in Neoproterozoic Pyrite: Implications for Links Between the Sulfur Cycle and Atmospheric Oxygen

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Abstract Body: The size of the seawater sulfate reservoir (SSR) depends on the oxidation state of Earth's surface because riverine sulfate supply is controlled by oxidative weathering of sulfide minerals on the continents and burial of sulfur as pyrite is controlled by the amount of dissolved oxidants in the ocean. The sulfur isotopic composition of pyrite can provide information on sulfate availability and isotopic properties during bacterial sulfate reduction (BSR). However, only pyrites that formed in direct communication with the SSR, i.e. in an euxinic water column or at the sediment-water interface, will reliably record its properties. We present a pyrite-multiple sulfur isotope record coupled to a numerical model from a Neoproterozoic succession in Svalbard, which was deposited on a thermally subsiding continental shelf between 835 and 620 Ma. $\delta^{34}S$ values throughout the succession are highly variable and range from -30 to +40‰, akin to published data from other coeval basins. These data suggest substantial variation in sulfate availability to BSR. However, redox proxies and pyrite contents suggest that BSR during deposition of pre-Sturtian units was restricted to pore waters. In contrast, BSR likely occurred at the sediment-water interface during deposition of the interglacial and post-Marinoan units. The interglacial units show $\delta^{34}S$ values up to +40‰, equal to estimates of coeval seawater sulfate, suggesting collapse of the SSR while post-Marinoan $\delta^{34}S$ values are lower than estimates for contemporaneous seawater sulfate, indicating a larger SSR. The post-Marinoan samples follow a Rayleigh-like trend in $\Delta^{33}S$-$\delta^{34}S$ space. Modeling suggests that sulfate is not the limiting factor during BSR and that some of the H_2S generated during BSR was lost, probably by migration into the overlying water column. A larger post-Marinoan SSR compared to the interglacial period is consistent with a rise in atmospheric O_2 concentration, supporting recent trace metal studies.

Abstract ID: 34710

Final Number: SG21A-06

Title: What influenced the rise and fall of atmospheric oxygen during the Phanerozoic?

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Co-authors: Karlis Muehlenbachs, University of Alberta, Edmonton, AB, Canada; Alex P Wolfe, University of Alberta, Edmonton, AB, Canada; Ryan C McKellar, Royal Saskatchewan Museum, Regina, SK, Canada; Martin Schoell, Retired, Washington, DC

Abstract Body: A new reconstruction of atmospheric oxygen, which is based on the $\delta^{13}C$ of terrestrial organic matter, indicates that pO_2 varied considerably during the Phanerozoic, but reached its maximum of 21% only in the recent geologic past. Throughout much of the Phanerozoic, variations in pO_2 closely followed variations in $^{87}Sr/^{86}Sr$ of marine carbonates, which indicates that pO_2 was primarily influenced by the rates of continental weathering and the associated burial of organic carbon and pyrite. During episodes of increased weathering, *i.e.*, during orogenetic cycles, more sedimentary carbon and sulfur was deposited, causing a rise in pO_2. Episodes of declining pO_2, on the other hand, were primarily the result of reduced continental weathering and continuous seafloor alteration, which resulted in a constant removal of oxygen through oxidation and hydration processes. High-pO_2 episodes, including the Late Carboniferous-Early Permian and Neogene-Quaternary were characterized by low global temperatures and the presence of extensive glaciations, whereas low-pO_2 episodes were typically linked to hothouse conditions. Assuming that atmospheric carbon dioxide is the main factor that controls global temperatures, this indicates that pO_2 and pCO_2, on a long-term scale, are inversely correlated. However, short-term fluctuations of pCO_2 may have been caused by processes, such as volcanism, that had only a limited effect on the global oxygen cycle. In addition to geological factors, Phanerozoic pO_2 was also influenced by the biological evolution. The appearance of lignin in the tissue of vascular plants, for example, allowed for more efficient soil carbon storage, which ultimately led to a considerable rise in pO_2 during the Paleozoic.

Abstract ID: 33836

Final Number: SG21A-07

Title: Ordovician climate simulations with an earth system model: Focus on the impact of atmospheric O_2 and CO_2 on deep ocean oxygen concentrations

Presenter/First Author: Daniel Frank D'Amico, Ohio State University Main Campus, Columbus, OH

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Co-authors: Alvaro Montenegro, The Ohio State University, Columbus, OH; Michael Eby, , ,

Published Material: N/A

Abstract Body: Stratigraphic evidence from the Ordovician suggests that widespread oceanic anoxia existed during the late-Middle to Late Ordovician (460-443 million years ago). While numerous observational studies have examined this issue, there have been relatively few numerical experiments attempting to model the conditions that might have contributed to the recorded low oxygen levels during the period. Previous Ordovician modeling efforts have focused on atmospheric concentration of CO_2 and its impacts on extreme climate change, including a short lived glaciation during the Hirnantian (~445 million years ago). Here we utilize the University of Victoria Earth System Climate Model, a model of intermediate complexity, to simulate the impacts of paleogeography and atmospheric CO_2 and O_2 concentrations on Ordovician deep ocean oxygen. Simulations were performed with two different CO_2 levels (14 and 20 times the preindustrial atmospheric level) and two distinct atmospheric O_2 concentrations (5 and 12% by volume). Modeled meridional overturning transport, sea surface and surface air temperatures are in general agreement with previous simulations of the period. The overturning is dominated by two cells with maximum transports ranging from -42 Sv around 20°N to 58 Sv around 10°S. While atmospheric CO_2 variability influences both ocean temperature and overturning, it has no significant impact on modeled deep ocean O_2. Experiments with the lower atmospheric O_2 concentration show fairly widespread anoxia, here defined as O_2 concentrations below 10 µmol L^{-1}, for the northern hemisphere with an average oxygen concentration of 4.39 µmol L^{-1}. Counter to many of the observations, the majority of the deep ocean in the southern hemisphere, where most continents are located, remains well oxygenated. Future simulations will further evaluate the impact of changes in biological activity and nutrient input on deep-ocean anoxia during the period.

Abstract ID: 35923

Final Number: SG21A-08

Title: Episodic Organic Carbon Burial During the Phanerozoic Indicated by a New Atmospheric pO_2 Record resources.

Presenter/First Author: Martin Schoell, Retired, Washington, DC

Presenter/First Author Email: mschoell@gas-consult.com

Abstract Body: A new reconstruction of Phanerozoic atmospheric pO_2, which is based on the $\delta^{13}C$ of terrestrial organic matter, indicates that at least four major episodes of continuous pO_2 increase occurred over the last 450 million years. Each of these episodes lasted between 20 and 50 million years. The increase in pO_2 during these episodes allowed us to estimate of the amount of organic carbon (OC) that needed to be buried in order to account for the pO_2 increases. The combined total for all four burial episodes is ~$4.4x10^{19}$ moles of OC. Using the accumulation of bitumen in the Athabasca tar sands deposit as a measure of scale (1 AE ~1.8 $x10^{12}$ barrels), we estimate the amount of OC burial during the burial events to be equivalent to ~2600 Athabasca deposits (see Table).

The timing of the four predicted OC burial events coincides with the formation of economically important coal, oil, and gas deposits. However, the amount of carbon stored in known deposits is ~2-3 orders of magnitude smaller than the amount of OC burial required to account for the pO_2 changes. This suggests that the vast majority of OC buried during the Phanerozoic still remains within its sedimentary host rocks, either as dispersed material, or as undiscovered resources.

Burial event	Time (ma)	% O2 change
OBE 1 Tertiary	40-0	13-21
OBE 2 Cretaceous	140-120	7-15
OBE 3 Trias-L. Jur	230-180	10-15
OBE 4 Carboniferous	310-340	12-19
		Total

Abstract ID: 35297

Final Number: SG23A-01

Title: Using co-produced water and disposal wells to assess the geothermal potential of sedimentary basins

Presenter/First Author: Grant A G Ferguson, University of Saskatchewan, Saskatoon, SK

Presenter/First Author Email: grant.ferguson@usask.ca

Published Material: Co-produced and injection figures have been presented. The geothermal analysis is new.

Abstract Body: Rich datasets from the oil and gas industry can reduce the level of uncertainty for geothermal developments. 700,000 wells have been drilled in the Western Canada Sedimentary Basin (WCSB) allowing for the creation of detailed geological models. In addition to this geological knowledge, extensive hydraulic characterization and fluid production and injection has occurred in the WCSB. Approximately 20 billion m^3 of water has been produced from this basin during oil and gas production and 23 billion m^3 has been injected. Here, hypothetical geothermal developments are explored using historical production and and injection rates and known temperatures. The ability to predict hydraulic performance of geothermal developments based on long-term records is not normally possible in other geothermal developments. This could be a key advantage to developing these lower temperature resources.

Abstract ID: 33475

Final Number: SG23A-02

Title: Electricity generation performance from low-grade heat in enhanced geothermal systems

Presenter/First Author: Marc-André Richard, Hydro-Québec, Shawinigan, QC

Presenter/First Author Email: richard.marc-andre@ireq.ca

Published Material: Eastern Canada and the North East U.S., with typical average temperature gradients of less than 30 °C/km, will be low-grade resources for Enhanced Geothermal Systems (EGS). Geothermal electricity generation must cope with significant power plant cooling, geothermal fluid pumping and temperature drop in production wells. The negative impact of these aspects is even more important if the power conversion efficiency is low due to the low resource temperature. The production lifetime of conduction dominated geothermal reservoirs may also be problematic. To analyse the potential for a geothermal electricity generation system from low grade resources, we developed a tool that takes into account electrical plant gross efficiency, energy spent in cooling, pumping of the geothermal fluid and temperature drop in the production wells. To simulate the geothermal reservoir, we represent reservoir fracture systems by an equivalent equidistant fracture network that provides a numerical solution linking reservoir properties, fluid temperature at the exit of the reservoir and time. Then, we analysed the impact of the most important parameters and explored strategies for the optimisation of electric generation from low grade EGS resources. Different scenarios were analysed (optimistic, realistic, and pessimistic). The results suggest that the initial reservoir temperature should be at least 150°C. The power plant must also be able to tolerate a large geothermal fluid temperature drop through the system lifetime. It is suggested that although the power plant efficiency optimisation is important, the reservoir engineering is critical when accessing low grade heat.

Abstract Body: Eastern Canada and the North East U.S., with typical average temperature gradients of less than 30 °C/km, will be low-grade resources for enhanced geothermal systems (EGS). Geothermal electricity generation must cope with significant power plant cooling, geothermal fluid pumping and temperature drop in production wells. The negative impact of these aspects is even more important if the power conversion efficiency is low due to the low resource temperature. The production lifetime of conduction dominated geothermal reservoirs may also be problematic.

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Abstract ID: 34882

Final Number: SG23A-03

Title: Interstage Heating Strategies for Double-Flash Geothermal Power Plant

Presenter/First Author: François Mathieu-Potvin, Laval University, Quebec,

Presenter/First Author Email: francois.mathieu-potvin@gmc.ulaval.ca

Published Material: The results were reported and published in the journal "Geothermics, 2015, vol. 54, pp. 82-95"

Abstract Body: More than 60% of the electricity generated by geothermal power plants in the world is produced from the heat of high temperature hydrothermal reservoirs. These high temperature power plants are typically of the Flash category (Single, Double or Triple-Flash), and it is well known that their efficiency is relatively low. Hence, to ensure economic sustainability of these power plants, it is desirable to improve their design

so that they can provide more energy with the same amount of geothermal fluid.

Recently, we proposed a novel strategy to improve Double-Flash power plants, which consists in extracting heat present in warmer parts of the thermodynamic cycle in order to use it in colder parts of the system, by means of an additional heat exchanger. These new designs are named "Interstage Heating", and are inspired from the work of DiPippo and Vrane (1991).

A numerical model was developed to simulate Interstage Heating processes in Double-Flash thermodynamic cycles, and the model was validated with results reported in literature. That numerical model was then used to optimize the operating parameter values (i.e., separator pressures) and to maximize the specific work output of the geothermal power plants.

Numerical results showed that by using Interstage Heating in Double-Flash designs, the specific work output of power plants may be increased by about 5%, the liquid content in the low pressure turbines may be decreased by about 50%, and the waste heat to power output ratio of power plants may be reduced by about 10 %. In other words, Interstage Heating provides a higher energy output from the same geothermal wells, it reduces the erosion rate of turbine blade, and it may reduce the initial cost of cooling systems in Double-Flash power plants. To summarize, Interstage Heating has the potential to provide significant benefits to owners of Double-Flash power plants.

Abstract ID: 35881

Final Number: SG23A-04

Title: PRELIMINARY FINDINGS INTO SPECIFIC STRATIGRAPY AND HYDRAULIC PROPERTIES FOR GEOTHERMAL ENERGY PROSPECTING ALONG THE WILLISTON BASIN

Presenter/First Author: Randy Rajiv Koon Koon, University of the West Indies, Arouca,

Presenter/First Author Email: randykoonkoon88@hotmail.com

Co-authors: Lotanna Ufondu, , ,

Published Material: The Mathematical model used within this paper is currently under review by the Editor-in-Chief Professor Soteris Kalogirou, D.Sc.. at the Renewable Energy Journal titled, "MATHEMATICAL MODELLING OF THE GEO-MECHANICAL & THERMAL STRAIN ON FRACTURE WALLS WITHIN A CONVENTIONAL GEOTHERMAL SYSTEM".

Abstract Body: Geothermal energy exploration is becoming a sustainable modification from the conventional hydrocarbon industry. Canada shows possible potential for this form of energy widely distributed across the Provinces. The paper serves to present the analysis of well core data within four wells in regards to their temperatures, permeability enhancements, and its dominant hydraulic flow paths. The area of Weyburn is chosen as the target region within the scope of the prominent Williston Basin. From these four wells, five cores are investigated and results generated as a means to display a criteria to analyse other well core data. Through bottom-hole temperature values, temperature vs depth plots are generated and assist to yield insight into favourable depths having suitable temperatures for potential binary systems. Through the use of a mathematical model that describes the deformation of fracture walls as a function of the fracture radius due to the effect of the geothermal fluid, analytical solutions for each core sample is generated that reveals which core structures deform the greatest in response to the fluid. Results are illustrated graphically via MATLAB plots and Excel Histograms. However, through COMSOL Multiphysics 4.3a software the Darcy's Law module is utilized to model the core geometry and the relevant Physics are implemented to generate 3D pressure isosurface models illustrating maximum flow paths. In addition, important 1D plots such as: Darcy's velocity flow, permeability, porosity and pressure along the core sample length are extracted to further analyse the system. Hence the geological cores of the identified wells of interest are modelled to show the extent of velocity flow magnitude and isosurfaces through these cores.

Abstract ID: 33296

Final Number: SG23A-05

Title: Thermal State Assessment of the St. Lawrence Lowlands with a 3D Geological Model

Presenter: Jasmin Raymond, Institut national de la recherche scientifique (INRS), Québec, QC

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First Author: Karine Bedard, Institut National de la recherche Scientifique, Quebec, QC

First Author Email: karine.bedard@ete.inrs.ca

First Author Student?: No

Co-authors: Maher Nasr, Institut national de la recherche scientifique (INRS), Québec, QC, Canada; Michel Malo, Institut National de la Recherche Scientifique-Eau Terre Environnement INRS-ETE, Quebec City, Canada

Published Material: The portion of the reasearch concerning BHT corrections has been partially presented to the Geothernal Ressources Concil 2014 annual conference as a poster (september 2014, Portland, Oregon).

Abstract Body: The Cambrian-Ordovician St. Lawrence Lowlands sedimentary basin covers approximately 20 000 km^2 in southern Quebec, Canada. Deep saline aquifers contain warm water that could potentially be used for geothermal energy. The thickness of the sedimentary cover reaches more than 3000 meters in the south-eastern part of the basin, offering significant thermal insulation. Basal sandstones of the Potsdam Group are prospective targets for natural reservoirs and the crystalline basement of the Grenville province may be a suitable host for enhanced geothermal systems.

The thermal state of the sedimentary basin has been assessed with a 3D geological model to evaluate the potential for geothermal power generation and direct use. The data used to create the 3D model included the geological map of the area, the interpreted basement structural map as well as oil and gas exploration well data. The bottom hole temperature (BHT) data available for 93 of those wells were corrected to estimate equilibrium temperatures that were integrated to the model. Thermal conductivity analyses of 56 outcrop rock samples were performed with a needle probe to determine properties of the modelled geological units. The temperature and conductivity results were then used to calculate the surface heat flow and estimate temperature at depth, assuming a purely conductive heat transfer.

In the 3D model, results indicate heat flow in the range of 36x10^{-3} to 107x10^{-3} W/m^2 with an average of 67x10^{-3} W/m^2. Local areas of higher heat flow (68x10^{-3} to 85x10^{-3} W/m^2) situated in the eastern part of the basin, close to Logan's Line, have sedimentary cover thickness of 3000 to 5500 meters. The equivalent thermal conductivity of the insulating caprocks in this area ranges from 2.4 to 2.7 W/mK. At a depth of 4 km, temperature above 120°C could be expected for the most promising areas.

Power production potential appears to be mostly associated to the deep basement whereas temperature of the basal sandstones indicates potential for direct use.

Abstract ID: 36561

Final Number: SG23A-06

Title: Comparing permeability of fault zones of geothermal and non-geothermal regions, compiled in a global fault zone permeability database.

Presenter/First Author: Jacek Scibek, McGill University, Montreal, QC

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Co-authors: Jeffrey M McKenzie, McGill University, Montreal, QC, Canada; Tom Gleeson, McGill University, Montreal, QC, Canada

Published Material: An update of this project was presented at the AGU 2014 by Scibek et al in abstract titled "How fault zones impact regional permeability and groundwater systems: insights from global database of fault zone studies."

Abstract Body: Fault zones are important fluid conduits in geothermal reservoirs, and the permeability of fault zones is also an important parameter in models assessing deep groundwater flow in sedimentary basins. In this study we conducted a review and compilation of existing fault zone hydrogeological data in various regions of the world, including many faulted sedimentary basins. The database focusses on fault zone permeability and conceptual permeability models published in multidisciplinary literature (structural- and hydro-geology, engineering geology, and geothermal projects among others). In regions with the largest data clusters, the occurrence of different dominant hydrogeologic effects of fault zones (barrier / conduit), and the locally estimated permeability magnitudes, were tabulated and compared for different geologic regions, lithologies, depths. Various data biases, as related to tests of fault zones, are also explored and compared.

The data from developed geothermal projects are compared to other fault permeability estimates at thermal springs (analytical and numerical solution of Darcy flux driven by convective heat flow). Starting with the methodology applied in Japan by Hanano and Kajiwara (1999) and regional mapping by Muraoka et al. (2006), a similar methodology is applied to other regions where hot thermal springs occur. 2D numerical flow models of heat+water flow are used to explore the assumptions and parameter sensitivities of these methods. Fault permeability data from sedimentary basins are compared globally with geothermal heat flux, depth, reservoir size and scale of measurement, number of wells drilled, and other parameters. These results are also compared to non-geothermal hydrogeological data of fault zone permeability in these regions.

The research result lead to a key question - are fault permeability data from developed geothermal fields transferable and/or scalable, or useful in any way, to exploration in geothermally undeveloped sedimentary basins?

Abstract ID: 36867

Final Number: SG23A-07

Title: Geothermal Potential of an Emergent Na-Cl Thermal Spring, Clarendon Plains Basin , Jamaica

Presenter/First Author: DeBonne Natalie Wishart, Central State University, Beavercreek, OH

Presenter/First Author Email: dwishart@centralstate.edu

Abstract Body: Analyzed chemical compositions of emergent low-temperature, Na-Cl type mineral waters from Milk River (MKR) spring situated in the Miocene Age limestone of central Jamaica were combined with a multicomponent geothermometric approach to estimate the geothermal reservoir temperature and depth of fluid circulation. Geochemical data provide interesting information on the origin, circulation, and temperature of this thermal fluid. Boron (B), lithium (Li), and strontium (Sr) concentrations reveal important information about mixing between seawater and geothermal fluids. Cationic ratios of Li/B vs. SO_4^{2-}/Cl^- indicate deep circulating fluid signatures derived mainly from water/rock interactions involving clastic rocks with water essentially resulting from seawater-derived brine. The drastic shift of $\delta^{18}O$ and δ^2H isotopes from the global meteoritic water line (GWML) indicates significant depletion of $\delta^{18}O$ in the region of influence from seawater. Log(Q/K) curves show a cluster of equilibrium temperatures over a range of 150-170°C for MKR. Quartz silica solubility geothermometers underestimated reservoir temperatures. A comparison of temperatures estimated from cation-exchange (Na/K, Na-K-Ca and Na-K-Mg) geothermometers computed from SOLGEO and geothermometric equations range between 153 to 197°C. The higher temperatures estimated for the fluids at depth compared to the emergence temperatures may be due to the circulation of seawater in permeable fractures serving as conduits supporting the upward flow of the geothermal fluids along a major tectonic structure-the east-west trending South Coast Fault (SCF). Chemical and isotopic data suggest the up-flow of deep, thermal, saline brines along fractures of the SCF. Based on hydrochemical, isotopic, geological, and structural data, a hydrogeological conceptual model for the circulation of geothermal fluids at Milk River spring is proposed.

Abstract ID: 34879

Final Number: SG41A-01

Title: Behavior of Marine Sulfate in Variably Sulfidic Oceans

Presenter/First Author: Linda C Kah, University of Tennessee, Knoxville, TN

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Co-authors: Miles A Henderson, , , ; Cara K Thompson, , ,

Published Material: Related abstract investigating only the Ordovician material was presented at GSA 2014. All of this is currently in preparation for publication.

Abstract Body: Our understanding of the oxygenation history of ancient oceans commonly derives from reservoir modeling of marine S-isotopes. Traditional modeling of S-isotopes has emphasized a single-reservoir model, in which the composition of the marine sulfate reservoir depends only on the magnitude and isotopic composition of input fluxes and output fluxes. An inherent assumption in this model is that bacterially reduced HS^- is either immediately extracted by reaction with available iron (e.g., within anoxic waters or sediment pore space) or immediately reoxidized, through a range of intermediate sulfur phases, to sulfate (e.g., within a well-oxygenated waters).

Much of the Proterozoic and early Paleozoic, however, preserves independent data that indicates persistent marine euxinia, wherein Fe^{2+} was at least locally insufficient to strip the water column of bacterially produced HS^-. Such conditions demand modeling the marine sulfur cycle as a dual-reservoir system, wherein marine SO_4^{2-} and HS^- are treated as distinct, reactive reservoirs, with their own input and output fluxes that affect both the behavior of the individual reservoirs as well as the degree of linkage between the two reservoirs. In this case, the isotopic composition of marine sulfate is affected directly by the magnitude and isotopic composition of traditional input and output fluxes that act over long time scales, as well as a suite of transitory input and output fluxes,

including bacterial sulfate reduction and a combination of chemical and biological sulfide oxidation.

Here we examine patterns of behavior in the marine sulfur cycle from Mesoproterozoic through Ordovician-aged strata (from China, Mauritania, Argentina, and Newfoundland), and interpret these patterns in terms of a dual-reservoir model. We show how systematic changes in sulfur isotope behavior related to the protracted oxygenation of the Earth's biosphere and growth of the marine sulfate reservoir over nearly 1 billion years of Earth history.

Abstract ID: 35973

Final Number: SG41A-02

Title: Epiclastic Versus Pyroclastic: Revised Age Constraints on Cryogenian Glacial Deposits in the Pocatello Formation, Idaho, U.S.A.

Presenter/First Author: Mark David Schmitz, Boise State University, Boise, ID

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Co-authors: Vincent Isakson, , , ; Carol M Dehler, Utah State Univ, Logan, UT; Adolph Yonkee, Weber State University, Ogden, UT; Francis A Macdonald, Harvard University, Cambridge, MA

Published Material: Cordilleran Tectonics Workshop, University of British Columbia-Okanagan

Abstract Body: Neoproterozoic glacial successions are recognized worldwide, and interpreted to record global glaciations as part of the 'Snowball Earth' model (Kirschvink, 1992; Hoffman et al, 1998). Although a fundamental tenet of the Snowball Earth hypothesis is a global synchrony of glaciogenic deposits, the number, timing, and correlation of these glacial episodes remain controversial, due to incomplete successions and limited geochronologic constraints.

The Neoproterozoic Pocatello Formation of southeastern Idaho exposes a thick (>1km), well-preserved stratigraphic succession containing glaciogenic strata and a cap dolostone with Marinoan characteristics (Dehler et al, 2011). Stacked diamictite-bearing intervals appear to record two glacial episodes, but absolute ages and relation to other Neoproterozoic glacial events are uncertain. Published ages from the lower Scout Mountain Member of the Pocatello Formation (Fanning and Link, 2004) are now known to be maximum depositional ages from epiclastic volcanic detritus (Keeley et al, 2013). We present new high-precision (CA-IDTIMS) U-Pb zircon ages of ~697 Ma from two felsic pyroclastic flows within the lower diamictite of the Pocatello Formation, which place the first robust constraints on the 'Sturtian' glaciation in this sector of the Laurentian margin. Exposures of the lower Pocatello Formation in Idaho thus appear to record only the latter half of the long Sturtian Snowball Earth glaciation (Rooney et al, 2014). By contrast, we will also introduce new data that falsify the earlier identification of a green argillite bed in the upper Scout Mountain Member as a ~667 Ma "reworked fallout tuff bed" (Fanning and Link, 2004), and demote its significance to a maximum depositional age from epiclastic detritus. Without a firm minimum age bracket, the correlation of the upper diamictite and associated cap carbonate in the Pocatello Formation to the Marinoan deglaciation remains tenable.

Dehler et al (2011) GSA Field Guide 21:181-192. Fanning and Link (2004) Geology 32:881–884. Hoffman et al (1998) Science 281:1342-1346. Kirschvink, J.L. (1992) *in* Schopf and Klein, The Proterozoic biosphere: a multi-disciplinary study: Cambridge University Press, p. 51-52. Keeley et al (2012) Lithosphere doi:10.1130/L226.1. Rooney et al (2014) PNAS 111:51–56.

Abstract ID: 33518

Final Number: SG41A-03

Title: Oxygen, Facies, and Secular Controls on the Appearance of Cryogenian and Ediacaran Body and Trace Fossils in the Mackenzie Mountains, Northwestern Canada

Presenter/First Author: Erik A Sperling, Scripps Institution of Oceanography, Cambridge, MA

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Co-authors: Calla Carbone, , , ; Justin Vincent Strauss, Harvard University, Cambridge, MA; David T Johnston, Harvard-Earth & Planet Science, Cambridge, MA; Guy Narbonne, , , ; Francis A Macdonald, Harvard University, Cambridge, MA

Published Material: Presented at the 2014 Palaeontological Association meeting, Leeds, United Kingdom.

Abstract Body: The causes behind the appearance of abundant macroscopic body and trace fossils at the end of the Neoproterozoic Era remain debated. Iron geochemical data from fossiliferous Ediacaran successions in Newfoundland suggested that the first appearances at that locality appeared to correlate with an oxygenation event. A similar relationship was claimed to exist in the Mackenzie Mountains, Canada, although later stratigraphic studies indicated that the stratigraphic sections analyzed for geochemistry were incorrectly correlated with those hosting the fossils. To directly connect fossil occurrences with geochemistry in the Mackenzie Mountains, we conducted a multi-proxy iron, carbon, sulfur, and trace element geochemical analysis of stratigraphic sections hosting both the Cryogenian 'Twitya discs' at Bluefish Creek as well as the Ediacaran fossils and simple bilaterian traces at Sekwi Brook. There is no clear oxygenation event correlated with the appearance of macroscopic body fossils or simple bilaterian burrows; however, some change in environment – a potential partial oxygenation – is correlated with increasing burrow width higher in the Blueflower Formation. Data from Sekwi Brook suggest that these organisms were periodically colonizing a predominantly anoxic and ferruginous basin. This seemingly incongruent observation is accommodated through accounting for differing timescales between the characteristic response-time of sedimentary redox proxies versus that for ecological change. Thus, hypotheses directly connecting ocean oxygenation with the appearance of macrofossils need not apply to all areas of a heterogeneous Ediacaran ocean. At least in the Mackenzie Mountains, the appropriate facies for fossil preservation appears to be the strongest control on the stratigraphic distribution of macrofossils.

Abstract ID: 36830

Final Number: SG41A-04

Title: Late-Ediacaran Resumption of Extension on the Western Laurentian Margin near Jasper, Alberta, Canada

Presenter/First Author: Thomas James Maguire, McGill University, Montréal,

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Co-authors: Galen P Halverson, McGill University, Montreal, QC, Canada

Abstract Body: The timing and nature of renewed latest-Ediacaran extension on the western Laurentian margin remains controversial after decades of study. Lower-greenschist facies sedimentary rocks with *Namacalathus-Cloudina* fossils near Jasper, Alberta, Canada present an attractive prospect for improving geochemical understanding of the key end-Proterozoic time, yet remain poorly studied due to correlation difficulties. Two pulses of sedimentation have been interpreted to record major episodes of extension: 1) Cryogenian intracontinental rift sediments, the Miette Group of the Windermere Supergroup, a 9km thick siliciclastic-dominated shallowing-up succession; 2) late-Ediacaran extension resumption accommodating 6km of carbonate-dominated passive margin sediments through the lower-Paleozoic, beginning with fluvio-marine and fluvial coarse-grained sandstones of the >2.2km thick Hamill-Gog (locally Gog) Group. At it's base, an erosional hiatus of widespread extent and non-uniform stratigraphic removal, the sub-Gog Unconformity, has complicated correlations of upper Miette strata, as have the lack of biostratigraphic clues in the Gog, indications of extension diachroneity, and a paucity of rocks suitable for absolute-dating methods. In the Jasper area, however, extension contemporaneous with the sub-Gog surface provides a locally-continuous record of Miette through Gog sedimentation in fault-bounded basins. Our sequence-stratigraphic correlations, complemented by biostratigraphic and high-resolution carbonate chemostratigraphic data, permit study area correlation across a complex paleotopography with several hundreds of meters of stratigraphic variability, and to age-constrained rocks globally. We establish a new age-constraint on Jasper-area margin collapse: it begins no earlier than ~552Ma and before 542 ± 0.3Ma, at odds with the sole regional U-Pb radiometric date of 569.6 ± 5.3Ma from the 150km-distant Hamill Group, confirming strong diachroneity along the margin.

Abstract ID: 34871

Final Number: SG41A-05

Title: Ediacaran soft-tissue preservation

Presenter/First Author: Marc Laflamme, University of Toronto, Mississauga, Mississauga, ON

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Co-authors: James D. Schiffbauer, , , ; SImon Alastair Francis Darroch, Smithsonian Institution, Washington, DC

Published Material: Preseneted similar results at the International Paleontological Congress in October 2014. Paper presently being written for publication.

Abstract Body: Biases in the fossil record must be considered before any meaningful signals can be retrieved. *Konservat-Lagerstätten,* sites that preserve soft-bodied organisms, represent the richest fossil source of anatomical information and offer more complete views of organismal diversity and disparity patterns in deep time. Understanding the early evolution and diversification of animals, as written in the Ediacaran fossil record, is reliant on our understanding of the preservational constraints affecting the fossilization of soft tissues in Ediacaran *Lagerstätten*. We have employed a two-pronged approach to aid in unraveling the geobiological intricacies in Ediacaran preservation. On the one hand, advanced instrumentation such as environmental scanning electron microscopy (ESEM), energy dispersive X-ray spectroscopic elemental mapping analyses (EDS)x-ray, photoelectron spectrometry (XPS), and electron probe microanalyzer wavelength dispersive X-ray spectroscopy (EPMA-WDS), was performed on sectioned Ediacaran fossils from Newfoundland and Namibia, revealing the importance of clay minerals and the precipitation of iron sulfides such as pyrite in casting the external morphology of the organisms. On the other hand, decay experiments conducted under controlled laboratory settings allowed for investigations into the replication of soft-tissue preservation, which identified controls on rates of tissue decay and early mineralization. This combined two-pronged approach provides a conceptual framework for understanding the distribution of Ediacaran-style preservation in time and space, and will help frame the paleoenvironmental settings and conditions where body fossils are preserved in the Neoproterozoic.

Abstract ID: 34171

Final Number: SG41A-06

Title: Biodiversity in the Precambrian Fossil Record: Constructing a Digital Database of the Ediacara Biota and Closing the Precambrian-Cambrian Evolutionary Gap.

Presenter/First Author: Thomas Howard Boag, University of Toronto, Toronto,

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Co-authors: Marc Laflamme, University of Toronto, Mississauga, Mississauga, ON, Canada; SImon Alastair Francis Darroch, Smithsonian Institution, Washington, DC

Abstract Body: Large, complex life first appears in the latest Ediacaran (579-541 Ma), characterized by globally distributed marine soft-bodied organisms colloquially called the Ediacara biota. Although it is well documented that these organisms went extinct prior to the Cambrian explosion of bilaterian animals, the ultimate cause is still unclear. Three hypotheses are proposed: 1) gradual and evolutionarily mediated biotic turnover in response to the appearance of metazoan 'ecosystem engineers'; 2) a taphonomic artifact produced by the disappearance of conditions required for preservation; and 3) a sudden, coeval mass extinction driven by perturbations to global geochemical cycles. Critical testing of these hypotheses requires a detailed understanding of Ediacaran biodiversity in both paleogeographic space and stratigraphic time. Here, I present preliminary results from an exhaustive integrated paleontological database that summarizes the known distributions of Ediacaran taxa, combined with geological characterization of Ediacaran depositional and taphonomic settings as compiled from both literature research and recent fieldwork. I include additional data on chronostratigraphy, lithostratigraphy, preservational mode, and mineralogy of local-scale diagenetic alteration. I find that the Ediacaran fossil record displays a distinct bias towards moldic-style preservation in coarse-grained siliciclastic lithologies – with comparatively little preserved in carbonate facies or as compressions in shales. I also find strong correlation between worker effort and genus richness among major localities worldwide. These data illustrate that accurately quantifying changes in Ediacaran biodiversity through time requires a variety of sample standardizing techniques. Ultimately, these findings will guide future fieldwork in targeting under-studied strata, paleoenvironments, and preservational windows, helping to resolve the tempo and mode of early animal evolution preluding the Cambrian explosion.

Abstract ID: 33441

Final Number: SG41A-07

Title: New Precambrian Trace Fossils, the End of the Ediacara Biota, and First Mass Extinction of Complex Life

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Co-authors: Marc Laflamme, University of Toronto, Mississauga, Mississauga, ON, Canada

Published Material: These findings are currently in review as part of two submitted manuscripts in peer-reviewed journals.

Abstract Body: The precambrian-Cambrian transition (542 Ma) marks perhaps the most dramatic geobiological change in the last billion years of Earth history, and yet remains poorly understood. This interval marks the extinction of the enigmatic Ediacara biota (a collection of multicellular eukaryotes whose affinities with modern metazoans are unknown), the Cambrian 'explosion' of modern animal groups, and a shift from stratified, microbially-dominated 'matgrounds', to more recognizable Phanerozoic 'mixgrounds' colonized by a wide variety of infaunal metazoans. Key to understanding this transition is unraveling the causes behind the extinction of the Ediacara biota, as these made way for the proliferation of modern animal groups. Here, we present new data from latest Ediacaran sections in southern Namibia that preserve both Ediacaran soft-body fossils, and trace fossils that represent the activity of Cambrian-type animals. We show that: 1) latest Ediacaran communities had low evenness and species richness, consistent with interpretation as 'stressed' ecosystems; and, 2) these Ediacaran communities co-existed with cnidarian grade trace-makers that may represent some of the earliest evidence for passive predation. Together, these findings provide support for a 'biotic replacement' model of the extinction of the Ediacara biota, in which extinction was protracted, and ultimately caused by the evolution of Cambrian-style predators and 'ecosystem engineers'. These findings also suggest that the first mass extinction of complex life was likely biologically caused and mediated, in stark contrast to the subsequent Phanerozoic 'Big Five' events.

Abstract ID: 33473

Final Number: SG44A-0339

Title: Nitrogen isotopes across a late Mesoproterozoic basin transect, Arctic Bay Formation, Nunavut

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Co-authors: Pierre Sans-Jofre, Université de Bretagne Occidentale, Brest, France; Marcus Kunzmann, McGill University, Montreal, QC, Canada; Devon Cole, Yale University, New Haven, CT; Timothy Gibson, McGill University, Montreal, QC, Canada; Peter William Crockford, McGill University, Montreal, QC, Canada; Galen P Halverson, McGill University, Montreal, QC, Canada

Published Material: A poster featuring an incomplete dataset will be presented at the Northeastern Geobiology Symposium at Princeton University. Similarly, an incomplete dataset will be used in an oral presentation at the GEOTOP Congress.

Abstract Body: Proterozoic ocean oxygenation is poorly understood, with various geochemical proxies resulting in seemingly contradictory models. Nitrogen isotope compositions of sedimentary organic matter, while regionally heterogenous, reflect the redox state of the global ocean. The late Mesoproterozoic Arctic Bay Formation, Nunavut, comprises hundreds of meters of organic-rich shales (up to 20 weight % TOC) deposited below storm wave base in a marine setting. Two sections were measured along a basin-shelf transect and analysed for nitrogen isotopes in bulk sediment and kerogen, organic carbon isotopes, and iron speciation. Within the more basinal section, $\delta^{15}N$ values range from 1.6-4.7‰, with a modal value of 2.0‰. In the more proximal (shelf break) section, $\delta^{15}N$ values range from 0.8-4.4‰, with a modal value of 2.2‰. A small offset is also seen in organic carbon isotopes, with the basinal section recording a modal $\delta^{13}C_{org}$ of -30.2‰, compared to -29.7‰ in the shelf break section. The offset between basinal and shelf break $\delta^{15}N$ values is interpreted to be a result of decreased nitrate stability, and therefore decreased oxygen concentrations, at depth. The lowest $\delta^{15}N$ values in the shelf break section (0.82‰) occur at a flooding surface, and may indicate the presence of an oxygen minimum zone adjacent to the shelf break. The measured range of $\delta^{15}N$ values (0.8-4.7‰) implies a relatively stabile nitrate reservoir consistent with the early Mesoproterozoic (~2‰). However, the modal values (2.4‰) are distinctly lower than the late Neoproterozoic (~4‰) or Phanerozoic (~5‰), suggesting that the ocean was not yet dominantly oxic.

Abstract ID: 36565

Final Number: SG44A-0340

Title: Application of the I/[Ca+Mg] Proxy to Interpreting the c. 810 Ma Bitter Springs $\delta^{13}C$ Anomaly

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Published Material: I already presented some of these I/[Ca+Mg] data frrom the Akademikerbreen Group in Svalbard at the Goldschmidt Conference 2014. I also presented my preliminary results as a poster.

Abstract Body: The ca. 810 Ma Bitter Springs carbon isotope anomaly is an abrupt and long-lived (5–10 m.y.) departure from the high $\delta^{13}C$ values that otherwise characterize early-middle Neoproterozoic seawtaer. This isotope anomaly, which reflects a -8‰ shift in mean seawater DIC carbon isotope composition, has been documented globally, but is perhaps best represented in carbonates from Svalbard and East Greenland. Given increasing evidence that Neoproterozoic oxygenation and eukaryotic diversification began well before the Ediacaran Period, the Bitter Springs anomaly is a logical interval to explore for geochechemical evidence of early Neoproterozoic redox change. To this end we have applied the I/[Ca+Mg] to carbonate rocks spanning the anomaly as a novel proxy for seawater redox potential that is highly sensitive to changes in oxygen content. These data are further compared with other trace element data on carbonates.

Iodine exists almost exclusively as iodide (I^-) and iodate (IO_3^-) in seawater, with the balance shifted towards iodate under more oxidizing conditions. Because IO_3^- can be incorporated in calcite crystal during carbonate precipitation, variations in I/[Ca+Mg] in carbonate may reflect fluctuations in seawater redox. The proxy has previously been applied to Cretaceous Ocean Anoxic Events (OAEs) and the Great Oxidation Event (GOE). Our data, available so far, from Svalbard and Greenland reveal two prominent features. First, the Bitter Springs anomaly is associated with low I/[Ca+Mg] ratios compared to carbonates above and below. Secondly, two spikes in I/[Ca+Mg] are associated with $\delta^{13}C$ recoveries (positive shifts), including the end of the Bitter Springs event and the smaller anomaly proceding it. We interpret these results to indicate that the Bitter Springs anomaly coincided with periods of expanded basin anoxia.

Abstract ID: 36310

Final Number: SG44A-0341

Title: Lost and found: the Islay carbon isotope excursion in Namibia is nearly 746 Ma in age

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Abstract Body: Before 2014, the Islay carbon isotope excursion (I-CIE) was assumed to directly predate the early Cryogenian Sturtian glaciation (717-659 Ma), notwithstanding a return to enriched $\delta^{13}C$ values before glaciation observed in some areas. On this assumption, a fruitless search for the I-CIE was conducted in northern Namibia for 20 years. There, Sturtian glacial deposits (Chuos Fm) are underlain by 1.0 km of mixed carbonate and clastic strata (OSG, Ombombo Subgroup) on the Northern Platform (Congo craton), and by a comparable sequence (USG, Ugab Subgroup) in the Northern Zone of the Damara orogen, directly south of the platform. OSG carbonate $\delta^{13}C$ increases stratigraphically upward from 1 to 8 permil VPDB, before falling to 3 permil at the top. A tuff in midsection was previously dated at 759±1 Ma (U-Pb). USG carbonate decreases upward from 6 permil in midsection to 0 permil at the top. The lower 140 m of USG carbonate, which conformably overlies rhyolite ash-flow tuff dated at 746±2 (U-Pb), was not previously sampled. In 2014, Re-Os isochron ages of 739.9±6.5 and 732.2±4.7 Ma were reported from black shales associated with the fall and rise of the I-CIE, respectively, in NW Canada (Rooney et al. PNAS 111(1), 51-6; Strauss et al. Geology 42(8), 659-62). These dates imply that the I-CIE is unrelated to Sturtian glaciation and ~20 Myr older then earlier assumed. Given this lead, we sampled the previously neglected lower USG carbonate interval. We find that $\delta^{13}C$ falls steeply from −1 to −5 permil in the first 30 m of section, after which it rises to 4 permil at the top of the lower carbonate interval. This CIE is too young to be the Bitter Springs stage and is the only negative CIE younger than ~760 Ma known in Namibia. Pending confirmation in correlative sections, we infer that the long-sought I-CIE occurs in the lower USG, in which case its age is a little less 746±2 Ma, compatible with Canadian Re-Os data and unrelated to Sturtian glaciation.

Abstract ID: 36312

Final Number: SG44A-0342

Title: Expanded records of early Ediacaran marine carbonate $\delta^{13}C$ from Namibia: synchronous foredeep initiation bordering the Kaoko and Damara orogens?

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Abstract Body: Shelf carbonates of the Tsumeb Subgroup (TSG) exposed in the Otavi fold belt (Namibia) offer an expanded record of early Ediacaran surface seawater chemistry. TSG includes late Cryogenian (Marinoan) glacial deposits and the global syndeglacial cap dolostone marking the base of the Ediacaran Period. The TSG shelf occupied the SW promontory of the Congo craton, the western margin of which collided with the east-facing Ribeira arc (SE Brazil) at 600-590 Ma, forming the Kaoko orogen (KO). In the west, the TSG ends with shelf drowning and foredeep clastic sedimentation. To the south, the TSG shelf faces the Damara orogen (DO), where a south-facing magmatic arc in the Central Zone (CZ), established by 560 Ma, collided with the Kalahari craton at ~550 Ma. The CZ is traditionally viewed as an attenuated extension of the Congo craton, but between them lies the most deep-seated and continuous total magnetic intensity anomaly in the country. We present new high-resolution $\delta^{13}C$ records for TSG from sites bordering the KO in the west and the DO nearly 400 km to the east at Tsumeb. The TSG can be divided into three chemostratigraphic units (T1-T3). T1 (0.2-1.0 km) was a 'catch-up' stage in which accommodation created during Marinoan glaciation was filled. It coincides with the Maieberg CIE, a steep fall from −1 to −6 permil VPDB, followed by gradual recovery to −1 permil. T2 (0.5-1.0 km) was a 'keep-up' stage, defined by a gradual smooth decline to −3 permil followed by a smooth but steeper climb to 2 permil. 'Keep-up' continued in T3 (0.4-0.8 km), defined by a sharp rise to unstable heavy values of 3-7 permil (west) and 5-11 permil (east), followed by a decline to 2 permil at the top of TSG in both areas. We infer that either clastic input from the KO ended carbonate sedimentation in the east, well beyond the limit of KO foredeep subsidence, or that clastic input in the east is related to tectonism in the DO 40-50 Myr before the terminal Congo-Kalahari collision.

Abstract ID: 35847

Final Number: SG44A-0343

Title: Dolomite Marine Cements Record Marine Anoxia During the Late Cryogenian

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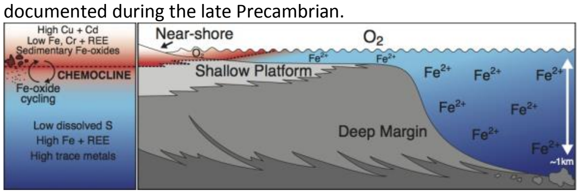
Co-authors: Malcolm William Wallace, , ,

Published Material: Some findings published in a short summary paper:Hood, Ashleigh VS, and Malcolm W. Wallace. "Marine cements reveal the structure of an anoxic, ferruginous Neoproterozoic ocean." *Journal of the Geological Society* 171.6 (2014): 741-744.More detailed finding have been accepted for publication (pending revisions) in Precambrian Research

Abstract Body: The Neoproterozoic was a time of great changes in the Earth's surface and marine environments, including a significant 'step' in the evolution and oxygenation of the oceans. However, the timing of this ocean oxygenation remains uncertain, particularly in regards to Cryogenian seas, which were disrupted by large periods of global glaciation. The recent recognition of primary dolomite marine cements in Cryogenian sequences of Namibia and Australia may help resolve the complex ocean chemical history of this time. These cements show well-preserved cathodoluminescence growth zonation and have optical properties indicating they preserve their original marine chemistry and can therefore be used as geochemical proxies for Late Cryogenian paleooceanography. In particular, the interglacial Cryogenian Oodnaminta Reef Complex, (Adelaide Fold Belt, Australia) contains abundant primary marine dolomite cements, which cover a significant palaeo-depth range. Analysis of these cements from nearshore facies (~0-2m), to deep framework facies (~1km) of the reef complexes reveals significant geochemical gradients with palaeo-depth. Iron is present in high concentrations in cements from deep and shallow reef facies, but is present only as Fe-oxides in nearshore facies. Chalcophile elements (Cu, Cd, Pb, Zn) are abundant in the nearshore and shallow cements, but decrease in concentration with depth. Rare earth element profiles are unusual, with shallow and deep facies showing convex profiles with negligible Ce/Ce* anomalies and positive Eu/Eu* anomalies.

Constrained by sedimentology, this carbonate geochemistry provides a detailed window into the structure and chemistry of an interglacial Cryogenian ocean. The marine cements reveal a pronounced chemical stratification, where a thin veneer of oxic surface waters existed over increasingly anoxic and Fe-rich seawater at depth. The distribution of strongly chalcophile elements (e.g. Cd and Cu) across this chemocline suggests that although ferruginous, deeper anoxic waters probably contained minor dissolved sulfide. These conditions describe a ferro-sulfidic ocean and encompass some of the most extreme anoxia yet documented during the late Precambrian.



Abstract ID: 35759

Final Number: SG44A-0344

Title: Testing Snowball Earth: Subsurface Sedimentology of the Neoproterozoic Kamoa Subbasin, Democratic Republic of Congo

Presenter/First Author: Kirsten Kennedy, University of Toronto, Toronto,

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Co-authors: Nicholas Eyles, University of Toronto, Claremont, ON, Canada; David Broughton, , , ; David Edwards, , ,

Abstract Body: Systematic drilling of over 1100 wells representing some 300 km of core through a world-class stratiform copper deposit in the Kamoa Subbasin (Katanga Supergroup, Democratic Republic of Congo) has been undertaken, providing data for an unusually thorough examination of facies during a putative Snowball Earth event. The stratigraphy in the Kamoa region is composed of basement Kibaran Supergroup quartzites and basalts, interdigitating Poudingue conglomerates and Mwashya Subgroup sandstones (up to 1600 m thick), Grand Conglomerat diamictites (1600 m thick), and Kakontwe Formation stromatolitic dolomites. The basin documents a complex extensional tectonic history that presents the primary control on sedimentation via syndepositional faulting, rapid subsidence, and volcanism. The geometry of faulted basement blocks is tracked through the distribution of basement-derived breccia and fan-delta conglomerates (Poudingue). These data indicate that the subbasin was bounded to the west and the east by basement blocks which partially separated the Kamoa Subbasin from the larger Katanga Basin, leaving an outlet to the south. The transition from relatively oxidized Mwashya sandstones to a stratigraphically complex slope-toe debrite-turbidite association (Grand Conglomerat Fm.) was accompanied by faulting, cannibalization of Poudingue gravels, minor volcanism, and an influx of mud. Grand Conglomerat diamictites have long been attributed to the Sturtian glacial event, yet display frequent changes in textural styles and composition and are interbedded with deepwater heterolithic strata, indicating that sediment sources and depositional lobes fluctuated over time. While the influx of mud at the Mwashya-Grand Conglomerat transition may be related to the onset of regional glaciation, the localized effects of sediment focussing, coeval volcanism, and the dynamic topography of an extensional basin should not be understated.

Abstract ID: 36573

Final Number: SG44A-0345

Title: New Age Constraints on Middle Ediacaran Chemostratigraphy, Biostratigraphy, and the East African Orogeny from the Arabian Shield

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Co-authors: Mark David Schmitz, Boise State University, Boise, ID; Grant M Cox, McGill University, Montreal, QC, Canada; Peter R Johnson, , Portland, OR; Marcus Kunzmann, McGill University, Montreal, QC, Canada; Thomas James Maguire, McGill University, Montréal, Canada; Alan S Collins, University of Adelaide, Adelaide, Australia

Published Material: Some of the stratigraphy and fossil claims are previously published in a 2013 paper in Terra Nova by Nettle et al. The current abstract, however, is based on new radiometric age data.

Abstract Body: The middle Ediacaran Jibalah Group fills a series of small, isolated, and minimally deformed sedimentary basins in the eastern and northern Arabian Shield. These mixed volcanic-siliciclastic-carbonate basins lay along strands of the Najd Fault System, an array of transpressional structures related to lateral escape during the late stages of the East African Orogeny (EAO). The abundance of tuffs and occurrence of putative Ediacaran fossils within the Jibalah Group present the potential to calibrate the middle Ediacaran Period. Here we report new U-Pb zircon ID-TIMS age constraints from two of the Jibalah basins: the Antaq and the Jifn. Three silicified tuffs in the cyclic, shallow marine to fluvial Muraykhah Formation, the uppermost of three formations in the Antaq basin, yield ages of 599.1±0.2, 593.7±0.2, and 593.6±0.2 Ma. These tuffs span the range from which possible *Charniodiscus* and *Aspidella* fossils have been reported. The new ages also suggest that the well-defined, 10m-scale Muraykhah cycles represent ~110–130 thousand years, consistent with orbital forcing. Ages from volcanic clasts and tuffaceous siltstones in the Jifn basin suggest that it is coeval with the Antaq basin, with a maximum age constraint of 585.5±0.5 Ma on the calcareous upper member of the Umm al'Aisah Formation. This member comprises a single shoaling upward sequence with turbidites and debrites at the base and grainstones and microbialaminites at the top. Isotopic data suggest that the Jifn basin was dominantly restricted, but intermittently connected to the open ocean. These data enable us to constrain the onset of the Shuram negative carbon isotope anomaly to <585.5 Ma and the rise in seawater $^{87}Sr/^{86}Sr$ to ≥0.7085 by this time. Collectively, these new ages indicate that the Najd Fault System and the Jibalah basins initiated between 618–600 Ma, prior to final closure of the Mozambique Ocean and terminal collision of the EAO.

Abstract ID: 33401

Final Number: SG44A-0346

Title: Uncovering late Ediacaran kinematics of the Avalonia terrane using paleomagnetism

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Co-authors: David AD Evans, Yale University, New Haven, CT; Phil J A McCausland, University of Western Ontario, London, ON, Canada; Bin Wen, Nanjing University, New Haven, CT

Abstract Body: Recently published paleomagnetic data from the Avalonia terrane, Newfoundland (Pisarevsky et al., 2012) show a 70° discordance between paleomagnetic mean directions from the Bull Arm Fm. (~570 Ma) and the Crown Hill Fm. (~550 Ma), which the authors attributed to local vertical-axis rotation between sampling sites, rotation of the entire terrane between 570 and 550 Ma, or rapid apparent plate motions possibly due to true polar wander. In this study, we collected 319 samples from 7 localities around Trinity and Bonavista Bays from the Bull Arm – Crown Hill stratigraphic interval. At Duntara, Bonavista Bay, Crown Hill Fm. redbeds are very stable to demagnetization and reproduce the moderate NW-down/SE-up direction from Pisarevsky et al. (2012). The 55m section has at least 7 reversals, implying (if primary) that the late Ediacaran geodynamo was in a rapidly reversing state. Crown Hill rocks at the nearby Tickle Cove record the same direction as the Duntara rocks at three sites, including two with a structural attitude similar to Bull Arm volcanics in the same area. If primary, this would show that the remanence discordance between Crown Hill and Bull Arm Fms. is stratigraphic rather than structural. A fold test at this locality is currently inconclusive but further analyses may

clarify. On the eastern margin of Trinity Bay, redbeds from the Maturin Pond Fm. (thought to be slightly older than Crown Hill Fm.), sampled over 260m at Heart's Content, yield a 2-polarity direction that is very steep NW-down/SE-up in geographic coordinates or shallow NW-down/SE-up in tilt-corrected coordinates. Additional localities and tests are needed to determine the age of remanence in these strata. Overall, our initial dataset suggests that variations in paleomagnetic remanence directions in the Bull Arm - Crown Hill sections of the Bonavista/Trinity Bay area are not due to local structural rotations, but instead indicate rapid apparent polar wander of the Avalonia terrane.

Abstract ID: 35456

Final Number: SG44A-0348

Title: Cycles of Nutrient Trace Elements in the Phanerozoic Ocean and Relationship to Atmosphere-Ocean Oxygenation

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Co-authors: Jacqueline Halpin, University of Tasmania, Hobart, Australia; Elena Lounejeva, , , ; Leonid V Danyushevsky, University of Tasmania, Hobart, TAS, Australia

Published Material: A version was presented at Goldschmidt 2014, but new data and interpretation has considerably changed the presentation

Abstract Body: Redox sensitive and nutrient trace element (TE) concentrations in the palaeo-ocean have commonly been interpreted to rise abruptly toward the end of the Neoproterozoic, and remain relatively constant through the Phanerozoic. This pattern has been considered to relate to a second stage of Earth oxygenation, resulting in, or a consequence of, the Cambrian explosion of life. Here we present a comprehensive dataset on the trace element content of marine sedimentary pyrite that defines several TE concentration cycles, on 70 to 120 million year wavelengths, with amplitude variations of several orders of magnitude. The cycles, which start in the Neoproterozoic and are best developed through the Paleozoic, have a similar pattern to the ocean $^{87}Sr/^{86}Sr$ record, suggesting that continental erosion and nutrient supply maybe a first order driver of the TE cycles. Molybdenum, thallium, selenium, cadmium, antimony and $^{87}Sr/^{86}Sr$ show cycles with a positive statistical correlation, whereas cobalt shows a negative correlation with this TE group and the $^{87}Sr/^{86}Sr$ pattern. The contrasting pattern of cobalt, which is demonstrated on all scales from a few million to a billion years is most probably due to its decrease in solubility under conditions of increasing oxidation. This opposite behavior to the other TE, implicates oxygenation as a second order driver of the redox sensitive TE cycles, and enables the tentative construction of an oxygenation curve for the Phanerozoic.

Abstract ID: 36663

Final Number: SG44A-0349

Title: Linking Atmospheric pO_2 to Geological Processes

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First Author Student?: No

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Published Material: 50% at AGU 2014 & GSA 2014.

Abstract Body: A new reconstruction of Phanerozoic atmospheric oxygen concentrations has been developed from terrestrial organic matter $d^{13}C$, revealing trends that correlate positively and significantly to those of marine carbonate-hosted $^{87}Sr/^{86}Sr$. However, the structure of this correlation is highly time-dependent, and is strongest during the upswings of Phanerozoic pO_2, in the range of 13 to 20% atmospheric O_2, that occur in the Late Paleozoic, the Jurassic, the Late Cretaceous, and the Cenozoic. We interpret these intervals to reflect combinations of orogenesis, weathering, and sedimentation that simultaneously raise ocean $^{87}Sr/^{86}Sr$ while enhancing burial of organic matter and pyrite, with the net effect of rapid and efficient oxygenation of the ocean-atmosphere system. During intervening intervals, the correlation between reconstructed atmospheric O_2 and ocean $^{87}Sr/^{86}Sr$ is much weaker, intimating that processes of O_2 removal are more complicated, temporally lagged, and inherently hysteretic. For example, deep-sea hydrothermal processes including Fe(II) oxidation and hydrous alteration of the ocean floor, while highly effective overall, produce a more sluggish response with respect to ocean-atmosphere deoxygenetion than the reverse process of O_2 re-supply mediated by burial. In support of the conceptual model that relates atmospheric pO_2 to the same processes that control ocean $^{87}Sr/^{86}Sr$, this linkage does not appear restricted to the Phanerozoic. Vanishingly low pO_2 inferred for much of the Meso- and Neoproterozoic is matched by $^{87}Sr/^{86}Sr$ ratios lower than any interval of the last 500 Ma, signifying particularly strong sea-floor O_2 sinks during the billion-year interval that presaged the Ediacaran oxygen spike, itself associated with an abrupt increase of $^{87}Sr/^{86}Sr$ and the rise of Metazoa.

SPACE PHYSICS AND AERONOMY

Abstract ID: 33762

Final Number: SPA11A-01

Title: Intermittent Scaling of the Solar Wind Data from Ulysses: Multifractal Analysis

Presenter/First Author: Anna Wawrzaszek, Space Research Center Polish Academy of Sciences, Warsaw,

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Co-authors: Wieslaw Marian Macek, Polish Academy Sciences, Warsaw, Poland; Marius Echim, Institute of Space Sciences, Bucharest, Romania

Abstract Body: We study the evolution of intermittency in interplanetary magnetic fields with the heliocentric distance and latitude by using large amount of data from Ulysses spacecraft measured during two solar minima (1995-1997, 2007-2008) and solar maximum (1999-2001). In particular, we consider small-scale fluctuations of the magnetic field embedded in the "pure" slow and fast solar wind. To distinguish different types of solar wind we use the following parameters: radial velocity, proton density, proton temperature, the distribution of charge states of oxygen ions, and compressibility of magnetic field. We exclude from our analysis any solar wind transients (shocks, CME, magnetic clouds), thus our analysis is relevant for the "pristine" state of the wind, fast and slow. In the next step we consider the chosen intervals for fast and slow solar wind and perform multifractal analysis of components of the fluctuating magnetic field. More precisely, to quantify the degree of multifractality (intermittency) we

determine about 500 multifractal spectra of the selected data sets (magnetic field components and intensity) and fit the observations with models of the intermittent turbulence.

The multifractal characteristics of the solar wind turbulence depend on the heliographic latitudes, heliocentric distance, and phase of the solar cycle. In general, we observe a somewhat smaller degree of multifractality at high latitudes during solar minimum for the fast solar wind, where turbulence evolves more slowly as compared with that at the ecliptic plane. Moreover, it seems that the multifractality exhibits a latitudinal dependence with some symmetry with respect to the ecliptic plane. The performed analysis provide a supporting evidence that the small-scale magnetic field fluctuations observed by Ulysses exhibit a multifractal behavior that is a persistent feature of fast and slow wind, at solar maximum and minimum.

Research supported by the European Community's Seventh Framework Programme (FP7=2007 - 2013) under grant agreement no 313038=STORM.

Abstract ID: 34901

Final Number: SPA11A-02

Title: Local Fluctuations and Correlations in Turbulent Cascade Rates in the Solar Wind

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Published Material: part in Coburn, et al. in Astrophysical Journal last year

Abstract Body: Politano and Pouquet showed in two 1998 papers that the turbulent heating rate in stationary homogeneous plasmas is proportional to the slope of certain signed third moments of fluctuations in Elsasser variables with scale distance. Using plasma data from the ACE spacecraft at L_1, we found that the required third moments are highly variable, so that months of data were needed to get the third moments at each scale to converge, so we could get a meaningful heating rate. These heating rates compared well with the in-situ heating of the solar wind deduced from the non-adiabatic decay of proton temperature from the corona to 1 AU. We thought the need for large amounts of data was due to intermittency. Lately, however, we discovered that in more local 1 to 12 hour ACE data sets, the third moment of fluctuations in Elsasser variables are in practically all cases proportional to scale, with correlation coefficients close to ±1. However, the slopes and inferred local cascade rates (we hesitate to call these heating rates) are highly variable among these shorter data sets. Combining many such local cascade rates converges on meaningful heating rates as before. Furthermore, the cascade rates for outward- and inward-travelling pseudo-energies (in each Elsasser variable) in these smaller data sets tend to be anti-correlated according to the local cross-helicity. Evidence of this will be presented in this talk. We are left with the questions: Is this variation in local behavior of the third moments in solar wind another aspect of intermittency? and What do the observed anti-correlation, its dependence on cross-helicity, and the negative local cascade rates mean?

Abstract ID: 34936

Final Number: SPA11A-03

Title: Solar Wind Turbulence: the Effects of Spherical Expansion on II and III Order Structure Functions

Presenter/First Author: Andrea Verdini, University of Florence, Firenze,

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Published Material: Some of the result will be also presented at EGU 2015 meetingPart of the results are contained in a paper currently under review

Abstract Body: The Expanding Box Model (EBM) is a framework for numerical simulations of turbulence that is able to capture the effect of spherical expansion while retaining the resolution for turbulence dynamics. We have recently shown that it can reproduce two important feature of solar wind turbulence, namely the component anisotropy and the emergence of jets at large scales. We present now an analysis of the simulated solar wind turbulence in terms of II-order and III-order structure function (SF).
We find that EBM simulations are able to reproduce the observed II-order SF anisotropy with respect to the local mean field (eddy shape) and further show that the overall anisotropy depends on the direction of increments on which SF are calculated. We finally present preliminary results on III-order SF in the EBM and compare them to homogenous turbulence simulations (MHD and Hybrid-PIC) in order to highlight the effects of expansion on the III-order SF anisotropy and the resulting cascade rate.

Abstract ID: 34851

Final Number: SPA11A-04

Title: External Versus Internal Triggering of Substorms: An Information-Theoretical Approach

Presenter/First Author: Jay Johnson, Princeton Plasma Physics Lab, Princeton, NJ

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Published Material: published in Geophysical Research Letters

Abstract Body: The role of external triggering of substorms through northward turning of the interplanetary magnetic field has been examined in a number of recent studies. While Hsu and McPherron (2002, 2004) argue that the strong association between external triggers defined by Lyons et al. (1997) and substorm onsets could be responsible for most substorms, Morley and Freeman (2007) argue that the association between northward interplanetary magnetic field (IMF) turnings and substorm onsets are coincidental rather than causal, because the same external triggers are also closely associated with an artificial list of substorm onsets generated with the Minimal Substorm Model, which has no requirement of northward IMF turning. We examine an expanded list of substorms using conditional redundancy, an entropy-based measure of conditional dependency, to examine whether northward IMF turning as an external trigger provides any additional information about substorm onset beyond knowing that there has been a period of sustained loading of energy flux (southward IMF). Our analysis reveals that only a few percent additional information is provided by the northward turning criterion, which is consistent with the statistics of surrogate data sets of external triggers constructed to coincide with 2% of substorms. We therefore conclude that northward turning of the IMF is, in general, coincidentally, rather than causally, associated with substorm onsets.

Abstract ID: 33920

Final Number: SPA11A-05

Title: Dynamical Critical Scaling of Space Storms

Presenter/First Author: James A Wanliss, Presbyterian College, Clinton, SC

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Published Material: JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, A03215, doi:10.1029/2009JA014642, 2010

Abstract Body: Energy dissipation in the terrestrial magnetosphere often follows an intermittent temporal pattern consisting of periods of high activity with sharply increased convection, compressional pulses, intensified fluctuations of field aligned, currents and many other bursty processes, separated by periods of quiescence. Although physical mechanisms of individual activity bursts in the inner magnetosphere have been investigated in numerous studies, in this paper we explore ensemble-averaged statistical properties of these events. We examine statistical properties of bursty multiscale energy dissipation in the inner magnetosphere of Earth based on the dynamics of the SYM-H index, a global marker of low-latitude geomagnetic fluctuations. We show that on average, and for time scales shorter than 2 h, temporal development of SYM-H bursts follows an algebraic form consistent with the predictions from the theory of nonequilibrium phase transitions. The power law exponents describing the probability distributions suggest that the main energy dissipation in the inner magnetosphere takes place because of large activity bursts such as major space storms as opposed to smaller activations whose contribution is less significant despite their much higher relative occurrence. The results obtained provide statistical evidence that the energy dissipation mechanisms associated with magnetospheric activity in the inner magnetosphere are essentially “scale-free,” displaying dynamical and statistical self-similarity.

Abstract ID: 34289

Final Number: SPA11A-06

Title: On the Role of Long-Range Connectivity in Space Plasma Complexity

Presenter/First Author: Giuseppe Consolini, National Institute of Astrophysics, Roma,

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Co-authors: Simone Benella, , ,

Abstract Body: In many frameworks space plasmas display a self-similar dynamics in response to external driving. This is, for instance, the case of the Earth’s magnetotail plasma sheet during magnetospheric substorms in response to solar wind changes. This behavior has been interpreted in terms of a near Forced and/or Self-Organized Criticality dynamics. However, there are some aspects of the event statistics that depart from what is expected for a near criticality dynamics, resembling features more similar to extremum statistics. Here, we investigate the role that long-range connectivity plays in the space plasma avalanching systems, presenting the results of a sandpile model on network. A discussion of the similarity and differences between classical SOC models and our network model is presented with reference to the criticality behavior and the intermittent nature of the dynamics.

This work is supported by the European Community's Seventh Framework Programme ([FP7/2007-2013]) under Grant no. 313038/STORM

Abstract ID: 33943

Final Number: SPA12A-01

Title: Forecasting Solar Wind Streams from Quiescent Solar Corona and Recurrent Geomagnetic Activity

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Abstract Body: The interaction of solar wind disturbances with the Earth’s magnetosphere often drives geomagnetic storms which can have adverse effects on technology and human activities. While fast transient solar disturbances, such as coronal mass ejections (CMEs), can produce the most intense geomagnetic storms, increases in geomagnetic activity are frequently associated with changes in the solar wind induced by coronal holes in the relatively quiescent corona. High-speed solar wind streams (HSS) emanating from coronal holes, which can survive several solar rotations, correlate well with geomagnetic activity; as observed in Canadian polar cap, auroral and sub-auroral zones. Forecasting solar wind disturbances represents one of the focal points of space weather research and operational activities. To forecast HSS, we use a solar wind speed forecast model based on an empirical relation (Wang-Sheeley-Arge type) between open coronal magnetic field lines and the solar wind speed. To derive the global coronal magnetic field we employ a potential source surface model and GONG magnetograms. Investigation of the short-term (5 day) solar wind forecast performance shows in general a good agreement between forecasted and observed solar wind speed during 2007-2013. To examine the disagreements, excluding CMEs, we follow an equatorial coronal hole through six solar rotations starting from its central meridian crossing on June 25, 2013. The results suggest that the inclusion of additional parameters related to numerically derived coronal holes into the empirical solar wind speed relation is necessary to improve the forecast. Furthermore, we examine the potential of a long-term (27 day) recurrent HSS forecast based on forecasted and observed solar wind from two previous solar rotations. In the quest to better forecast geomagnetic activity, we compare and discuss these results with a long-term forecast of recurrent geomagnetic activity derived only from Canadian ground magnetic observations.

Abstract ID: 33223

Final Number: SPA12A-02

Title: Study of the Formation and Topology of Flux Transfer Events using Global Numerical Simulation

Presenter/First Author: Germán Fariñas Pérez, National Institute for Space Research, Sao Jose dos Campos, SP

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Abstract Body: We have analyzed a global magnetohydrodynamic (MHD) simulation of the magnetosphere to study the formation and magnetic topology of flux transfer events (FTEs) for reconnection during assumed interplanetary plasma and magnetic field conditions. All the interplanetary conditions have been kept constant during the simulation time. The interplanetary magnetic field (IMF) had a large southward-duskward component. The grid resolution at the subsolar magnetopause is sufficiently high to allow the formation of FTEs. We observe the spontaneous formation of FTEs under constant solar wind conditions and

zero dipole tilt. Five FTEs with clear magnetic perturbations have been detected. The characteristics of these five FTEs are identified, among them, the beginning and end of their magnetic signature, sense of propagation, speed of propagation and time onset of their movement. The first, second and fourth FTEs travel northward, while the others two move southward. The bipolar B_N signature and the intensification of the core magnetic field (B_M) are presented in all FTEs. The sense of propagation is mainly northward-dawnward in the Northern Hemisphere and southward-duskward in the Southern Hemisphere, which is consistent with the orientation of flows for a southward-duskward IMF case. The cross section of the first FTE has been analyzed in terms of the projected magnetic field, thermal pressure and core magnetic field. The typical magnetic characteristics of a flux rope were found. However, the analysis of the magnetic topology reveals that this structure is not a typical flux rope. Instead it is formed by two interlinked flux tubes which together seem to present similar characteristics of a flux rope. The magnetic topology over the magnetopause was calculated to study the generation mechanism of this event. Flow vortices have been observed in every FTE event. The flow vortices bring together regions of different magnetic topologies, which drive subsequent processes of magnetic reconnection. This could be the cause of the increased complexity in the topology observed after the interlinked flux tubes occurrence.

Abstract ID: 34649

Final Number: SPA12A-03

Title: The Global Structure and Time Evolution of Dayside Magnetopause Surface Eigenmodes

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Abstract Body: Theoretical work and recent observations suggest that the dayside/subsolar magnetopause may support its own eigenmode, consisting of propagating surface waves which reflect at the northern and southern ionospheres forming a standing wave. These magnetopause surface eigenmodes (MSE, also called Kruskal-Schwarzchild modes) have been proposed as source of magnetospheric Ultra-Low Frequency (ULF) waves with frequencies less than 2 mHz. Due to their large wavelengths and long periods, it is difficult to observe these waves in situ and characterize their global structure. Theoretical predictions exist for their global structure, but these are based on models with idealized geometries and zero flow shear. We use BATS-R-US global magnetohydrodynamic (MHD) simulations to study the magnetospheric response to impulsive solar wind dynamic pressure increases. Resonantly excited waves are observed whose global properties are largely consistent with the theoretical predictions for MSE and cannot be explained by other known ULF wave modes. These results demonstrate MSE can exist in realistic magnetic field geometries with nonzero flow shear.

Abstract ID: 35996

Final Number: SPA12A-04

Title: Shape of the terrestrial plasma sheet in the near-Earth magnetospheric tail as imaged by the Interstellar Boundary Explorer (IBEX)

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Abstract Body: We present remote, continuous observations from the Interstellar Boundary Explorer (IBEX) of the terrestrial plasma sheet location up to ~16 earth radii (R_E) back in the magnetospheric tail using energetic neutral atom (ENA) emissions. The time period studied includes two orbits near the winter and summer solstices, thus associated with large negative and positive dipole tilt respectively. Continuous side-view images reveal a complex shape that is dominated mainly by large-scale warping due to the diurnal motion of the dipole axis. Superposed on the global warped geometry are short-time fluctuations in plasma sheet location that appear to be consistent with plasma sheet flapping and possibly twisting due to changes in the interplanetary conditions. We conclude that the plasma sheet warping due to the diurnal motion dominates the average shape of the plasma sheet. Over short times, the position of the plasma sheet can be dominated by twisting and flapping.

Abstract ID: 33143

Final Number: SPA12A-05

Title: The Role of Multiple Atmospheric Reflections in the Formation of Electron Distribution Functions in the Diffuse Aurora Region

Presenter/First Author: George V Khazanov, NASA Goddard Space Flight Center, Greenbelt, MD

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Co-authors: Alex Glocer, NASA/GSFC, Greenbelt, MD; David G Sibeck, NASA/GSFC, Greenbelt, MD

Abstract Body: The precipitation of high-energy magnetospheric electrons ($E > 500$-600 eV) in the diffuse aurora contributes significantly to the energy flux into the Earth's ionosphere. It has been found [Khazanov et al., JGR, 2014] that quantifying this flux at the upper boundary of the ionosphere requires a consideration of the entire coupled ionosphere-magnetosphere system. In the diffuse aurora, precipitating electrons initially injected from the plasmasheet via wave-particle interaction processes degrade in the atmosphere toward lower energies and produce secondary electrons via impact ionization of the neutral atmosphere. These precipitating electrons can be reflected back into the magnetosphere from the conjugate atmospheres, leading to a series of multiple reflections that can greatly influence precipitating flux at the upper ionospheric boundary (700-800 km) and the resultant secondary electron population. We present a solution of the Boltzman-Landau kinetic equation that uniformly describes the entire electron distribution function in the diffuse aurora, including the affiliated production of secondary electrons ($E < 600$ eV). This solution takes into account, for the first time, the role of multiple atmospheric reflections of the precipitated electrons that were initially moved into the loss cone via wave-particle interaction processes in the Earth's plasmasheet. Our results will be compared with the THEMIS observations.

Abstract ID: 36344

Final Number: SPA12A-07

Title: Investigation of the Causes of Anomalous Ionosphere Electron Density Variations

Presenter/First Author: Philip G Richards, George Mason University Fairfax, Dunn Loring, VA

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Abstract Body: This research investigates the causes of anomalous diurnal behavior of the mid latitude ionospheric electron density known as the Weddell Sea Anomaly. Our approach is to use the FLIP ionosphere model together with measurements of electron density from ground based ionosondes, electron density profiles from the COSMIC satellites, neutral densities from TIMED-GUVI, and in situ ion and neutral densities from the Atmosphere Explorer-C satellite. This paper demonstrates the inadequacy of previously proposed explanations of these unusual nighttime enhancements, and investigates the hypothesis that neutral density variations play a key role in their formation. In particular, we demonstrate that the magnetic declination effect on neutral winds is not the main cause of Weddell Sea Anomaly.

Abstract ID: 35408

Final Number: SPA21A-01

Title: Characterization of the Energy-Dependent Response of Riometer Absorption

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Published Material: The paper with the same title has been recently accepted:Kellerman, A. C., Y. Y. Shprits, R. A. Makarevich, E. Spanswick, E. Donovan, and G. Reeves (2015),Characterization of the energy-dependent response of riometer absorption, J. Geophys. Res. Space Physics, 120, doi:10.1002/2014JA020027.http://onlinelibrary.wiley.com/doi/10.1002/2014JA020027/abstract

Abstract Body: Ground based riometers provide an inexpensive means to continuously remote sense the precipitation of electrons in the dynamic auroral region of Earth's ionosphere. The energy-dependent relationship between riometer absorption and precipitating electrons is thus of great importance for understanding the loss of electrons from the Earth's magnetosphere. In this study, statistical and event-based analyses are applied to determine the energy of electrons to which riometers chiefly respond. Time-lagged correlation analysis of trapped to precipitating fluxes shows that daily averaged absorption best correlates with ~ 60 keV trapped electron flux at zero-time lag, although large variability is observed across different phases of the solar cycle. High-time resolution statistical cross-correlation analysis between signatures observed by riometer stations, and assuming electron motion due to gradient and curvature drift, results in inferred energies of 10-100 keV, with a clear maximum in occurrence for 40-60 keV
electrons. One event is considered in detail utilizing riometer absorption signatures obtained from several stations. The mean inferred energies for the initial rise time and peak of the absorption after correction for electric field effects were ~ 70 keV, and ~ 60 keV, respectively. The analyses presented provide a means to characterize the energy of electrons to which riometers are responding in both a statistical sense, and during the evolution of individual events.

Abstract ID: 35268

Final Number: SPA21A-02

Title: New Perspectives on Small-Scale and Rapidly Varying Auroral Structures from CASSIOPE e-POP Fast Auroral Imager (FAI) Observations

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Abstract Body: The Fast Auroral Imager (FAI) on the CASSIOPE Enhanced Outflow Probe (e-POP) consists of two CCD cameras, which measure the atomic oxygen emission at 630 nm and prompt auroral emissions in the 650 to 1100 nm range, respectively, using a fast lens system and high quantum-efficiency CCDs to achieve high sensitivity, and a common 26 degree field-of-view to provide nighttime images of about 650 km diameter at apogee (1500 km). The FAI is capable of operating in four viewing modes: nadir viewing, for imaging over a large latitude range; Earth-target viewing, for pointing at an emission target of fixed altitude, latitude and longitude; limb viewing, for measurement of altitude profiles; and inertial pointing; for imaging of an inertial target such as a star field. The near infrared camera provides up to two images of 0.1 sec exposure per second, with a spatial resolution of a few km in the nadir viewing mode, while the 630-nm camera provides one image of 0.5 sec exposure every 30 seconds. The four viewing modes make possible the observations of a variety of auroral and airglow phenomena, such as transpolar arcs and drifting polar patches, rapidly varying and small-scale auroral structures in the auroral oval, and detached and stable auroral red (SAR) arcs as well as airglows at lower latitudes. We will focus on new features in the observed data and the resulting new perspectives on auroral structures in the context of high-resolution studies of the ionosphere.

Abstract ID: 35454

Final Number: SPA21A-04

Title: Imaging the Dynamic Auroral Ionosphere and Polar Ionosphere Using Incoherent Scatter Radar and All-Sky Imaging

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Abstract Body: Advanced Modular Incoherent Scatter Radar (AMISR) systems have enabled multi-dimensional observations within the nightside auroral zone (PFISR) and deep within the polar cap (RISR). AMISR systems are phased-array radars capable of beam steering on a pulse-to-pulse cadence. Heinselman and Nicolls [2008] described a technique for determining the horizontal plasma flow pattern from AMISR measurements and applied this method to the estimation of E-region neutral winds. More recently, Nicolls et al., [2014] enhanced this technique to determine the electrostatic potential at F-region altitudes using a minimum curvature estimator [Cosgrove et al., 2014]. We present results of studies that have made use of the velocity field imaging applied to auroral electrodynamics in the nightside region and polar cap.

A next step forward in ISR imaging is to fold in complimentary data sources that can be used with the ISR data to improve estimates of ionospheric parameters. All-sky color imagers, collocated with ISRs, make line-of-sight measurements of the visible light emission at a variety of different wavelengths corresponding to different physical processes. Given an incident electron spectrum, forward electron transport models have been used to predict visible auroral emission and volume ionization rate, which can be indirectly observed by ISR. The all sky imagers generally provide measurements over a larger field-of-view and at much higher time cadence than ISR, thus the measurements contain useful information that can be used to enhance the spatial and temporal resolution of the 3-D electron density estimation. We present a new technique for merging photometric and ISR observations to generate improved estimates of the 3-D electron density structure in the auroral ionosphere. The improved electron density estimate can be used to determine the 3-D conductivity, and, when combined with vector electric field images, the 3-D current structure can be determined in a localized region. We discuss the applicability of this technique to monostatic ISR and the AMISR system. We use this technique to investigate currents systems and energy transfer in the auroral ionosphere, and for studies of high latitude auroral conductivity to ingestion into models.

Abstract ID: 35692

Final Number: SPA21A-05

Title: Source and evolution of the ionospheric F-region tongue of ionization and patches

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Co-authors: Jing Liu, , , ; Alan Geoffrey Burns, National Center for Atmospheric Research, Boulder, CO; Stanley C Solomon, National Center for Atmospheric Research, Boulder, CO

Abstract Body: The high-resolution NCAR Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) has been employed to numerically study the source and evolution of the ionospheric F-region tongue of ionization (TOI) and patches, which are electron density enhancements in the polar region with fine structures. The model is run for different interplanetary magnetic field (IMF) conditions. It is found that the formation of TOI and patches is critically dependent on the Universal Time (UT). TOI and patches occur preferentially at the UT when the high latitude ion convection pattern is closer to the daytime high middle latitude ionosphere so more plasma can be transported into the polar region. This UT dependence is different between the northern and southern hemispheres because of the different separations of the magnetic poles from the geographic poles in the two hemispheres. Furthermore, the effect of subauroral polarization streams (SAPS) on the formation of TOI and patches is examined by running the TIEGCM with and without the SAPS in the model.

Abstract ID: 35888

Final Number: SPA21A-06

Title: Spatial characteristics of pulsating aurora as a function of latitude

Presenter/First Author: Robert Michell, Southwest Research Institute, San Antonio, TX

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Co-authors: Marilia Samara, NASA Goddard Space Flight Center, Greenbelt, MD; Donald L Hampton, University of Alaska Fairbanks, Fairbanks, AK

Abstract Body: We will present an analysis of the spatial characteristics of pulsating aurora from 3 different latitudes where pulsating auroral features have been observed using green line all-sky imaging at 3 frames per second. At higher latitudes---near the polar cap boundary at 74 degrees geomagnetic latitude---the auroral patches of pulsating appear larger and more spread out longitudinally. At auroral latitudes of 66 degrees geomagnetic latitude---where we have the most observations--the patches are smaller and irregularly shaped. At lower latitudes--sub-auroral, 55 degrees geomagnetic latitude--the auroral patches are even smaller. We will quantify the differences between the spatial characteristics of pulsating aurora at these three different latitudes. An understanding of these differences in spatial characteristics will be used to gain insight into the magnetospheric processes causing the electron precipitation for these three distinctly different latitude regimes.

Abstract ID: 36832

Final Number: SPA21A-07

Title: Small-scale Structure and Variability in Mid-Latitude Ionospheric Plasma Convection

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Abstract Body: The plasma of the mid-latitude ionosphere is perturbed by strong electric fields that extend equatorward of the usual auroral zone during disturbed periods. The resulting plasma density irregularities and plasma convection are observed with the radars of the new mid-latitude SuperDARN chain. In addition, the radars regularly observe backscatter from the ionosphere on the nightside during quiet times at subauroral latitudes; these velocities measure only tens of meters per second and appear to be well organized. The fields of view of the mid-latitude radars overlap extensively forming common volumes in the North American sector that make it possible to map the structure and variability of the convection with high confidence at the smallest resolutions afforded by the radar measurements, namely, tens of seconds in time and tens of kilometers in distance. We describe early results from a study of the characteristic scales of velocity variation in mid-latitude plasma convection and the connection to effects in Magnetosphere-Ionosphere-Thermosphere coupling.

Abstract ID: 35227

Final Number: SPA22A-01

Title: Enhanced N2 and O Neutral Densities as an Explanation of Rapid Electron Density Decay Following Ionization Surges in the Ionosphere

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Published Material: Preliminary results of the study were presented at 2014 AGU Fall Meeting, poster SM43A-4258, "The interaction of high-m guided poloidal alfven waves with magnetospheric electrons and the ionosphere".

Abstract Body: On April 21, 1993, between 0320 and 0400 UT, the EISCAT radar and ground based magnetometers recorded evidence of intense Pc5 waves and electron precipitation with a wide energy spectrum [*Lester, Davies, and Yeoman*, 2000]. The high-energy (40 keV) part of the precipitation started about an hour earlier and created dense plasma at an altitude near 100 km. Immediately before the event, the plasma density was monotonically decaying above 100 km with no maximum in the F-layer. The flux of electrons with energies below a few keV was pulsating with the wave frequency (5.2 mHz) and produced a sequence of strong but short-lived plasma density enhancements at altitudes between 150 km and 300 km. The dense plasma produced during each precipitation pulse decayed completely within just two minutes. The event is analyzed using a numerical model of the coupled ionosphere and magnetosphere developed by [*Sydorenko and Rankin*, 2013]. When MSIS thermospheric neutral densities were used in the model, the rate of plasma density decay was more than two times lower than is necessary to explain the observations, and the density maximum in the F-layer appears. The reason for this is an abundance of oxygen atoms and, correspondingly, atomic oxygen ions, which have no direct recombination process. In order to achieve the required plasma density decay rate and altitude profile in the simulation, the density of nitrogen and oxygen molecules is increased by a factor ranging from 7 to 18 in an altitude range between 100 and 320 km, while the density of oxygen atoms is decreased by a factor of 3.5 below 350 km. A qualitatively similar modification of the composition of neutrals in the thermosphere during periods of intense magnetospheric activity is known from observations and numerical models [*Prolss and Fricke,* 1976; *Mikhailov and Foster*, 1997].

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Sydorenko D. and R. Rankin, J. Geophys. Res., v.118, p.5562-5578 (2013).

Abstract ID: 34444

Final Number: SPA22A-02

Title: Characteristics of short-range HF echoes in the presence of sporadic E layers

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Abstract Body: SuperdARN HF radars often detect echoes at short ranges. These are traditionally associated with the E region irregularities generated through the electrojet plasma instabilities. However, determination of the real height of echo detection or irregularity location is difficult; this severely limits possibility of relating echo characteristics with specific electroject instability processes. We investigate a special class of SuperDARN echoes observed in the presence of strong sporadic E layers that block HF radio wave penetration deep into the ionosphere so that the echoes are very likely received from the lower E region, below 100 km. Joint data of the Clyde River (CLY) HF radar and Pond Inlet (PI) CADI ionosonde are considered. We give statistics on typical echo power, Doppler velocity and spectral width of such echoes and compare them with the same characteristics for non-Es cases. We conclude that the only clearly identifiable difference of Es-related CLY echoes is their generally smaller velocities although, occasionally, values close to the nominal ion-acoustic speed can be seen. We also compare CLY velocities at short ranges with simultaneous CLY measurements at far ranges as well as with the velocity data from other SuperDARN radars and the PI ionosonde.

Abstract ID: 36647

Final Number: SPA22A-03

Title: High-Resolution Observations of Ionospheric Plasma from Swarm and ePOP

Presenter/First Author: David J Knudsen, University of Calgary, Calgary, AB

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Co-authors: Johnathan K Burchill, University of Calgary, Calgary, AB, Canada; William Edward Archer, University of Calgary, Calgary, Canada; Taylor Grant Cameron, University of Calgary, Calgary, AB, Canada; Matthew Patrick, University of Calgary, Calgary, AB, Canada; Yangyang Shen, , ,

Abstract Body: The ionosphere has been probed extensively at scales of 1 km and larger, both from the ground and in situ. However, numerous observations have shown that ionospheric structuring on finer scales is widespread, and that the most highly structured events are often also the most intense. This talk will present new observations on sub-kilometer scales from ion and electron distribution imaging sensors currently flying on two satellite missions launched in late 2013, namely the European Space Agency's Swarm mission and Canada's Enhanced Polar Outflow Probe. Swarm's Thermal Ion Images are used to produce on-board velocity moments at a rate of 16 per s, with a corresponding spatial resolution of approximately 500 m. The ePOP Surpathermal Electron Imager captures 2-D distributions of electron fluxes at having energies up to 350 eV, on spatial scales as small as 70 m in bursts lasting 5-10 minutes. This talk will present Swarm and ePOP observations of highly structured ionospheric plasma including fast flow channels and associated Poynting flux and anisotropic ion heating, structured ion upflow, and velocity-dispersed suprathermal electron bursts in the auroral zone.

Abstract ID: 34401

Final Number: SPA22A-04

Title: Low-Altitude Cusp Ion Upflow and Downflow at Kilometer Scales

Presenter/First Author: Johnathan K Burchill, University of Calgary, Calgary, AB

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Co-authors: David J Knudsen, University of Calgary, Calgary, AB, Canada; Stephan C Buchert, IRF Swedish Institute of Space Physics Uppsala, Uppsala, Sweden

Abstract Body: We present detailed observations from the Swarm Electric Field Instruments of vertical ion flow, ion temperature, electron

temperature, and electron density structured on scales of a few to tens of kilometers in the vicinity of Earth's magnetic cusps. Swarm measures upflow and downflow and plasma heating on scales as small as the measurement resolution of ~4 km (<0.1° of magnetic latitude). Structured upflows are at times observed in association with electron heating, frictional ion heating, both, or neither. Structured ion downflows with warm ion temperatures are often observed poleward of the upflow. We test the hypothesis that these downflows are populations of poleward-convecting heated upflows that, not having attained escape velocity, splash into the polar cap ionosphere.

Abstract ID: 36003

Final Number: SPA22A-05

Title: High resolution observations of plasma properties around sporadic E layers at low latitude in the evening sector: evidence for unexpected electrodynamic feedback and parallel currents.

Presenter/First Author: Jean-Pierre St-Maurice, University of Saskatchewan, Saskatoon, SK

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Co-authors: Aroh Barjatya, Embry-Riddle Aeronautical University, Daytona Beach, FL; Matthew D Zettergren, Embry-Riddle Aeronautical Univ, Daytona Beach, FL

Published Material: The presentation is based on results initially presented in a JGR paper published in 2013.

Abstract Body: Rocket observations of the low latitude E region were carried out near the Kwajalein atoll during the EQUIS II campaign. The observations took place in the early evening sector, but well after sunset. High spatial resolution (100 m) observations were made of the electron density and temperature, together with the two perpendicular electric field components and the two neutral wind components (zonal and meridional) that are known to be able to drive sporadic E (Es) layers. Two Es layers were indeed observed. Two well-defined electron temperature (Te) peaks were also recorded above each Es layer. The Te peaks reached of the order 1000 K, which is very large when compared to the expected 300 K expected for the E region. Our analysis of the data revealed that the electric field played a strong role in the formation of the top Es layer while the bottom layer appeared to match expectations from the observed neutral winds. Undulations in the perpendicular electric field triggered by the impact on the F region dynamo field of the Es layers themselves was also such that the evolution of the top Es layer was affected by its own location. The Te peaks were found to be consistent with field-aligned currents (FAC) of the order of a few micro-amp per meter square. It was also noted that Te in the Es layers was hotter than expected, suggesting that even more intense FAC were involved in those locations. The FAC responsible for the Te peaks had to be related to the bottom-side of the F region nighttime dynamo while the FAC associated with the Es layer peaks were due to diverging Hall currents related to the steep changes in the conductivities in conjunction with a relatively strong zonal electric field. These observations suggest that parallel currents are an important part of the night-time electrodynamics around Es layers and that the formation of Es layers can be more complicated than normally thought. Results from first calculations will be presented.

Abstract ID: 35437

Final Number: SPA22A-06

Title: Some New Results in Solar Terrestrial Coupling

Presenter/First Author: David J Thomson, Queen's University, Kingston, ON

Presenter/First Author Email: djt@mast.queensu.ca

Published Material: Studies of solar modes in terrestrial and spacecraftdata continue to surprise and I discuss several new results.First, both p--modes and low frequency g-modes are detectablein geomagnetic data. Below ~1 mHz the magneticsignal to noise ratio is better than that of optical data.Second, at frequencies above the Sun's 5.1 mHz acoustic cutoff frequency,spectra of geomagnetic data have many high-Q lines with the characteristic 136uHzspacing of solar modes. This should allow better characterizationof solar pseudo (pp) modes.Third, because ACE is in a synodic orbit and Ulysses' orbitis nearly sidereal, one can test the identification ofsolar g-modes by looking at frequency agreement on theazimuthal quantum numbers.This gives several g-modes with all the expected singletsdetected and in agreement.

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signal to noise ratio is better than that of optical data.
Second, at frequencies above the Sun's 5.1 mHz acoustic cutoff frequency, spectra of geomagnetic data have many high-Q lines with the characteristic 136uHz
spacing of solar modes. This should allow better characterization of solar pseudo (pp) modes.
Third, because ACE is in a synodic orbit and Ulysses' orbit is nearly sidereal, one can test the identification of solar g-modes by looking at frequency agreement on the
azimuthal quantum numbers. This gives several g-modes with all the expected singlets detected and in agreement.
Because these modal signatures are seen in interplanetary space, in the magnetospere, and in the solid earth, they must traverse the ionosphere and should be seen there as well.

Abstract ID: 33700

Final Number: SPA22A-07

Title: Modulation of the Ionospheric Total Electron Content by ULF Waves

Presenter/First Author: Viacheslav Pilipenko, Space Research Institute RAS, Moscow,

Presenter/First Author Email: pilipenk@augsburg.edu

Abstract Body: An intriguing effect was found while analyzing the small-scale variations of total electron content (TEC) derived from global positioning system (GPS) signals. We found a response in TEC variations to intense global Pc5 pulsations with periods of a few mHz covering the CGM latitudes ~58°-75° during the recovery phase of the strong magnetic storms on Oct. 2003. The GPS-TEC technique has turned out to be a powerful method to study the interaction of ULF waves with the ionosphere. During periods with intense Pc5 geomagnetic wave activity distinct pulsations with the same periodicity were found in the TEC data from high-latitude GPS receiving stations in Scandinavia. Wavelet and cross-spectral analysis showed a high coherence between the periodic geomagnetic and TEC variations. Combined usage of magnetometers and GPS/TEC is a very promising way to reveal the physical mechanism of disturbances. The relative amplitude of TEC periodic fluctuations DTEC/TEC was about or even larger than the relative amplitude of geomagnetic variations DB/B. The effect of TEC modulation by Pc5 waves is not well understood and is still a challenge for the MHD wave theory. Various possible modulation mechanisms have been estimated, but no mechanism has been firmly identified.

Abstract ID: 34701

Final Number: SPA31A-01

Title: Probing Ionosphere-Magnetosphere coupling with the combination of in-situ and ground based measurements: the GREECE mission

Presenter/First Author: Marilia Samara, NASA Goddard Space Flight Center, Greenbelt, MD

Presenter/First Author Email: marilia.samara@nasa.gov

Co-authors: Robert Michell, Southwest Research Institute, San Antonio, TX; Guy Alan Grubbs, University of Texas at San Antonio, San Antonio, TX; Donald L Hampton, University of Alaska Fairbanks, Fairbanks, AK; John W Bonnell, University of California Berkeley, Berkeley, CA; Keiichi Ogasawara, Southwest Research Institute, San Antonio, TX

Published Material: The specific findings were not reported but an overview of the GREECE mission was given at the Fall AGU in San Francisco, December 2014.

Abstract Body: The Ground-to-Rocket Electrodynamics-Electrons Correlative Experiment (GREECE) sounding rocket successfully launched from Poker Flat, Alaska on 03 March 2014 reaching an apogee of 335 km. GREECE launched into a dynamic post-midnight auroral arc event—rich in particle and wave signatures—that occurred directly over the downrange imaging site of Venetie, AK. The onboard electron detectors measured the precipitating electrons, which were then compared to the optical auroral structures that they were responsible for. The ground-based auroral imaging consisted of 6 different imagers with a total of 3 separate fields of view, providing information about the aurora on both the large-scale (>10 km) and the small scale (~100 m). This yielded multi-emission line intensities of the auroral brightness at the magnetic footprint of the rocket critical for our main goal of exploring the correlation of the sheer flows—often observed in high resolution imagery during aurora—and the in situ signatures of precipitating particles and waves. The emission line brightness data correlate well with electron characteristics taken by the Acute Precipitating Electron Spectrometer (APES). The ultimate goal is to characterize the auroral emissions produced from a known precipitating electron distribution, such that we can more accurately use ground-based imaging and photometry to infer the characteristics of the precipitating electrons. These techniques can then be applied over larger scales and longer times, when only multi-spectral imaging data are available with no corresponding in situ data. Moreover, using both electron detectors and the electric field instrument on board GREECE we were able to determine that the auroral flows are not caused by large-amplitude electric fields in the low altitude (<400 km) ionosphere. The nature of the electron precipitation reveals that the flow structure is caused by motions of the electron source region, occurring much farther out in the near-Earth space environment.

Abstract ID: 36552

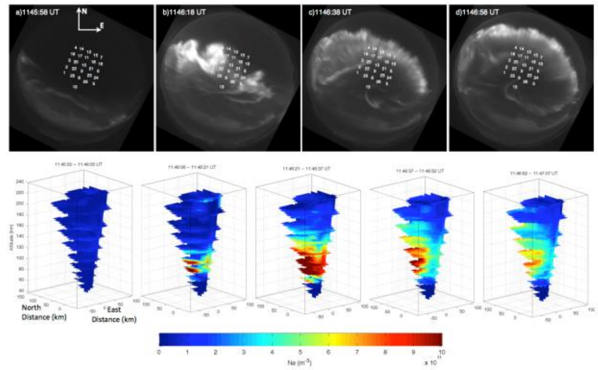
Final Number: SPA31A-02

Title: Relativistic electron precipitation and substorm auroras

Presenter/First Author: Joshua L Semeter, Boston Univ, Boston, MA

Presenter/First Author Email: jls@bu.edu

Abstract Body: We report evidence for relativistic electron precipitation in substorm auroras. Multi-beam measurements by the electronically steerable Poker Flat Incoherent Scatter Radar (PFISR) reveal transient patches of ionization extending below 70 km altitude. These regions are restricted to the poleward edge of the auroral expansion phase. Reconstructed vertical density profiles, analyzed using a particle penetration model, suggest that the primary electron spectrum contains a significant population in the 300-600keV range. Proton precipitation is ruled out due to the limited horizontal extent of these regions and the extreme energies required for protons to penetrate to these altitudes. This electron population is not likely produced by near-Earth acceleration mechanisms. The likely source lies in the magnetotail, where substorm dipolarization can readily energize electrons to the relativistic range. Our interpretation is supported by magnetically conjugate measurements from the THEMIS satellite for one of these events, which reveal a remarkably impulsive reconfiguration of the magnetotail preceding one of these events. These results exemplify the unique scientific capability of common volume measurements by electronically steerable ISR and wide-field cameras.



Abstract ID: 35370

Final Number: SPA31A-03

Title: Electrodynamic Coupling Between Inertial Scale Alfven Waves and the High-latitude Auroral Ionosphere

Presenter/First Author: Dmytro Sydorenko, University of Alberta, Edmonton, AB

Presenter/First Author Email: sydorenk@ualberta.ca

Published Material: The model description and several aspects of ion upflow formation were published in JGR in 2012 and 2013; some details of feedback instability and wave emission were presented at 2011 AGU Chapman conference, Fairbanks, ALaska.

Abstract Body: Small scale inertial Alfven waves (IAWs) can accelerate auroral electrons and are considered to be an important part of energy coupling between the magnetosphere and high latitude ionosphere. The coupling of IAWs with the ionosphere is affected by wave and background precipitation, heating due to wave and convection electric fields, and strong vertical nonuniformity of the bottom layers of the ionosphere. We have developed a comprehensive two-dimensional numerical model of the coupled magnetosphere and ionosphere that includes these effects. The model considers torsional Alfven waves in the presence of an externally imposed convection electric field, chemical reactions between ions and neutrals, various cooling and heating processes, and a parametric model of electron precipitation. The model's spatial resolution in the E-layer can be as fine as tens of meters in the horizontal direction, and hundreds of meters in the vertical direction. We present applications of the model that are designed to understand reflection of waves with short transverse wavelength from the ionosphere, formation of ion upflows, feedback instabilities, and emission of Alfven waves by convecting plasma nonuniformities in the E-layer. The results are compared with observations from the Canadian ePOP satellite, and ground-based instruments of the GO-Canada observatory.

Abstract ID: 35855

Final Number: SPA31A-04

Title: Small-scale secondary electron features and FACs in diffuse and pulsating aurora

Presenter/First Author: Sarah Jones, NASA Goddard Space Flight Center, Greenbelt, MD

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Co-authors: Marc Lessard, University of New Hampshire Main Campus, Durham, NH; Leroy Cogger, Retired, Calgary, Canada; Andrew W Yau, University of Calgary, Calgary, AB, Canada; David J Knudsen, University of Calgary, Calgary, AB, Canada; Kristina A Lynch, Dartmouth College, Hanover, NH; Dirk Lummerzheim, University of Alaska Fairbanks, Anchorage, AK; Hans Stenbaek-Nielsen, , , ; Allison N Jaynes, University of Colorado Boulder, Boulder, CO

Published Material: The preliminary findings were presented in poster format at previous AGU conferences. Currently a manuscript is in preparation.

Abstract Body: Observations of small-scale structures in the secondary and backscattered populations associated with diffuse and pulsating aurora have been observed by several spacecraft including ePOP, REIMEI, and the ROPA sounding rocket. We present in situ observations of such sub-keV electron precipitation mapped into the THEMIS GBO all-sky images, with evidence of field aligned currents and acceleration through parallel electric fields. These observations are consistent with Sato et al. (2002, 2004) who show FAST measurements of sub-keV inverted-V structures collocated with pulsating aurora. In the case of ROPA, the sub-keV electron signatures appear to be the result of secondary / backscattered electrons that are accelerated downward through a potential at an altitude above the spacecraft. Thus the intermittency of the sub-keV signatures seen in the ROPA measurements would reflect structure in the accelerating potential, suggesting small scale, local electric field structure above the spacecraft. A lack of velocity dispersion in these accelerated, secondary electron signatures is consistent with an acceleration region that is not far from the spacecraft, or may suggest a lack of temporal variation in the associated accelerating field structure during the measurement. PFISR observations of similar pulsating aurora show, in some directions, high altitude electron density enhancements that likely correspond to sub-keV electron signatures. The higher altitude density enhancements associated with the sub-keV electron signatures more or less align with gaps between lower altitude density enhancements presumably caused by the pulsating patches. This raises questions as to the role of the ionosphere in the generation of pulsating aurora.

Abstract ID: 35354

Final Number: SPA31A-05

Title: Correlated ULF Waves, Whistler-mode Chorus and Pulsating Aurora Observed by the Van Allen Probes and Ground-based Systems

Presenter/First Author: Allison N Jaynes, University of Colorado Boulder, Boulder, CO

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Co-authors: Marc Lessard, University of New Hampshire Main Campus, Durham, NH; Kazue Takahashi, Applied Physics Laboratory Johns Hopkins, Laurel, MD; Ashar Ali, University of Colorado at Boulder, Boulder, CO; David Malaspina, University of Colorado, Boulder, Boulder, CO; Craig Kletzing, University of Iowa, Iowa City, IA; John R Wygant, University of Minnesota Twin Cities, Minneapolis, MN; Eric Donovan, University of Calgary, Calgary, AB, Canada; J Bernard Blake, Aerospace Corporation Santa Monica, Santa Monica, CA; Robert Michell, Southwest Research Institute, San Antonio, TX; Marilia Samara, NASA Goddard Space Flight Center, Greenbelt, MD; Emma Spanswick, University of Calgary, Calgary, AB, Canada

Published Material: Preliminary findings reported at LWS meeting (Oct 2014) and more analysis reported at AGU (Dec 2014). Final work is expected to be published before Joint Assembly in the Pulsating Aurora special issue of JGR.

Abstract Body: Theory and observations have linked equatorial VLF waves with pulsating aurora for decades, invoking the process of pitch-angle scattering of 10's keV electrons in the equatorial magnetosphere. Recent satellite studies have strengthened this argument, by showing strong correlation between pulsating auroral patches and (1) lower-band chorus observed by THEMIS and (2) 30-100 keV electron modulation in the vicinity of geosynchronous orbit observed by GOES. Additionally, a link has been made between Pc4-5 compressional pulsations and modulation of whistler-mode chorus using THEMIS. Here we present simultaneous in-situ observations of structured chorus waves and an apparent field line resonance as a result of a substorm injection, observed by Van Allen Probes, along with ground-based observations of pulsating aurora. We demonstrate the possible scenario being one of substorm-driven ULF pulsations modulating chorus waves, and thus providing the driver for pulsating particle precipitation into the Earth's atmosphere. We also show, for the first time, a particular 3-Hz modulation of individual chorus elements. Such modulation has been noticed as a high-frequency component in camera data of pulsating aurora for decades, and is possibly a result of nonlinear chorus wave interactions.

Abstract ID: 35679

Final Number: SPA31A-06

Title: Dynamics of auroral particle acceleration by kinetic Alfvén waves

Presenter/First Author: Robert L Lysak, University of Minnesota Twin Cities, Minneapolis, MN

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Abstract Body: It is now generally believed that there are at least two forms of auroral particle acceleration: a nearly monoenergetic acceleration through quasi-static parallel electric fields, and a broad-band acceleration associated with the propagation of kinetic Alfvén waves along auroral field lines. This Alfvénic acceleration also takes on two forms. In the low-β region at low altitudes, the electrons can be accelerated in bulk by the parallel electric field. At higher altitudes, where the plasma β is larger than the electron-to-ion mass ratio, electrons can be accelerated due to a Landau damping process. Furthermore, the precipitation of electrons due to Alfvénic acceleration leads to conductivity enhancements in the ionosphere, which can provide a positive feedback in structuring auroral currents. In addition, the production of secondary and backscattered electrons modifies the structure of the auroral flux tube and can set up conditions conducive to the formation of plasma double layers. These interactions will be illustrated through numerical simulations of the interaction of kinetic Alfvén waves with the auroral ionosphere.

Abstract ID: 34572

Final Number: SPA31A-07

Title: New Features of Substorm and Storm Dynamics Revealed by Coordinated ISR-ASI Measurements of Auroral Dynamics

Presenter/First Author: Larry R Lyons, University of California Los Angeles, Los Angeles, CA

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Co-authors: Toshi Nishimura, University of California Los Angeles, Los Angeles, CA; Donald Hampton, University of Alaska Fairbanks, Fairbanks, AK; Vassilis Angelopoulos, University of California Los Angeles, Los Angeles, CA; Eric Donovan, University of Calgary, Calgary, AB, Canada; Michael J

Nicolls, SRI International Menlo Park, Menlo Park, CA; Steven Chen, SRI International Menlo Park, Menlo Park, CA

Abstract Body: Coordinated imager and radar observations of the auroral oval have previously revealed that bursts of enhanced flow within the plasma sheet lead to most magnetosphere-ionosphere disturbances (i.e., PBIs, streamers, substorms). Using incoherent-scatter radar and all-sky-imager observations, we have identified weak, azimuthally moving auroral features near the equatorward boundary of the auroral oval. We find that they are associated with large azimuthal flow bursts in the SAPS region, and we find evidence that they originate from tail flow bursts that are guided to the SAPS by the large-scale evening side convection. We have evidence that some of these flow bursts can extend earthward of the pre-existing SAPS region, leading to ring current earthward injections and proton aurora. We have previously seen that localized flow enhancements from the polar cap can contribute significantly to plasma sheet flow bursts and substorm expansion phase activity. We now have found striking new evidence that these polar cap flow enhancements feed new plasma into the head of the westward traveling surge, and thus may play a critical in driving the surge.

Abstract ID: 35211

Final Number: SPA31A-08

Title: Ion Temperature Anisotropy Measured in Regions of Strong Electric Fields Adjacent to Auroral Arcs

Presenter/First Author: William Edward Archer, University of Calgary, Calgary,

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Co-authors: David J Knudsen, University of Calgary, Calgary, AB, Canada; Johnathan K Burchill, University of Calgary, Calgary, AB, Canada; Matthew Patrick, University of Calgary, Calgary, AB, Canada; Jean-Pierre St-Maurice, University of Saskatchewan, Saskatoon, SK, Canada

Published Material: Some of these findings were recently accepted pending minor review in "ESA's Swarm Mission, One Year in Space", a special edition of GRL.

Abstract Body: The Swarm satellites observe strongly anisotropic ion temperatures at 500 km altitude with temperature anisotropy ratios varying from 2 to 10. Coincident measurements with THEMIS All-Sky imagers suggest that these highly localized regions of ion heating are associated with strong electric fields at the edge of auroral precipitation. The ion temperature enhancements appear to depend on electric field strength and are comparable to what is expected from ion frictional heating theory. However, the observed perpendicular-to-parallel temperature ratios exceed the values predicted by existing calculations of collisional heating by as much as a factor of 2 in the strongest flows. If these observations are an accurate representation of the steady state collisional environment, they suggest that the collisional cross-sections currently used in collisional heating calculations should be revised. However it is also possible that the measurements are not made in a steady state environment, in which case a velocity distribution dispersion associated with vertical transport and occurring on a scale of minutes would also be able to affect the observed anisotropies.

Abstract ID: 33382

Final Number: SPA32A-01

Title: Simulations of the Dynamics of the Radiation Belts using VERB 4D Diffusion-convection code

Presenter/First Author: Yuri Shprits, Massachusetts Institute of Technology, Cambridge, MA

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Co-authors: Adam C Kellerman, University of California Los Angeles, Los Angeles, CA; Alexander Drozdov, University of California Los Angeles, Los Angeles, CA; Ksenia Orlova, University of California Los Angeles, Los Angeles, CA

Published Material: 60% of these resuls were presented at the fall AGU meeting.

Abstract Body: Modeling and understanding of ring current and radiation belt coupled system has been a grand challenge since the beginning of the space age. In this study we show long term simulations with a 3D VERB code of modeling the radiation belts with boundary conditions derived from observations around geosynchronous orbit. We also present 4D VERB simulations that include convective transport, radial diffusion, pitch angle scattering and local acceleration. VERB simulations show that the lower energy inward transport is dominated by the convection and higher energy transport is dominated by the diffusive radial transport. We also show that at energies of 100s of keV a number of processes work simultaneously including convective transport, radial diffusion, local acceleration, loss to the loss cone and loss to the magnetopause.

Abstract ID: 33145

Final Number: SPA32A-02

Title: Observations of a Global Coherence Scale Modulating Electron Loss Due to Plasmaspheric Hiss

Presenter/First Author: Aaron W Breneman, The University of Minnesota, Minneapolis, MN

Presenter/First Author Email: awbrenem@gmail.com

Published Material: Talk presented at Fall AGU 2014.

Abstract Body: Over 40 years ago it was suggested that electron loss in the region of the radiation belts that overlaps with the high density plasmasphere is largely due to interaction with an electromagnetic plasma wave called plasmaspheric hiss. Motivated by the difficulty of observing this loss process on satellites alone, the Balloon Array for Radiation Belt Relativistic Electron Losses (BARREL) mission was designed to provide complementary observations of bremsstrahlung x-rays generated by hiss-scattered electrons colliding with atmospheric neutrals after removal from the radiation belts. In addition to providing direct evidence that hiss causes electron loss, we have discovered that 1-20 min period fluctuations of x-rays and hiss amplitude are coherent on spatial scales comparable to the size of the plasmasphere, far exceeding the few km scale on which wave-particle interactions operate. Our results established a new correlation scale and indicate that electrons as far inwards as the electron slot region may be more strongly influenced by dynamics of the magnetosphere than previously thought. These effects have not been currently incorporated into global radiation belt electron loss models.

Abstract ID: 34614

Final Number: SPA32A-03

Title: Electron and proton precipitation during a solar storm: Observations of a SEP and CME-shock arrival by BARREL.

Presenter/First Author: Alexa Halford, Dartmouth College, Hanover, NH

Presenter/First Author Email: Alexa.Halford@gmail.com

Published Material: The precipitation due to the CME-Shock arrival and subsequent magnetosphereic phenomena has been submitted to JGR. Portions of this work have been presented at the AGU fall meeting and the LWS meeting in November 2014.

Abstract Body: The Balloon Array for Radiation belt Relativistic Electron Losses (BARREL) observed X-rays from precipitating electrons as well as Solar energetic proton events (SEPs) in the Earth's atmosphere. During the second campaign in January 2014 two SEP events were detected in the BARREL payloads as they produced atmospheric X-rays, ɣ-rays, and directly injected protons observed by the scintillator on the BARREL payloads. A total of 6 payloads were up during the solar storm beginning 7 January with an X-class flare at 1832 UT, spread across a wide range of L and MLT. Payload 2I was on open field lines for the entire event while 2T (2W) crossed from open (closed) to closed (open) field lines over the course of the three days. Payloads 2K and 2L were moving from the inner magnetosphere (L ~ 4) to higher field lines (L>6.6) while 2X stayed within the inner magnetosphere (L<6.6). Throughout this time, there were multiple conjunctions with the Van Allen Probes and good agreement with when and at what L- values the energetic protons were observed. As the SEP subsided, the CME-shock originating from the active region reached the magnetosphere, compressing it and ultimately generating an electric field impulse and chorus waves leading to precipitation of lower energy electrons (10's – 100's of keV) observed by 2 payloads located near noon and in close conjunction with the Van Allen Probes and GOES. The electron precipitation was observed to be due to a combination of the electric field impulse and ultimately chorus waves. This is a unique event as BARREL observed portions of the entire solar/geomagnetic storm process.

Abstract ID: 34190

Final Number: SPA32A-04

Title: Precipitating Solar Energetic Particles and Higher Latitude Geomagnetic Environment

Presenter/First Author: Sharad Chandra Tripathi, Barkatullah University, Bhopal,

Presenter/First Author Email: risingsharad@gmail.com

Co-authors: Pramod Kumar Purohit, National Institute of Technical Teachers' Training and Research, Bhopal, India; Parvaiz Ahmad Khan, , , ; Ashok Kumar Gwal, , ,

Abstract Body: Solar Energetic Particles the most devastating Solar Transients disturbes completely the high latitude electrical systems after precipitation. They are responsible for the aurora and infact drive the geomagnetic storms as well in some way. In the present analysis the spectral behavior of Solar Energetic Particles have been investigated with respect to the current systems and geomagnetic storms. The ionospheric responses in different hemispheres have also been investigated. The Geomagnetic disturbance indices Dst and PC have been used in the present study and fairly good correlation has been found between particle spectral indices and PC index. In accordance different ionospheric responses have been observed in the different hemispheres during geomagnetic storms.

Abstract ID: 34570

Final Number: SPA32A-05

Title: Particle Precipitation in the Thermosphere-Ionosphere

Presenter/First Author: Stanley C Solomon, National Center for Atmospheric Research, Boulder, CO

Presenter/First Author Email: stans@ucar.edu

Abstract Body: Energetic particles from the magnetosphere ionize the high-latitude thermosphere at altitudes above about 100 km, causing auroral displays to occur, and contributing to formation of the ionosphere. During geomagnetic disturbances, the number and energy of these particles intensifies, leading to dramatic increases in ionization, conduction of magnetospheric currents, and significant heating and disturbance of the thermosphere-ionosphere system. Chemical changes accompany these increases, driven primarily by dissociation of molecular nitrogen and formation of odd-nitrogen compounds. This presentation will give an overview of processes driven by this particle "precipitation" into the thermosphere/ionosphere, and discuss some of the uncertainties involved in measuring and modeling the magnitude and variability of ionized and dissociated gases produced in the aurora.

Abstract ID: 34667

Final Number: SPA32A-06

Title: Chorus intensity modulation driven by time-varying field-aligned low-energy plasma

Presenter: Wen Li, University of California Los Angeles, Los Angeles, CA

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Co-authors: Jacob Bortnik, University of California Los Angeles, Los Angeles, CA; Jun Liang, University of Calgary, Calgary, AB, Canada; Richard M Thorne, University of California Los Angeles, Los Angeles, CA; Larry R Lyons, University of California Los Angeles, Los Angeles, CA; Vassilis Angelopoulos, University of California Los Angeles, Los Angeles, CA; Olivier Le Contel, Laboratoire de Physique des Plasmas, Palaiseau, France; Hans Ulrich Auster, Technical University of Braunschweig, Braunschweig, Germany; John W Bonnell, University of California Berkeley, Berkeley, CA

Published Material: A preliminary version of this in AOGS2014

Abstract Body: Recent studies have shown that chorus waves are responsible for scattering energetic electrons that drive the pulsating aurora. While some of the chorus intensity modulation events are correlated with <~100 eV electron density modulation, most of the chorus intensity modulation events in the post-midnight sector occur without apparent density changes. Although it is generally difficult to find evolution of low-energy (<~20 eV) electron fluxes due to constraints imposed by the spacecraft potential and ESA energy range limit, we identified using THEMIS satellite data that low-energy ions of ~100 eV show density modulation that is correlated with chorus intensity modulation. Those low-energy ions and electrons are field-aligned with major peaks in 0 (for northern hemisphere winter event) and 180 (for northern hemisphere summer event) deg pitch angle, indicating that outflowing plasma from the sunlit hemisphere is the source of the low-energy plasma density modulation near the equator. Plasma sheet plasma density and ambient electric and magnetic fields do not show modulations that are correlated with the chorus intensity modulation. Assuming charge neutrality, the low-energy ions can be used to represent cold plasma density in wave growth rate calculations, and the enhancements of the low-energy plasma density are found to contribute most effectively to chorus linear growth rates. These results suggest that chorus intensity modulation is driven by a feedback process where outflowing plasma due to energetic electron precipitation increases the equatorial density that drives further electron precipitation.

Abstract ID: 33710

Final Number: SPA34A-0350

Title:

Weak Arc Electrodynamics using ePOP and DMSP Observations on July 28, 2014

Presenter/First Author: William K Peterson, University of Colorado at Boulder, Boulder, CO

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Abstract Body: On July 28, 2014 at 00:48:14 the Canadian ePOP and DSMP F17 satellites were in near magnetic conjunction over a weak arc feature in the southern polar cap. They were near the same altitude (DSMP: 876km ePOP:1175 km). The precipitating electron flux estimated at DMSP was ~2 ergs/s-cm2) almost all of it coming from electrons with energies significantly greater than 100 eV. The Suprathermal Electron Imager (SEI) on ePOP observed a weak precipitating flux of low energy (less than 100 eV) electrons associated with a field aligned current system observed on both satellites. Here we present detailed observations and compare them with calculations made using the Field aligned interhemispheric plasma (FLIP) code.

Abstract ID: 33932

Final Number: SPA34A-0351

Title: Contribution of Ion Velocity Shears in the Direct Generation of Small-Scale Irregularities in the High-Latitude F Region

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Published Material: Part of this research was presented at the DASP meeting in February 2014. These results have not been published yet.

Abstract Body: Plasma instabilities play an important role in producing small-scale irregularities in the ionosphere. In particular, current-driven electrostatic ion-acoustic (CDEIA) instabilities contribute to high-latitude F-region electrodynamics. CDEIA instabilities are affected by ion velocity shears. Ion velocity shears are observed near auroral arc edges, sometimes coexisting with thermal ion upflow processes and field-aligned currents (FAC). The detection of naturally enhanced ion-acoustic lines (NEIALs) near the edges of auroral structures, often linked with ion upflows and parallel FACs, suggests that shear-modified CDEIA instabilities could take place in these regions. These observations led us to investigate whether these shears could enhance the incoherent scattering from CDEIA waves in the high-latitude F-region. We studied the effects of ion velocity shears on the theoretical incoherent scatter radar (ISR) spectrum density function (SDF) for stable plasmas. We found that, under the right conditions, small shears produce significant enhancements in ISR spectra, especially for directions near perpendicular to the geomagnetic field. This could lead to overestimations in the interpreted electron to ion temperature ratio and electron density when using standard ISR fitting procedures.

Abstract ID: 34175

Final Number: SPA34A-0352

Title: Improved Techniques for Monitoring and Investigating Polar Cap Absorption

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Abstract Body: Shock waves produced in front of coronal mass ejections can accelerate solar energetic protons Earthward where they are guided by the Earth's magnetic field into the high-latitude polar cap region. Energetic >10 MeV protons can penetrate into the ionosphere increasing ionization in the D-region causing a polar cap absorption (PCA) event potentially blocking out high frequency (HF) radio communications at high latitudes. This is of direct importance to the safety of transpolar flights which communicate using the affected radio signals. Riometer instruments are able to monitor variations in ionospheric absorption by observing background cosmic radio noise. This paper presents a newly developed two-dimensional display for viewing riometer-derived absorption on a Canada-wide scale. Two display options are examined: (1) displaying observations at the coordinates of riometers stations, and (2) modeling absorption across the entire high-latitude region. Such visualization tools will greatly enhance the monitoring and investigation of ionospheric effects on HF radio communication allowing system operators to optimize system performance thereby contributing to the reduction of economic losses during PCA events.

Abstract ID: 33199

Final Number: SPA34B-0354

Title: Effect of solar flare and solar wind on space weather variation

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Published Material: this contained published in Research in astronomy and astrophysics in volume 15, number 1, 2014. and some part underproses in other journals

Abstract Body: Today's challenge for space weather research is to quantitatively predict the
dynamics of the magnetosphere from measured solar wind and interplanetary magnetic
field (IMF) conditions. Correlative studies between geomagnetic storms (GMSs)
and the various interplanetary (IP) field/plasma parameters have been performed to
search for the causes of geomagnetic activity and develop models for

predicting the
occurrence of GMSs, which are important for space weather predictions. We find a
possible relation between GMSs and solar wind and IMF parameters in three different
situations and also derived the linear relation for all parameters in three situations.
On the basis of the present statistical study, we develop an empirical model. With the
help of this model, we can predict all categories of GMSs. This model is based on the
following fact: the total IMF Btotal can be used to trigger an alarm for GMSs, when
sudden changes in total magnetic field Btotal occur. This is the first alarm condition
for a storm's arrival. It is observed in the present study that the southward Bz component
of the IMF is an important factor for describing GMSs. A result of the paper is
that the magnitude of Bz is maximum neither during the initial phase (at the instant
of the IP shock) nor during the main phase (at the instant of Disturbance storm time
(Dst) minimum). It is seen in this study that there is a time delay between the maximum
value of southward Bz and the Dst minimum, and this time delay can be used
in the prediction of the intensity of a magnetic storm two-three hours before the main
phase of a GMS. A linear relation has been derived between the maximum value of
the southward component of Bz and the Dst, which is Dst =
(¡0:06)+(7:65)Bz +t.
Some auxiliary conditions should be fulfilled with this, for example the speed of the
solar wind should, on average, be 350 km s¡1 to 750 km s¡1, plasma ¯ should be low
and, most importantly, plasma temperature should be low for intense storms. If the
plasma temperature is less than 0:5£106 K then the Dst value will be greater than the
predicted value of Dst or if temperature is greater than 0:5£106 K then the Dst value
will be less (some nT).

Abstract ID: 36683

Final Number: SPA34B-0355

Title: Changes in lower ionosphere during solar flare and storm occurred on 9 March 2012

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Abstract Body: Effect of low-latitude D-region ionosphere is examined during the space weather events of solar flare and the geomagnetic storm, occurred on 9 March 2012, by means of the associated perturbations of several subionospheric VLF/LF signals. VLF data recorded at the time of solar flare show an amplitude enhancement of 2.5dB and a strong fluctuation in the amplitude of the VLF signals during the recovery phase of the flare event, which is due to geomagnetic storm and persisted through the end of the data-recording period. Further, signal absorption is seen during recovery. We suggest that both the subsequent fluctuations and signal absorption were associated with variations in the precipitation flux of energetic electrons onto the upper atmosphere due to storm. The occurrence rate of lightning-induced electron precipitation (LEP) events, as recorded on several VLF/LF signals as well as tweek analysis results were seen to be highly variable with geomagnetic activity on the day. Quantitative modeling of subionospheric VLF/LF wave propagation incorporating energetic electron flux measurements yield results consistent with the variations in the VLF signal amplitude observed.

Abstract ID: 36716

Final Number: SPA34B-0356

Title: Investigation of correlation between the lower ionospheric perturbations with seismic anomaly as detected by subionospheric VLF signals

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Abstract Body: The seismogenic lower ionosphereic perturbations in association with the earthquakes are being investigated here, using subionospheric VLF propagation. As the target to find correlation between the VLF propagation anomaly (average nighttime amplitude, nighttime fluctuation) and earthquakes we have analyzed a long period of data over 5 years from 2010 to 2014. VLF data analysis is done for the propagation path from NWC (in North West Cape, Australia) to Agra, India. As the latest advancements in the VLF method analysis we have used the fluctuation power spectra in the frequency range of atmospheric gravity waves (period = 10 min to 100 min) to confirm the presence of seimo-ionospheric perturbations. Further superimposed epoch analysis has been undertaken, in order to find the correlation of the ionospheric perturbations with seismic activity. Analysis results show that there occur significant anomalies in VLF propagation few days (3 and 5 days) before the earthquake, indicating significant correlation with the earthquakes. Finally we have discovered an important correlation between number of pre/after shocks and anomalous signal i.e. ionospheric anomalies.

Abstract ID: 36777

Final Number: SPA34B-0357

Title: Solar flare induced sudden amplitude/phase anomalies as a consequence of ionospheric D-region perturbation

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Published Material: Submitted in "Astrophysics and Space Science" and the manuscript is under review.

Abstract Body: The results of solar flare induced D-region perturbation studies along a short great circle path (GCP = 6690 km) lying entirely in the low and equatorial latitude region are presented. We use SoftPAL receiver at Agra (Geograph. lat. 27.2°N, long. 78°E), India and monitor NWC signal (f= 19.8 kHz) transmitted from Australia. We analyze the data for the year

2011 and find that the results of amplitude and phase perturbations, time delay, zenith angle independence, and electron density variation in the lower ionosphere are consistent with those observed along similar paths at low and high latitudes. The new work includes; (i) the distribution of peak X-ray flares in the mixed solar cycle period 2011 responsible for clear and measurable sudden phase anomalies (SPAs) is different from that in minimum solar cycle period, though the cut off hardening factor is the same; (ii) the phase anomalies are evaluated in terms of X-ray fluence (J/m^2); (iii) the perturbation due to X-class of flare is used to calculate the electron densities in 70-60 km height range which are found to be 60-80 % lower than those in the polar region where X-ray flare is followed by solar proton event.

Abstract ID: 34704

Final Number: SPA34B-0362

Title: Localization and Turbulent Spectrum of 3-D Kinetic Alfvén Wave in Intermediate Beta Plasma

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Co-authors: R P Sharma, Indian Institute of Technology Delhi, India, Delhi, India; Nitin Yadav, IIT Delhi, New Delhi, India

Abstract Body: Numerical simulation of the coupled normalized equations guided by the 3-D kinetic Alfvén wave (KAW) and slow magnetosonic wave dynamics in the intermediate beta plasma have been demonstrate in the present study. We have examined the localization/filamentation and power spectrum of 3-D kinetic Alfvén wave for this nonlinear interaction. Pump KAW exerts a ponderomotive force on the slow magnetosonic wave and thereby results in localization of the wave. The coupling between KAW and slow magnetosonic wave has been studied numerically and the results were found to be consistent with the observation of THEMIS spacecraft in magnetopause.

Abstract ID: 34728

Final Number: SPA34B-0363

Title: Role of Kinetic Alfvén Wave in Energy Transportation in Magnetopause

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Abstract Body: The transportation of energy is the vital subject in space physics. Magnetohydrodynamic waves are known to play very important role in plasma transportation. In the present work, we have studied the localization of kinetic Alfvén wave (KAW), which is three dimensionally propagating. These localized structures might be a possible candidate for transported energy at small scales in dissipation range of turbulent spectra. For this scenario, governing dynamical equation of KAW has been derived taking ponderomotive nonlinearity into account. Furthermore, these equations are solved numerically using pseudo spectral method in magnetopause regime to analyse the localized structures of KAW and corresponding turbulent spectrum. Spectrum shows steeper scaling followed by inertial range and this steepening is due to the transportation of energy from large to small scale, which eventually contributes to heating of plasma. The present mechanism may be useful for explaining the plasma heating and particle acceleration in magnetopause.The present study is correlated with the observations made by Chaston et al. [2008] using THEMIS data.

Reference

Chaston, C., et al. (2008), Turbulent heating and cross-field transport near the magnetopause from THEMIS, Geophys. Res. Lett., 35, L17S08,doi:10.1029/2008GL033601.

Abstract ID: 36507

Final Number: SPA34C-0367

Title: 1/k-Spectrum in the Sub-Inertial Domain of Turbulence: A Shell-Model Approach.

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Co-authors: Rossana De Marco, INAF-Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy; Vincenzo Carbone, Departmento de Fiscia, Arcavacata di Rende, Italy

Abstract Body: Many physical and astrophysical fluid and plasma turbulent systems display the presence of a 1/f (or 1/k assuming Taylor's hypothesis) spectral domain at temporal (or spatial) scales above the inertial range, whose origin is still not understood. Here, we investigate the formation of a 1/k spectral domain in fluid and MHD turbulence systems in the sub-inertial range (k < k0 where k0 is the injection scale) by means of shell-model simulations. Our results suggest that the 1/k domain emerges as a consequence of competing direct and inverse cascading process. The relevance of our results for observations in space and astrophysical contexts is briefly discussed.

The research leading to these results has received funding from the European Community's Seventh Framework Programme ([FP7/2007-2013]) under Grant agreement no. 313038/STORM, MIUR-PRIN grant 2012P2HRCR on "The active Sun and its effects on Space and Earth climate" and the ASI-INAF agreement no. I/022/10/0.

Abstract ID: 34756

Final Number: SPA34C-0369

Title: Circularly Polarized Dispersive Alfvén Wave In Solar Wind Turbulence

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Published Material: No, the present article is to be submitted in a scientific journal soon.

Abstract Body: ***Abstract***

The physical properties of solar wind turbulence and its evolution have been an intense topic of exploration for decades. The inertial range of Solar wind turbulence can be described by a magnetohydrodynamic model. The dispersive range of the solar wind turbulence likely consists of several kinds of waves. The obliquely propagating waves, e.g., the kinetic Alfvén wave and whistler wave, are considered to be an important factor in the solar wind turbulence. On the other hand, parallel propagating right(R) and left(L) circularly polarized Alfvén/ ion cyclotron wave in the framework of Hall MHD are also thought to be essential ingredients of the solar wind turbulence. Recently, He et.al[1] have used the magnetic field data from the STEREO spacecraft to calculate the magnetic helicities in the solar wind turbulence. Their analysis indicates the possible existence of Alfvén -cyclotron waves and their coexistence with the right handed polarized fluctuations (kinetic Alfvén waves or whistler waves). In the present article we intend to study the temporal evolution of right and left circularly polarized dispersive Alfvén wave (DAW) and their role in the solar wind turbulence. Dispersion is considered on account of the finite frequency (frequency comparable to ion gyro frequency) of the pump wave. The individual DAW dynamics of two modes in the presence of the density fluctuations (ion acoustic/magnetosonic) is obtained and simulated numerically. We have then studied the transient evolution of DAW when transverse density perturbations are present in the background. The power spectrum is investigated which shows a steepening for scales larger than the proton inertial length. This is consistent with the recent work by Meyrand et.al[2]. The observations in the solar wind also indicate that L and R modes coexist uptil the pump wave frequency remains less than or comparable to the ion cyclotron frequency[1].

References : [1] J. He, E. Marsch, C. Tu, S. Yao and H. Tian, *Astrophysical Journal*, **731**, 85 (2011) [2] R. Meyrand and S. Galtier, *Phys. Rev.Lett.*, ***109***, *194501*(2012)

Abstract ID: 34787

Final Number: SPA34C-0370

Title: Multi-scale Structural Analysis of Magnetosheath Turbulence with Rank Ordered Fractals

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Co-authors: Costel Munteanu, University of Oulu, Oulu, Finland; Tom Chang, Massachusetts Institute of Technology, Cambridge, MA

Abstract Body: In-situ measurements of magnetic field fluctuations in the terrestrial magnetosheath revealed fundamental differences between the quasi-perpendicular and quasi-parallel geometries. In the quasi-parallel case the fluctuations are strongly intermittent as suggested by the scale dependent non-Gaussian wings of the probability distribution functions (PDFs) and the scale dependent behaviour of their fourth order moment. A previous study of the intermittent magnetosheath turbulence for a quasi-parallel geometry (Sundkvist et al., PRL, 2007) discussed the energy dissipation in terms of reconnecting thin current sheets scaling with the local Larmor radius. The Rank Ordered Multifractal Analysis (ROMA) is a data analysis method constructed with the aim of identifying the various individual fractal behaviour of multifractal fluctuations (Wu and Chang, Phys Rev E, 2008). ROMA is capable of disentangling the ranges of fluctuations that exhibit the same fractal (self-similar) dimension in terms of the local invariant property based on the scaled amplitude of fluctuations and thereby identifying the different regimes of fluctuations (e.g., persistency) and physical processes (e.g., kinetic/MHD). A ROMA analysis of the intermittent turbulence in the magnetosheath describing the multiscale and dissipation behaviour over ranges of scales, in the coarse-grained sense, will be presented. We will also discuss the relevance of the analysis for general studies of turbulence in solar system plasmas.

Research supported by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 313038/STORM, and a national grant CNCS–UEFISCDI, project number PN-II-ID-PCE-2012-4-0418.

Abstract ID: 33554

Final Number: SPA34C-0371

Title: Statistical Analysis of Intermittency in the Solar Wind using Rank-Ordered Multifractal Analysis of Ulysses data

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Abstract Body: The intermittent properties of the turbulence in the solar wind are investigated using Ulysses data and the direct Rank-Ordered Multifractal Analysis (ROMA) developed by Chang & Wu (2008). Ulysses databases were carefully selected previously in the framework of the STORM project (http://www.storm-fp7.eu/) in order to use only pure slow and fast solar wind data. They correspond to 3 time periods : 1997-1998 and 2007-2008 for the solar minimum and 1999-2001 for solar maximum.

We start by illustrating the key-features of ROMA applied on Ulysses magnetic field data recorded in the fast solar wind and explain the usefulness of the method to understand plasma complexity and turbulence. Then we provide the multifractal (ROMA) spectra s(Y) obtained for different heliographic latitudes, radial distances and types of wind (fast versus slow). We discuss the statistical properties of the intermittency for each data set as resulting from ROMA analysis.

Research supported by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 313038/STORM and the US National Science Foundation.

T. Chang and C.C. Wu, Rank-Ordered Multifractal Spectrum for Intermittent Fluctuations, Phys. Rev. E77, 045401(R), 2008

Abstract ID: 33768

Final Number: SPA34C-0372

Title: Non linear effects associated with kinetic Alfvén wave in solar wind plasmas.

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Published Material: These findings will be shortly submitted after minor revisions in a scientific journal.

Abstract Body: The nonlinear phenomena are of striking importance in understanding the particle acceleration, heating and turbulence in the interplanetary space. Alfvén waves are known to be the exact solution of the ideal magnetohydrodynamic (MHD) system and when this MHD Alfvén wave develops a large perpendicular wave number transverse to the ambient magnetic field it creates kinetic Alfvén wave (KAW). These waves may be responsible for accelerating the solar wind and powering the solar wind turbulence. Plasma contains a variety of low frequency modes like ion acoustic, magnetosonic mode and even the low frequency KAW. The ponderomotive force of (relatively high frequency, high power) pump KAW may be used to excite the low frequency KAW. This is the motivation of the present work to analyze the nonlinear dynamics of relatively high frequency pump KAW in the presence of comparatively low frequency KAW perturbation and its effect on the solar wind turbulence. For this purpose the dynamical equations to analyze the nonlinear dynamics of relatively high frequency pump KAW in the presence of comparatively low frequency KAW perturbation are derived. The numerical solution has been carried out for the coupled system of equations by using the pseudospectral method for space integration and finite difference method along with the predictor corrector scheme for the evolution in time. The coupled system of nonlinear dynamical equations is analyzed to study the nonlinear effects associated with pump KAW and the resulting turbulent spectra at 1 AU. The averaged power spectrum in the quasisteady state (ensemble contains 10 spectra) obtained follows the Kolmogorov scaling which further steepens after k>1. Therefore, this nonlinear interaction due to KAWs may lead to the distribution of energy among the large and intermediate wavenumbers at k>1[Saharoui et al., 2010; Howes et al. 2008]. Energy transfer is implicated by the spectral index followed by the turbulent energy spectrum. The process of filamentation attributed to the energy transfer amongst the nonlinearly interacting modes is also studied. The present model may have some applicability to understand the initiation of turbulence in the solar wind.

References

1. Howes, G. G. et al.: 2008, *J. Geophys. Res*., 113, A05103.
2. Sahraoui, F. et al.: 2010, *Phys.Rev. Lett.* 105, 131101.

Abstract ID: 34068

Final Number: SPA34C-0373

Title: Effect of Background Fluctuations on Nonlinear Evolution of Kinetic Alfvén Wave and Turbulent Spectrum

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Abstract Body: Effect of Background Fluctuations on Nonlinear Evolution of Kinetic Alfvén Wave and Turbulent Spectrum

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ABSTRACT

We have studied the effect of background density fluctuations on the formation of localized large amplitude structures and turbulent spectrum of kinetic Alfvén wave (KAW) applicable to magnetopause. Numerical simulation has been performed to study these structures. Localization becomes more intense with the growth of numerous structures at later times. From the results, we found that background fluctuations affect the localization process of KAW. Simulation results reveal that power spectrum deviates from Kolmogorov scaling at the transverse size of KAW, equal to ion gyroradius. Steepening of power spectrum at shorter wavelengths may be accountable for heating and acceleration of the plasma particles. Thus the presented coupling suggests a mechanism of energy transfer from larger length-scales to smaller length-scales. The relevance of present investigation with observations collected from the THEMIS spacecraft in magnetopause is also discussed [Chaston et al., 2008].

Reference

[1] Chaston, C., J. Bonnell, J. P. McFadden, C. W. Carlson, C. Cully, O. Le Contel A. Roux, H. U. Auster, K. H. Glassmeier, V. Angelopoulos, C. T. Russell (2008), Turbulent heating and cross-field transport near the magnetopause from THEMIS, *Geophys. Res. Lett., 35, L17S08.*

Abstract ID: 34745

Final Number: SPA34C-0375

Title: Small-scale Turbulence in The Terrestrial Magnetosheath by Cluster Observations

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Abstract Body: Terrestrial magnetosheath is the interface region between the solar wind and the Earth's magnetosphere. The interaction between the solar wind plasma and the magnetospheric plasma results in the formation of a very complex and turbulent region associated with intensive and highly variable fluctuations in all plasma parameters. By using different approaches we attempt to identify and characterize the quasi-linear waves and coherent structures arising from the dynamical behavior of magnetosheath plasma at scales around the proton scale. The data analysis is based on Cluster spacecraft measurements.

The research leading to these results has received funding from the European Community's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n 313038/STORM.

Abstract ID: 34098

Final Number: SPA34D-0376

Title: Nonlinear Effects of Inertial Alfvén Wave in Low Beta Plasmas

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Co-authors: R P Sharma, Indian Institute of Technology Delhi, India, Delhi, India; Nidhi Gaur, Indian Institute of Technology Delhi, New Delhi, India

Published Material: This is already in under review in the SCI journal.

Abstract Body: This paper is devoted to the study of the nonlinear interaction and propagation of high frequency pump inertial Alfvén wave (IAW) with comparatively low frequency inertial Alfvén wave (IAW) with emphasis on nonlinear effects and applications within space plasma and astrophysics for low - plasma. We have developed the set of dimensionless equations in presence of ponderomotive nonlinearity due to high frequency pump IAW in the dynamics of comparatively low frequency IAW. Stability analysis and numerical simulation has been carried out for the coupled system comprising of pump IAW and low frequency IAW to study the localization and turbulent spectra, applicable to auroral region. The result reveals that localized structures becomes more complex and intense in nature at the quasi steady state. From the obtained result, we found that the present model may be useful to study the turbulent fluctuations in accordance with the observations of FAST/THEMIS spacecraft.

Abstract ID: 35185

Final Number: SPA34D-0378

Title: Motion of the Polar Cap Arcs and Associated Plasma Flows

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Co-authors: Alexandre V Koustov, University of Saskatchewan, Saskatoon, SK, Canada; Keisuke Hosokawa, University of Electro-Communications, Tokyo, Japan

Abstract Body: Arc-like auroral structures in the polar cap often move in the dawn-dusk direction. Speeds of such motions vary between ~100 m/s and 2 km/s depending on the magnetic local time of observations. In the midnight sector, typical speeds of 300-500 m/s have been reported. We show that these values are somewhat larger than plasma flow speeds in the zonal direction typically observed by the Clyde River SuperDARN HF radar. This raises a question whether the zonal motion of the polar cap arcs is consistent with the projection of the ExB plasma velocity on the direction of the shift. In this study, we consider several events of the polar cap arc monitoring with the Resolute Bay 630 nm all-sky imager and concurrent measurements of the plasma flow with the PolarDARN/SuperDARN HF radars and Resolute Bay–North AMISR incoherent scatter radar to assess typical plasma flows established in the ionosphere while the arcs move through the common field-of-view. We show that the optical arcs zonal speed is close to the ExB velocity component. We also investigate the microstructure of plasma flows in the arcs' vicinity by adding to the large-scale SuperDARN convection patterns data from localized AMISR measurements. For one event, plasma density and magnetometer measurements on the SWARM satellite are added to estimate the location and intensity of the field-aligned currents.

Abstract ID: 35236

Final Number: SPA34D-0379

Title: Auroral Response to Sudden Changes in the Solar Wind and IMF

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Co-authors: Eric Donovan, University of Calgary, Calgary, AB, Canada; Eric M. Grono, University of Calgary, Calgary, AB, Canada; Brian J Jackel, University of Calgary, Calgary, AB, Canada

Abstract Body: Sudden changes in the solar driver of magnetospheric activity provide us with exciting opportunities to study the physics of the aurora. In this talk, we focus on how sudden impulses, where the solar wind dynamic pressure changes significantly and quickly, affect the auroral distribution. In particular, we look at polar cap aurora observed in the Oxygen redline with the new Geospace Observatory (GO) Canada REdline Geospace Observatory (REGO) network of imagers, focusing on a sudden impulse that occurred around 11 UT on December 23, 2014. During this event, clearly as a result of the sudden impulse, numerous pre-existing transpolar arcs brighten significantly and stay bright for hours following. The pre-existence, multiplicity, and brightening of the transpolar arcs all speak to their origin.

Abstract ID: 35284

Final Number: SPA34D-0380

Title: Electron Energy Dispersion as seen by the ePOP Suprathermal Electron Imager

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Published Material: Some of this work was reported in a poster at the CEDAR Workshop in 2014. Taylor Cameron*, David Knudsen, Jonathan Burchill. Electron Energy Dispersion as seen by the ePOP Suprathermal Electron Imager, CEDAR Workshop 2014, Seattle

Abstract Body: A candidate mechanism for accelerating auroral electrons is acceleration by Alfven waves. These waves can accelerate electrons to velocities of the order of the Alfven speed. Wave acceleration has been linked to energy dispersion, a distinct signature that can be seen in particle detectors. This signature is a burst of electrons where the higher energy ones appear first, followed by decreasing energies. Using data from the Suprathermal Electron Imager (SEI) onboard the enhanced Polar Outflow Probe (ePOP), we document instances of low energy electron dispersion. These events are supported by VLF electric field data, also from ePOP. We also report inverse electron dispersion events, where energy increases with time. This phenomenon has not been recorded in the literature. These observations are not consistent with transient Alfven wave acceleration alone. We explore an alternative explanation involving a slowly drifting source, and present results of a simple simulation of this.

Abstract ID: 35304

Final Number: SPA34D-0381

Title: Ionospheric Radio Science with ePOP at Auroral Latitudes

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Published Material: Some of the background to presentations at COSPAR SA 2014, Moscow, 2-10 August, 2014 and atURSI GASS2014, Beijing, 16-23 August 2014 will reappear here.

Abstract Body: The orbit of the Canadian small satellite CASSIOPE allows the Enhanced Polar Outflow Probe (ePOP) payload that it carries to directly observe ionospheric processes at a variety of altitudes and latitudes. The 325km x 1500km elliptical orbit at 81° inclination permits comparison of topside collisionless plasmas with denser plasmas below and of mid-latitude plasmas with polar-cap ones. In coordinated operations of the ePOP Radio Receiver Instrument (RRI) with measurements by the SuperDARN (SD) radars, the RRI has recorded HF signals originating at the Saskatoon and Rankin Inlet SDs. Here, the combination of both EM propagation directly incident from the radar emitters and of signals backscattered from nearby irregularities provides new insights into the nature of coherent backscatter. Transionospheric propagation through the F region modified by ionospheric heaters and detected by the RRI is used to image the structure therein, and to better understand electromagnetic propagation through irregular media. Spontaneous radio emissions at very low frequency and medium frequency borne of auroral-particle free-energy sources manifest a variety of spatial scales.

Abstract ID: 34347

Final Number: SPA41A-01

Title: Global Plasmaspheric Electron Density Simulations of Pre-dawn and Post-dusk Geomagnetic Events Observed by the Van Allen Probes

Presenter/First Author: Sebastian De Pascuale, University of Iowa, Iowa City, IA

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Published Material: A poster on the content of this proposal was presented at the 2014 AGU Fall Meeting in San Francisco, CA under the Dawn-Dusk Asymmetries in Solar Wind-Magnetosphere-Ionosphere Systems session. The findings were also reported in an internal Los Alamos Space Weather Summer School Research Reports circulation at LANL, but have not yet been submitted for peer-review. That work is currently in preparation for submission to the Journal of Geophysical Research.

Abstract Body: We use in situ measurements by the Van Allen Probes (RBSP) to validate a globally applicable plasmaspheric electron density model (RAM-CPL), which is based on ionospheric outflow rates and electric field drivers as proxies for system refilling and erosion respectively. The model is a key component of the RAM-CPL suite in describing the temporal evolution of plasma density in the equatorial plane of the magnetosphere. In addition to considering absolute density values, this study employs a composite definition of the plasmapause boundary as a standard metric for comparison between observations and the model. Because the dynamics of the plasmasphere are governed on different timescales ranging from minutes to days, we consider geomagnetic events for which the RBSP satellites are at conjunction to sample fine-scale density variation as well as large-scale structure. Furthermore, the pre-dawn and post-dusk sectors of the observations provide adequate constraints on the candidate electric field drivers of the plasmasphere. The good agreement attained by the RAM-CPL plasmasphere model can be utilized to predict density conditions in magnetic local time and L-parameter sectors distant from an RBSP orbit of interest. These simulations reproduce plasmapause radial locations to within 0.6 Earth radii (RE) of RBSP observations and we investigate further the competing effects of plasmaspheric refilling and erosion on model performance.

Abstract ID: 34500

Final Number: SPA41A-02

Title: Long-Lived Plasmaspheric Drainage Plumes and the Plasma-Source Dilemma

Presenter/First Author: Joseph Borovsky, Space Science Institute Los Alamos, Los Alamos, NM

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Co-authors: Dan Welling, University of Michigan, Ann Arbor, MI; Michelle F Thomsen, Planetary Science Institute, Los Alamos, NM; Michael Denton, Space Science Institute Boulder, Boulder, CO

Published Material: Journal of Geophysical Review 2014

Abstract Body: Long-lived (weeks) plasmaspheric drainage plumes during long-lived high-speed-stream-driven storms were explored. Geosynchronous-orbit spacecraft see the plumes as streams of dense plasmaspheric plasma continuously advecting sunward toward the dayside magnetopause. The standard assumption is that the plasmaspheric plumes are the drainage of plasma from a built-up outer plasmasphere. Computer simulations indicate that drainage from the outer plasmasphere can only supply a plume for about 2 days. Plumes that are 5 days old are common and plumes lasting 15 days have been seen. The question arises for long-lived plumes (and for any plume older than about 2 days): Where is the plasma coming from? Magnetospheric sources and ionospheric sources will be explored.

Abstract ID: 36399

Final Number: SPA41A-03

Title: Plasmasphere refilling rates as deduced from Ukraine incoherent scatter radar data by FLIP simulation for the last solar minimum

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Abstract Body: During the last solar minimum, anomalously high nighttime H^+ densities was observed over the Kharkiv, Ukraine incoherent scatter radar (49.6° N, 36.3° E, L=2.1). The standard physical model underestimates the H^+ densities by a factor of 2 in March 2006 and a factor of 3 in March 2009. The calculations indicate that the higher measured topside ionosphere H^+ densities are most likely due to higher neutral hydrogen densities. It could be the result of weaker than usual magnetic activity, which would reduce the energy input to high latitudes. Prolonged low activity periods could cause a global redistribution of hydrogen and also allow more neutral hydrogen to settle down from the exosphere into the mid latitude ionosphere. The finding of the need for higher H densities agrees well with recent H-alpha airglow measurements and it is important for accurate modelling of plasmasphere refilling rates. Our calculations with the FLIP model show that the refilling rate is increased by a factor of 2 when the NRLMSISE H density is increased by a factor of 3 and no other changes made to the model inputs. These refilling rates agree well with those observed at geosynchronous orbit (L=6.6) after a magnetic storm in June 2007. We have also found that the refilling rate varies significantly with longitude. Simulations in the American sector would underestimate the maximum refilling rate observed at geosynchronous orbit by more than 50%.

Abstract ID: 35319

Final Number: SPA41A-04

Title: The global distribution, energy source, and scattering effects of magnetosphic waves in the Earth's inner magnetosphere

Presenter/First Author: Qianli Ma, University of California Los Angeles, Los Angeles, CA

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Co-authors: Wen Li, University of California Los Angeles, Los Angeles, CA; Richard M Thorne, University of California Los Angeles, Los Angeles, CA; Jacob Bortnik, University of California Los Angeles, Los Angeles, CA

Published Material: Besides our new results first reported in this presentation, the previous findings in the following papers will be cited: Global distribution of equatorial magnetosonic waves observed by THEMIS, by Ma et al., Geophysical Research Letters, 2013; Magnetosonic wave excitation by ion ring distributions in the Earth's inner magnetosphere, by Ma et al., Journal of Geophysical Research, 2014; The trapping of equatorial magnetosonic waves in the Earth's outer plasmasphere, by Ma et al., Geophysical Research Letters, 2014.

Abstract Body: Equatorial magnetosonic waves are highly oblique whistler-mode electromagnetic emissions between the proton gyrofrequency and the lower hybrid resonant frequency, widely distributed in the Earth's inner magnetosphere, and may have potentially important effects in particle scattering in the radiation belts. Our global survey of magnetosonic waves using THEMIS fff data products has shown that the most intense magnetosonic waves are distributed on the dawn-noon sectors, with maximum root-mean-square averaged wave amplitudes ~50 pT and occurrence rates ~20%. Our instability analysis on a typical magnetosonic wave event has demonstrated that the unstable ion ring distributions could provide the free energy for the wave excitation outside the plasmapause or in the outer region of the plasmasphere. Although magnetosonic waves cannot be excited deep inside the plasmapause, the locally observed waves can be originated from the outer region and stay trapped in the plasmasphere, which is confirmed by our analysis on the wave perpendicular propagation. The magnetosonic waves can cause electron pitch angle and energy scattering via Landau resonance and transit time effects, and we further investigate their general influences on energetic electrons in the Earth's inner magnetosphere.

Abstract ID: 34550

Final Number: SPA41A-05

Title: Control of Energetic Ring Current Ion Spectra by EMIC Waves

Presenter/First Author: Danny Summers, Memorial University of Newfoundland, St John's, NL

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Co-authors: Run Shi, Memorial University of Newfoundland, St John's, NL, Canada

Abstract Body: The dense thermal regions in the magnetosphere comprising the plasmasphere and plasmaspheric plumes play a key role in influencing the energetic ion and electron populations not least because electromagnetic ion cyclotron (EMIC) waves are typically generated inside or close to these thermal regions. Here we address the process of gyroresonant pitch-angle scattering of energetic ions by EMIC waves in the inner magnetosphere. Specifically we test the hypothesis that EMIC waves closely control the shapes and intensities of energetic ion spectra. The limiting energetic ion flux of a trapped population is assumed to be determined by a steady-state marginal-stability criterion in which a convective wave gain condition is applied over all frequencies for which EMIC wave growth occurs. We find that, assuming a multi-ion background plasma,the limiting energetic ion spectrum varies as 1/E for large energy E. We compare the numerical model solutions for the limiting spectra with observed energetic ion spectra at Earth measured by the Van Allen Probes.

Abstract ID: 33962

Final Number: SPA41A-06

Title: The Relation of Chorus, Hiss and the Plasmasphere

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Co-authors: Wen Li, University of California Los Angeles, Los Angeles, CA; Richard M Thorne, University of California Los Angeles, Los Angeles, CA

Abstract Body: Recent work has shown strong theoretical support for the association of plasmaspheric hiss and whistler-mode chorus waves. In particular, it was shown that chorus waves originating in the low-density region outside the plasmasphere, are able to propagate away from their equatorial source region to higher latitudes, avoiding the effects of intense Landau damping, and enter into the plasmasphere where they merge into plasmaspheric hiss waves. In this talk, we review the chorus-hiss connection mechanism, and discuss the important role that the plasmasphere plays in this process. We discuss our method of modeling the plasmasphere, and show recent results based on THEMIS and Van Allen Probes data.

Abstract ID: 33629

Final Number: SPA42A-01

Title: Global Storm-Time Depletion of the Outer Electron Belt

Presenter/First Author: Aleksandr Y Ukhorskiy, Applied Physics Laboratory Johns Hopkins, Laurel, MD

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Published Material: A similar talk was presented in the 2014 Fall AGU meeting.

Abstract Body: The outer radiation belt consists of relativistic (>0.5 MeV) electrons trapped on closed trajectories around Earth where its magnetic field is nearly dipolar. During increased geomagnetic activity electron intensities in the belt can vary by orders of magnitude at different spatial and temporal scale. The main phase of geomagnetic storms often produces deep depletions of electron intensities over broad regions of the outer belt. Previous studies identified three possible processes that can contribute to the depletions: fully adiabatic inflation of electron drift orbits caused the ring current growth, electron loss into the atmosphere due to pitch-angle scattering by plasma waves (e.g., EMIC and whistler waves),

and electron escape through the magnetopause boundary. In this paper we investigate the relative importance of the magnetopause losses to the rapid depletion of the outer belt observed at the Van Allen Probes spacecraft during the main phase of March 17, 2013 storm. The intensities of > 1 MeV electrons were depleted by more that an order of magnitude over the entire radial extent of the belt in less than 6 hours after the sudden storm commencement. For the analysis we used three-dimensional test-particle simulations of global evolution of the outer belt in the Tsyganenko-Sitnov (TS07D) magnetic field model with the inductive electric field. The comparison of the simulation results with electron measurements from the MagEIS experiment shows that the magnetopause losses account for most of the observed depletion at L>5, while at lower L shells the depletion is adiabatic. Both the magnetopause losses and the adiabatic effect are controlled by the change in global configuration of the magnetic field due to storm-time development of the ring current; a simulation of electron evolution without a ring current produces a much weaker depletion.

Abstract ID: 33718

Final Number: SPA42A-02

Title: Simulation of Earth's Radiation Belt Electron Dynamics and Its Comparison to Van Allen Probes Observations

Presenter/First Author: Wen Li, University of California Los Angeles, Los Angeles, CA

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Co-authors: Richard M Thorne, University of California Los Angeles, Los Angeles, CA; Qianli Ma, University of California Los Angeles, Los Angeles, CA; Jacob Bortnik, University of California Los Angeles, Los Angeles, CA

Abstract Body: The highly dynamical evolution of the Earth's outer radiation belt electron fluxes is due to a competition between various loss and acceleration processes. In this study, we focus on analyzing a few interesting events observed by the Van Allen Probes, including a very rapid electron acceleration event up to multi-MeV energies within ~12-16 hours, and a long-term slow decay event where MeV electrons slowly move towards the Earth in association with a slow decay in electron fluxes. Using the UCLA 3D particle diffusion code, we simulate the evolution of the electron phase space density by including important physical processes, such as electron energy diffusion and pitch angle scattering caused by whistler-mode chorus waves, plasmaspheric hiss, and electromagnetic ion cyclotron waves, and radial diffusion driven by ultra low frequency waves. By comparing the simulation results to Van Allen Probes observations, we quantify the role of each physical process in each event. We further discuss the preferential solar wind conditions that lead to the rapid electron acceleration up to multi-MeV and the gradual electron radial transport towards the Earth.

Abstract ID: 34540

Final Number: SPA42A-03

Title: ULF Wave Properties and Implications for Radiation Belt Interactions

Presenter/First Author: Michael Hartinger, Virginia Polytechnic Institute and State University, Hampton, VA

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Abstract Body: Ultra Low Frequency (ULF) waves drive radial transport of radiation belt electrons, potentially leading to depletions or enhancements in relativistic electron fluxes. Rapid transport can occur via a drift-resonant interaction between azimuthal electron drift motion and large scale, coherent ULF wave fields. Several parameters affect transport timescales in addition to the radial phase space density profile; these include wave amplitude, frequency, propagation direction, and azimuthal structure. We report statistical results of the first three parameters using 6 years of THEMIS satellite observations, discussing their implications for drift-resonant interactions. We also discuss how ground-based/in situ observations of azimuthal structure could be added to these observations to better constrain transport timescales.

Abstract ID: 33212

Final Number: SPA42A-04

Title: New e-POP Observations of Topside Ionospheric Ion Outflows: Implications on Inner Magnetosphere Composition and Dynamics

Presenter/First Author: Andrew W Yau, University of Calgary, Calgary, AB

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Published Material: N/A

Abstract Body: The high-latitude topside ionosphere is an important source of cold plasma for the Earth's inner magnetosphere. In this talk, we present initial Enhanced Polar Outflow Probe (e-POP) observations of ion outflows from the topside auroral and polar-cap ionosphere: we will focus on specific features in these observations, which reveal the occurrence of localized regions of enhanced ion up-flow velocities down to the F-region at different magnetic local times; the persistence of non-negligible up-flows at quiet times; and the larger-than-expected fluxes of atomic and molecular nitrogen ions in the observed up-flow. These observed features will be discussed in conjunction with recent outflow modeling results, and in the context of their implications on the composition and dynamics of the inner magnetosphere during both quiet and active times.

Abstract ID: 36200

Final Number: SPA42A-05

Title: Ultra-fast ULF Wave Diffusion: Impacts on the Structure and Dynamics of the Van Allen Belts

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Abstract Body: In recent work we have discovered regimes of ultra-fast ULF wave diffusion which occur in response to specific solar wind drivers during magnetic storms. We review the impacts these periods of ultra-fast ultra-low frequency (ULF) wave power on the dynamics of ultra-relativistic electrons in the Van Allen belts. We place emphasis on the significance of using properly characterised time-series of ULF waves for accurately evaluating their impacts for both acceleration and loss. Specifically we compare results derived from observed wave power with those from more standard approaches using statistical characterisations based on geomagnetic indices such as Kp, revealing the importance of properly characterising the waves through the course of the main and recovery phases of geomagnetic storm-time Van Allen radiation belt dynamics. We find using the observed ULF wave power presents a remarkable explanation for the overall dynamics of the belts in terms of the impacts of inward and outward radial diffusion in association with plasmasheet sources and magnetopause shadowing. At ultra-relativistic energies the resulting dynamics demonstrate a remarkable simplicity which is controlled by the ULF wave power. Especially at ultra-relativistic energies, ULF wave power can explain the morphologies of the Van Allen belts in the form of either one, two or three belts.

Abstract ID: 36749

Final Number: SPA42A-06

Title: ULF wave power and radial diffusion during geomagnetic storms driven by different solar wind drivers

Presenter/First Author: Kyle R Murphy, NASA Goddard Space Flight Center, Greenbelt, MD

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Co-authors: Ian Robert Mann, University of Alberta, Edmonton, AB, Canada; Louis Ozeke, University of Alberta, Edmonton, AB, Canada; David G Sibeck, NASA/GSFC, Greenbelt, MD; Jonathan Rae, University College London, London, United Kingdom

Abstract Body: ULF waves are recognized as playing an important role in the dynamics of the Earth's radiation belts through the action of ULF wave radial diffusion. ULF wave diffusion coefficients are typically defined using a statistical approach, parameterized by either geomagnetic indices or solar wind drivers such as solar wind velocity. However, during geomagnetic storms the ULF wave dependence on solar wind conditions may vary significantly from the solar cycle average. Consequently, accurately modelling the ULF wave response and their impact on the radiation belts during geomagnetic storms via radial diffusion is difficult even with a database of statistically defined radial diffusion coefficients. This is because ULF wave power during geomagnetic storms represents extreme values in the distribution and can vary significantly from one storm to another, thus deviating from any statistical characterization. Here we investigate ULF wave power during two different types of geomagnetic storms, those driven by coronal mass ejections (CMEs) and those driven by co-rotating interaction regions (CIRs), and demonstrate that the response of ULF wave power and the resulting derived diffusion coefficients is significantly different between these two types of storms, and from that inferred using solar cycle average ULF wave parameterizations. In addition, we model the response of the radiation belts during these different types of storms, characterizing how the dynamics of the radiation belts can vary during different storms and different ULF wave driving conditions including the overall transport rates and the penetration of the belts to low-L.

Abstract ID: 34357

Final Number: SPA42A-07

Title: Observations of Ultra-relativistic Electrons in the Earth's Radiation Belts: Recent Results from the Van Allen Probes Mission

Presenter/First Author: Shrikanth G Kanekal, NASA Goddard Space Flight Center, Greenbelt, MD

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Abstract Body: The Earth's radiation belts are comprised of energetic trapped and transient charged particles and usually show an outer zone separated from an inner zone by a "slot region" bereft of energetic electrons. The outer zone comprises mostly of electrons and is home to a variety of physical processes, which energize as well as scatter these particles. These processes result in both enhanced and depleted flux levels depending upon whether energization or loss (due to scattering or escape through the magnetopause) dominates. These dynamics of outer zone electrons are driven by various interplanetary drivers, such as, shocks, coronal mass ejections and high-speed solar wind streams. At times the energized electron spectra can be quite hard and result in ultra-relativistic electrons of energies as high as ~10s of MeV. Here we report on a study of ultra-relativistic electron dynamics using data from the Van Allen probes mission. Van Allen probes comprises two identically instrumented spacecraft carrying a comprehensive suite of particle, plasma waves and fields instrumentation. The Relativistic Electron-Proton Telescope (REPT) experiment on board the Van Allen Probes measures electrons in the range ~2 to >10 MeV and provides both pitch angle and spectral information. In this study, we examine, electron spectra and pitch angle distributions and their evolution during ultra-relativistic flux enhancement events. The temporal evolution of spectra and pitch angle distributions can shed light on the underlying physical process of pitch angle scattering, and energization of these extremely high-energy electrons in the Earth's magnetosphere. We will also investigate the nature of the often observed extreme rapidity with which electrons are energized and lost at these very high energies.

Abstract ID: 34522

Final Number: SPA42A-08

Title: Quantitative Analysis of the First Balloon REP Event with Conjugate EMIC Wave Observations

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Published Material: Published in GRL in Dec 2014

Abstract Body: Electromagnetic ion cyclotron (EMIC) waves were observed at multiple observatory locations for several hours on 17 January 2013. During the wave activity period, a duskside relativistic electron precipitation (REP) event was observed by one of the BARREL balloons, and was magnetically mapped close to GOES-13. We simulate the relativistic electron pitch-angle diffusion caused by gyroresonant interactions with EMIC waves using wave and particle data measured by multiple instruments on board GOES-13 and the Van Allen Probes. We show that the count rate, the energy distribution and the time variation of the simulated precipitation all agree very well with the balloon observations, suggesting that EMIC wave scattering was likely the cause for the precipitation event. The event reported here is the first balloon REP event with closely conjugate EMIC wave observations, and our study employs the most detailed quantitative analysis on the link of EMIC waves with observed REP to date.

Abstract ID: 33952

Final Number: SPA43A-01

Title: New Multi-Spacecraft Observations of the Earth's Van Allen Radiation Belts

Presenter/First Author: Daniel N. Baker, University of Colorado at Boulder, Boulder, CO

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Co-authors: Shrikanth G Kanekal, NASA Goddard Space Flight Center, Greenbelt, MD

Published Material: Baker, D.N., et al., An inpenetrable barrier to ultrs-relativistic electrons in the Van Allen Radiation Belts, Nature, submitted, 2014.

Abstract Body: The first great scientific discovery of the Space Age was that the Earth is enshrouded in toroids, or "belts", of very high-energy magnetically trapped charged particles. Early observations of the radiation environment clearly indicated that the Van Allen belts could be delineated into an inner zone dominated by high-energy protons and an outer zone dominated by high-energy electrons. Subsequent studies showed that electrons in the energy range 100 keV < E< 1 MeV often populated both the inner and outer zones with a pronounced "slot" region relatively devoid of energetic electrons existing between them. This two-belt structure for the Van Allen moderate-energy electron component was explained as being due to strong interactions of electrons with electromagnetic waves just inside the cold plasma (plasmapause) boundary. The energy distribution, spatial extent and particle species makeup of the Van Allen belts has been subsequently explored by several space missions. However, recent observations by the NASA dual-spacecraft Van Allen Probes mission have revealed wholly unexpected properties of the radiation belts, especially at highly relativistic (E > 2 MeV) and ultra-relativistic (E > 5 MeV) kinetic energies. In this presentation we show using high spatial and temporal resolution data from the Relativistic Electron-Proton Telescope (REPT) experiment on board the Van Allen Probes that multiple belts can exist concurrently and that an exceedingly sharp inner boundary exists for ultra-relativistic electrons. Using additionally available Van Allen Probes data, we demonstrate that these remarkable features of energetic electrons are not due to a physical boundary within Earth's intrinsic magnetic field. Neither is it likely that human-generated electromagnetic transmitter wave fields might produce such effects. Rather, we conclude from these unique measurements that slow natural inward radial diffusion combined with weak, but persistent, wave-particle pitch angle scattering deep inside the Earth's magnetosphere can conspire to create an almost impenetrable barrier through which the most energetic Van Allen belt electrons cannot migrate.

Abstract ID: 35661

Final Number: SPA43A-02

Title: Identifying the Energization and Loss Processes of Relativistic Electrons with Multipoint Observations and Simulations

Presenter/First Author: Mei-Ching Hannah Fok, NASA Goddard Space Flight Center, Greenbelt, MD

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Abstract Body: The relativistic electron populations in the Earth's radiation belts are highly dynamic during geomagnetically active periods. Their variations are controlled by the balance of energization and loss processes. It is a challenge to untangle the relative contributions from different mechanisms. With multipoint measurements and comprehensive radiation-belt models available recently, it becomes possible to identify the responsible processes for the observable changes. In this paper, we study a few relativistic-electron events using particle and field data from the Van Allen Probes, THEMIS and geostationary missions. We will also simulate the events with our Comprehensive Inner Magnetosphere-Ionosphere (CIMI) model. By combining data analysis and simulation methods, we seek to identify the major energization and loss mechanisms of relativistic electrons and determine how their roles change with different solar wind conditions.

Abstract ID: 35476

Final Number: SPA43A-03

Title: Recent Advancements of Understanding of Relativistic Electrons in the Inner Belt

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Published Material: FALL AGU. Some of the results are to be published in JGR (just accepted)

Abstract Body: No instruments in the inner radiation belt are immune from the unforgiving penetration of the highly energetic protons (10s of MeV to GeV). The inner belt proton flux level, however, is relatively stable, thus for any given instrument, the proton contamination often leads to a certain background noise. Measurements from the Relativistic Electron and Proton Telescope integrated little experiment (REPTile) on board Colorado Student Space Weather Experiment (CSSWE) CubeSat, in a low Earth orbit, clearly demonstrate that there exist sub-MeV electrons in the inner belt because of their flux level is orders of magnitude higher than the background, while higher energy electron (>1.6 MeV) measurements cannot be distinguished from the background. Detailed analysis of high-quality measurements from the Relativistic Electron and Proton Telescope (REPT) and Magnetic Electron Ion Spectrometer (MagEIS) on board Van Allen Probes, in a geo-transfer-like orbit, provides, for the first time, detailed measurements of energetic electrons in both inner belt and outer belt, covering a wide energy range, from 10s of keV to multiple MeV. In this presentation, detailed pitch angle distribution of sub-MeV electrons from MagEIS measurements and quantified upper limits on multiple MeV electrons from REPT measurements will be discussed. These upper limits are rather different from flux levels in the AE8 and AE9 models, which were developed based on older data sources. For 1.7, 2.5, and 3.3 MeV electrons, the upper limits are about one order of magnitude lower than predicted model fluxes. The implication of this difference is profound in that unless there are extreme solar wind conditions, such as strong interplanetary shocks and coronal mass ejections, which have not happened yet since the launch of Van Allen Probes, enhancements of MeV electrons do not occur in the inner belt even though such enhancements are commonly seen in the outer belt.

Abstract ID: 34828

Final Number: SPA43A-04

Title: Measuring the Pitch-Angle Scattering of Radiation-Belt Electrons as They Drift Across the Plasmaspheric Drainage Plume

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Published Material: Journal of Geophysical Research 2014

Abstract Body: Using the multisatellite SOPA data set of radiation-belt electrons at geosynchronous orbit, the pitch-angle scattering of radiation-belt electrons in plasmaspheric drainage plumes is investigated. When geomagnetic activity is high a plasmaspheric drainage plume flows in the dayside magnetosphere, crossing geosynchronous orbit post noon local time. Radiation-belt electrons drift from dawn to dusk across the dayside magnetosphere and during high geomagnetic activity they drift through the drainage plume. The locations of the drainage plumes are identified with the MPA plasma instrument onboard the geosynchronous satellites and the anisotropy of the radiation-belt electrons is measured upstream (dawnward) and downstream (duskward) of the drainage-plume crossings. Combining the measurements from 5 spacecraft from 126 drainage-plume crossings, statistical analysis of the reduction in anisotropy of the radiation-belt electrons across the drainage plumes yields estimates for the rate of pitch-angle scattering of the electrons within the plumes. The pitch-angle-diffusion coefficients estimated from the scattering measurements are of the magnitude as expected values for EMIC waves in the plume at high electron energies (1.5 MeV) and as expected values for whistler-mode hiss in the plume at lower electron energies (150 keV).

Abstract ID: 34757

Final Number: SPA43A-05

Title: Precipitation Loss and Nonlinear Acceleration of Broadband Energetic Electrons by Whistler Chorus Waves

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Co-authors: Yoshizumi Miyoshi, Nagoya University, Nagoya, Japan

Abstract Body: The electron radiation belts, especially the outer radiation belt, have intense and rapid variation during geomagnetic storms. Whistler chorus wave is a plausible candidate to explain the flux variation in the heart of the outer belt through wave-particle interactions. While the quasi-linear model has been used to describe the wave-particle interactions so far, it has been proposed that nonlinear properties of whistler chorus elements can influence on the flux variation through the nonlinear scattering process, which cannot be described in the quasi-linear model. This study using test particle simulation code GEMSIS-RBW conducts electron precipitation loss and acceleration with the nonlinear scattering process by whistler chorus elements in the dipole magnetic field model. The simulations show that the broadband energetic electrons can be scattered by whistler chorus elements propagating from the magnetic equator to high magnetic latitudes. We will discuss precipitation flux of electrons in broadband energy range between keV and MeV, and influences of the nonlinear scattering process on the flux variation. The simulation studies would be applied to understand observation data from future mission such as ERG.

Abstract ID: 33997

Final Number: SPA43A-06

Title: Probing the Relationship Between Radiation Belt Electron Precipitation and Electromagnetic Ion Cyclotron (EMIC) Waves

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Published Material: The preliminary findings of this study were shown in a poster at Fall AGU 2014.

Abstract Body: Electromagnetic ion cyclotron (EMIC) waves have been hypothesized to be a primary source of precipitation loss of radiation belt electrons, contributing to the net response and dynamics of the outer radiation belt. Here we present simultaneous, conjugate measurements of EMIC wave activity, measured at GOES and on the ground, and energetic electron precipitation, seen by the 2013 BARREL balloon campaign, on two consecutive days in January 2013. The various overlapping, interacting plasma populations present are examined, as well as solar wind and geomagnetic conditions that contribute to the wave generation and wave-particle interactions. This study examines the temporal and spatial structure of EMIC waves and electron precipitation observed on Jan 18-19 2013 and provides direct evidence for this wave-particle interaction. This event is put in context through comparisons of global EMIC wave distributions to MeV electron precipitation events.

Abstract ID: 34446

Final Number: SPA43A-07

Title: Van Allen Probes, NOAA, and Ground Observations of an Intense Pc 1 Wave Event Extending 12 Hours in MLT and its Resulting Depletion of the Outer Radiation Belt

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Published Material: Preliminary results were presented at the Fall 2014 AGU Meeting.

Abstract Body: Although most studies of the effect of EMIC waves on relativistic electrons have focused on wave events in the afternoon sector in the outer plasmasphere or plume region, strong magnetospheric compressions provide an additional stimulus for EMIC wave generation across a large range of local times and L shells. We present here observations of the effects of an intense, long-duration wave event on February 23, 2014. Waves extending 8 hours in UT and over 12 hours in MLT were stimulated by a gradual 4-hour rise and subsequent sharp increases in solar wind pressure. Large-amplitude linearly polarized hydrogen band EMIC waves (up to 25 nT p-p) appeared for over 4 hours at both Van Allen Probes as they moved near apogee from late morning through local noon, when these spacecraft were outside the plasmapause, in a region with densities ~5-20 cm^{-3}. Wave activity was also observed by ground-based induction magnetometers in Finland, Antarctica, Canada, Russia, and Japan, and briefly by GOES-13 and -15 in the midnight sector. Ten passes of NOAA-POES and METOP satellites near the northern hemisphere footpoint of the Van Allen Probes (over Siberia) showed the presence of 30-80 keV subauroral proton precipitation, often over extended L shell ranges; other passes identified a narrow L-shell region of precipitation over Canada. Observations of relativistic electrons by both Van Allen Probes showed that this wave event preferentially reduced the fluxes of more field-aligned and more energetic radiation belt electrons at both L* = 4.5 and 5.2, confirming the effectiveness of EMIC-induced loss processes, as predicted in recent theoretical studies, for this event.

Abstract ID: 33835

Final Number: SPA43A-08

Title: Comparison of POES and SAMPEX Observations of Radiation Belt Particles Precipitation

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Published Material: AGU fall meeting 2013. More progress has been made since then.

Abstract Body: The phenomenon of Duskside Releativistic Electron Precipitation (DREP) was first proposed by Thorne and Kennel [1971] as scattering of electrons by electromagnetic ion cyclotron (EMIC) waves at the plasmapause boundary on the duskside. Duskside precipitation is known to occur over a broad radial distribution (L = 3–8) and a wide range of magnetic activity levels, from small substorms (Lorentzen et al. 2000) to major Coronal Mass Ejections (CME) driven storms (Kokorowski et al. 2008). Furthermore, it does not strongly correlate with geomagnetic storms, and has slower temporal variations, from minutes to hours (Millan et al., 2002). Comess et al, JGR 2013 analyzed the energy spectrum for such precipitation events from 1992 to 2004 obtained from SAMPEX, a low Earth orbiting satellite, and found they follow an exponentially decreasing distribution. This study re-examines a selection of SAMPEX events with the NOAA-POES satellites, a low altitude, polar orbiting network of spacecraft measuring electrons and protons, which show good conjunctions with SAMPEX on 8th January 2004. Using the SAMPEX e-folding energy and POES Medium Energy Proton and Electron Detector (MEPED 0o) geometric factors obtained through GEANT simulations (Yando et. al., 2011), a model of the expected counts in each POES MEPED channel has been constructed for the events and compared with the observed counts. This work paves the way towards estimating the energy spectrum of precipitation from POES observations, which will allow for detailed observations of precipitation during the post- SAMPEX era.

Abstract ID: 36043

Final Number: SPA44A-0383

Title: Van Allen Probes observations of oxygen cyclotron harmonic waves in the inner magnetosphere

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Published Material: Some of the results were presented at the Fall AGU 2014 mini-GEM

Abstract Body: Waves with frequencies in the vicinity of the oxygen cyclotron frequency and its harmonics are often observed on the Van Allen Probes spacecraft in the inner equatorial magnetosphere during geomagnetically active times. We will present observations of these waves during the main phase of a geomagnetic storm on November 1, 2012. Oxygen cyclotron harmonics were observed simultaneously by fluxgate magnetometers onboard two satellites, at L~3 in the early morning magnetic local time sector, just outside the plasmapause (as monitored by the spacecraft potential). Analysis of the magnetic field data in field aligned coordinate system showed that these harmonic waves are heft-hand polarized and propagating obliquely to the background magnetic field. Observations of associated energetic particle distributions by the HOPE instrument suggest that anisotropic (peaked at 90-degree pitch angles) oxygen distributions with energy ~1-2 keV might have provided the energy source for these waves, however further theoretical analysis is warranted to establish the nature of this wave instability. Since polarization and propagation angle of oxygen cyclotron harmonic waves are very similar to electromagnetic ion cyclotron (EMIC) waves, which are believed to influence ring current and radiation belt dynamics, they may be also important for energetic particle dynamics in the inner magnetosphere.

Abstract ID: 34063

Final Number: SPA44B-0384

Title: A Web-Based HF Near Real Time Tool based on a Neural Network based Bottomside Profile Model for the Ionosphere

Presenter/First Author: Mohamed Osman Yousif, University of New South Wales, Sudan,

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Co-authors: Sami Mohamed Sharif, University of Khartoum, Khartoum, Sudan

Abstract Body: A web-based HF near real time tool based on a neural network based bottomside profile model for the Ionosphere is developed. The model gives near real time calculations for the Maximum Usable Frequency (MUF) and the Optimum Working Frequency (FOT) for distances shorter than 2000 km. The tool is named UKIS and it relies on critical frequencies and virtual heights. In this paper we run UKIS over Sudan using monthly median critical frequencies and virtual heights data from IRI and also we run UKIS over Three Australian cities using both near real time and archived critical frequencies and virtual heights obtained from digisonde stations in order to train the neural networks based ionospheric model. For validation we use SAO-Explorer which is a software developed by University of Massachusetts Lowell Centre of Atmospheric Research (UMLCAR) to get near real time Ionograms from different cities and then we scale MUF from the oblique ionograms between Digisonde stations using SAO-Explorer. Finally a comparison between predicted MUF with measured MUF is presented.

Abstract ID: 35241

Final Number: SPA44B-0385

Title: Plasmaspheric plume analysis during the 2013 Cluster close separation campaign

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Abstract Body: During the last Cluster close separation campaign (July-October 2013), two of the four Cluster satellites were only tens of kilometers apart, while the two others were located at a few hundreds of kilometers. This configuration offers an exceptional opportunity to analyze the plasmasphere with very high space and time resolution around the time of perigee at about 4 R_E. In particular, plasmaspheric plumes were crossed by the satellites on several occasions.
This poster presents such an event on 13 July 2013 with electron density data obtained from the WHISPER instrument onboard Cluster. A plasmapause test particle simulation is used to provide a global view of the plasmasphere and plasmapause. Also, the electron density is inferred inside the plume from EMFISIS/Waves observations taken onboard the two Van Allen Probes spacecraft, which crossed the same plume and provide another view.
The initial formation and global evolution of the plume are studied using the general context and data from the satellites at their respective locations. Density irregularities are observed inside the plume. Some are very stable at only a few kilometers scale, while others persist also at larger scales. Their spatial gradient is studied as well as their motion with the help of multi-spacecraft analysis.

Abstract ID: 35091

Final Number: SPA44B-0386

Title: Relationship between plasmapause obtained from Cluster, solar wind and geomagnetic activity

Presenter: Fabien Darrouzet, Belgian Institute for Space Aeronomy, Brussels,

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First Author Student?: No

Co-authors: Giuli Verbanac, , ,

Published Material: The paper associated to this study is in preparation

Abstract Body: Using Cluster satellite data and especially the observations of the instrument WHISPER from 2007 to 2011, we determined the electron number density along the orbit of the satellites to study the relationships between the plasmapause positions and different solar wind coupling functions and geomagnetic indices. A cross-correlation analysis was performed for three magnetic local time (MLT) sectors and for all MLT taken together. The plasmapause indicators suggest the faster plasmapause response in the post-midnight sector. The time lags are approximately 2-27 hours, always increasing with the MLT sector.
The obtained fits clearly resolve the MLT structures. All studies show that the plasmapause is more earthward during geomagnetically active periods with the plasmapause bulge displaced toward dusk. The variability of the plasmapause is the largest for low values of the indicators.
At low activity levels, the plasmapause position exhibits the largest values on the dayside and smallest in the post-midnight sector.
Displacements towards larger values on the evening side (between 16 and 01 MLT) and lower values on the dayside (between 7 and 16 MLT) are identified for enhanced magnetic activity. Based on the correlation coefficients, we conclude that all studied indicators are capable to well describe the observed plasmapause position. Our results are used to improve our understanding of the physical mechanisms involved in the plasmapause formation.

Abstract ID: 35689

Final Number: SPA44C-0387

Title: Inter-hourly Variability of Total Electron Content during the quietest days over Akure, within the Equatorial Ionospheric Anomaly region

Presenter/First Author: Toyese Tunde Ayorinde, Organization Not Listed, Akure,

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Abstract Body: The Inter-hourly variability of the total electron content (TEC) was examined using a fixed GPS receiver installed at Akure (7.3^{o}N, 5.3^{o}E, dip latitude -2.62^0), based on two years data (Jan 2010-Dec 2011). Akure is a station within the equatorial ionospheric anomaly EIA region. The day to day variability was calculated by converting the observed slant TEC (*STEC*) value into the vertical TEC (*VTEC*) for every 1 hr and the differencing (ΔTEC) with its corresponding value from the previous day. The result showed the mean monthly TEC value varies from the minimum at 0200 hrs LT to a peak at about 1400 hrs LT and then decreases. There is a clear daily variation which depicts the expected temporal variability. The seasonal variation of the day to day variability of TEC over Akure in both years maximize (> 13 TECU) during Equinoctial months and minimizes (< 8 TECU) during the Solstice months. During equinoxes the study shows that the Inter-hourly variability of TEC in autumnal equinox period is high compared to the vernal equinox period. There is a significant relationship between solar activity and the Inter-hourly variability of TEC over Akure in the two years (2010&2011) with a higher level of dependence on solar activity in 2010.

Abstract ID: 35853

Final Number: SPA44C-0388

Title: Science Highlights from the BARREL Antarctic Balloon Campaigns

Presenter/First Author: Robyn M Millan, Dartmouth College, Hanover, NH

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Co-authors: John Glen Sample, University of California Berkeley, Berkeley, CA; Michael McCarthy, University of Washington Seattle Campus, Seattle, WA; David Miles Smith, University of California Santa Cruz, Santa Cruz, CA

Published Material: A similar poster was presented at the Fall 2014 AGU meeting.

Abstract Body: The Balloon Array for Radiation belt Relativistic Electron Losses (BARREL) is an Antarctic balloon investigation designed to study electron loss from Earth's radiation belts. Two BARREL balloon campaigns were carried out from Antarctic Research Stations SANAE IV and Halley VI in January-February 2013 and 2014. During each campaign, 20 small (~20 kg) balloon payloads were launched to an altitude of 38 km to maintain an array of payloads distributed in L-value and magnetic local time. Each balloon carried a NaI scintillator to measure the bremsstrahlung X-rays produced by precipitating relativistic electrons as they collide with neutrals in Earth's atmosphere, and a DC magnetometer to explore the nature of Ultra Low Frequency temporal modulations of precipitation. We present several science highlights from BARREL. Precipitation was observed over a range of energies with temporal and spatial structure at a variety of scales. The combination of BARREL with in situ (e.g. Van Allen Probes, THEMIS) and ground-based (e.g. riometer, VLF) measurements provides a unique opportunity to study wave-particle interactions, and to quantify the spatial scale of energetic precipitation.

Abstract ID: 32987

Final Number: SPA44C-0389

Title: Study of field aligned current (FAC) with D-component (east-west)and interplanetary electric field (Ey) during three different HILDCAA events

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Abstract Body: Field Aligned Currents (FACs) play an important role for the coupling between ionosphere and magnetosphere. This coupling is directly influenced by solar wind and interplanetary magnetic field (IMF). In this work we observe characteristics of FACs during HILDCAAs (High-Intensity, Long duration, Continuous AE activity) by using high resolution OMNI data set consisting of 1-min averaged ACE, Wind, IMP 8 and Geo-tail magnetic field. We also observe the perturbations in the ΔD (east-west) component of the geomagnetic field from the low latitude station (Vassouras) to predicate the field aligned currents. For three different HILDCAA events, the characteristics of FACs and perturbations in the ΔD component observe are quite dissimilar. The wavelet techniques (CWT, DWT and wavelet modulus correlation) and cross-correlation also show different results for each event. The times and frequencies resolution of FAC and ΔD obtained from CWT are different in each event. The nature of square wavelet coefficients obtain from DWT for FAC and ΔD are totally different. Both FAC and ΔD show good wavelet modulus correlation with components of interplanetary magnetic field (By and Bz) at the time of HILDCAA. We also observe the cross-correlation between FAC and ΔD, FAC and Ey and Ey and ΔD. During the non-storm HILDCAA, FAC shows negative correlation with ΔD. But it shows positive correlation for CIR and ICME preceding HILDCCAs. Similary, Ey and FAC also show negative correlation during non-storm HILDCAA but other two events show positive correlation. Finally, Ey and ΔD show positive correlation for all events. Observing these results, it can be suggested that the ground magnetic datasets obtained from low latitude may serve as the proxy for interplanetary conditions in the solar wind.

Abstract ID: 33187

Final Number: SPA44C-0390

Title: DIURNAL AND SEASONAL VARIATIONS OF THE Sq FOCI LATITUDES ALONG AFRICAN MERIDIAN

Presenter/First Author: Owolabi OLADEJO Charles, Federal University of Technology Akure, Iye,

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Co-authors: Babatunde Rabiu, , , ; Olukayode S Oluyo, , ,

Published Material: These findings were reported at African Geophysical Society conference held in Abuja, Nigeria on the 7th of June 2014 and are under review by a scientific Journal-Advances in Space Physics Research-ELSEVIER

Abstract Body: The hourly data of the horizontal component (H) of the geomagnetic field monitored simultaneously at three stations of International Real-time Magnetic Network (INTERMAGNET) and twelve stations of Magnetic Data Acquisition System (MAGDAS) along African Meridian have been used to analyse the latitudinal variation of Sq current foci under the quiet condition in the year 2009 when the solar activity was extremely low (average sunspot number R_Z=3.1). Our results showed that the Sq current foci at both hemispheres exhibit a rise mostly during pre-noon hours and a decline during post-noon hours. The seasonal variation of latitudes of the Sq foci presented intermittent poleward and equatorward shift in both hemispheres. The Sq foci exhibited variability and maximised at local noon of the observatory stations' locality. The Sq foci latitudes on either side are mostly poleward in March equinox. Our correlation analysis results between the foci latitudes show high negative correlation in March and September equinoxes and negatively weak correlation in June solstice. The correlation in December solstice has been found to be positively weak.

Keywords: Solar Quiet Variation Foci, Geomagnetic Field, Ionospheric Current System.

Abstract ID: 33324

Final Number: SPA44C-0391

Title: THE RESPONSE OF THE IONOSPHERE OVER ILORIN TO SOME GEOMAGNETIC STORMS

Presenter/First Author: Benjamin Wisdom Joshua, Kebbi State University of Science and Technology, Aliero,

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Co-authors: Jacob Olusegun Adeniyi, , , ; Bodo W Reinisch, Lowell Digisonde International, Lowell, MA; Isaac Adimula, , , ; Shola Adebiyi, , ,

Published Material: The paper has been published with the Journal of Advances in space research, but has not been presented in any Scientific meeting. the details are as follows: Joshua, B.W., J.O. Adeniyi, I.A. B.W. Reinisch Adimula, O.A. Oladipo, O.A. Olawepo, S.J. Adebiyi, The response of the ionosphere over Ilorin to some geomagnetic storms. Advances in Space Research, 2014 COSPAR. http://dx.doi.org/10.1016/j.asr.2014.08.027. Published by Elsevier Ltd.

Abstract Body: The effects of some geomagnetic storms on the F2 layer peak parameters over Ilorin, Nigeria (Lat. 8:53°N, Long. 4.5°E, dip angle, -2.96°) have been investigated. Our results showed that the highest intensity of the noon bite-out occurred during the March equinox and lowest during the June Solstice on quiet days. Quiet day NmF2 disturbances which appeared as a pre-storm enhancement, but not related to the magnetic storm event that followed were observed at this station. These enhancements were attributed to the modification of the equatorial electric field as a result of injection of the Auroral electric field to the low and equatorial Ionosphere. For disturbed conditions, the morphology of the NmF2 on quiet days is altered. Daytime and nighttime NmF2 and hmF2 enhancements were recorded at this station. Decreases in NmF2 were also observed during the recovery periods, most of which appeared during the post-noon period, except the storm event of May 28-29. On the average, enhancements in NmF2 (i.e. Positive phases) are the prominent features of this station. Observations from this study also indicate that Dst, Ap and Kp which have been the most widely used indices in academic research in describing the behavior of geomagnetic storms, are not sufficient for storm time analysis in the equatorial and low latitude Ionosphere.

Abstract ID: 33650

Final Number: SPA44C-0392

Title: A COMPARATIVE STUDY OF TEC AT LOW AND MIDDLE LATITUDES OF AFRICA DURING DIFFERENT SOLAR ACTIVITY PHASES

Presenter/First Author: Kotoye Afolabi Adegboyega, University of Lagos, Yaba,

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Co-authors: Bolaji Oluwasegun, , , ; Oyeyemi O Elijah, , , ; Abe O E, , ,

Abstract Body: The total electron content (TEC) variability for three levels of solar activities; high solar active period (HSP; year 2000), moderate solar active period (MSP; year 2004) and low solar active period (LSP; year 2008) over middle and low latitudes of Africa were investigated. We have studied the day-to-day, monthly mean, seasonal relative standard deviation (SVR) and yearly mean changes. As expected, for the middle (Sutherland) and low (Libreville) latitudes, TEC variability was observed to be highest during HSP and higher in MSP compared to LSP. Comparing TEC variability between Sutherland and Libreville in each phase, the TEC magnitudes in each phase of the solar levels is always higher in Libreville compared to Sutherland during daytime hours. The range in magnitude of TEC during HSP at Libreville is ~ 50TECU-130 TECU and at Sutherland, it ranges between ~ 20 TECU and ~ 80 TECU. For MSP, the range was between ~ 35 TECU and ~ 80 TECU and between ~ 10 TECU and ~ 40 TECU at Libreville and Sutherland, respectively. In year 2008, the TEC magnitudes variability observed at Libreville is higher (~38 - ~59 TECU) compared to that of Sutherland (~20 - ~1TECU). Although, it is expected that SVR generally decreases when solar activity increases especially at nighttime. Interestingly, our results show that at different phases of solar activities on all seasons and hours, the SVR magnitudes at Sutherland were ~ halved of magnitudes observed at Libreville. Apart from photo-ionization that influences their magnitudes at different levels, their location played significant role regarding additional magnitudes of TEC. We therefore suggest stronger equatorial low latitude anomaly associated with the photo-ionization as the primary mechanism that initiated these higher magnitudes of TEC at Libreville. This is possible, since Libreville is situated along the highly variable equatorial anomaly crests of Africa and Sutherland is found where the anomaly is absent. The yearly mean changes on HSP, MSP and LSP at Libreville and Sutherland are also investigated and possible mechanisms responsible for their variability were discussed.

Abstract ID: 33669

Final Number: SPA44C-0393

Title: Spatial Variations of GPS-Measured Total Electron Content over Nigeria

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Published Material: The presentation was reported during 2014 African Geophysical Society Conference held in Abuja, Nigeria between June 2nd to 6th. *It was Organized by National Space Research* and *Development Agency, Abuja*. The paper is currently under review.

Abstract Body: This paper examined the spatial variations of the ionospheric Total Electron Content (TEC) over Nigeria using the GPS data obtained from Nigeria Network Observation Stations (NIGNET) in the year 2012. GPS data for year 2012 recorded at various stations in Nigeria ranging from geographic latitude 4.80°N to 12.47°N and geographic longitude 3.40°E to 12.50°E was used for this study. Analysis of spatial variations of TEC, which features Sunrise, 12 noon, Sunset and daily maximum variations of TEC, were performed within the period under consideration and the result engaged to generate local TEC maps. At 07:00 LT, due to the relative position of the sun as the sun rises, TEC decreases westwards across all the latitudes and it is found to be weakest at this time because the intensity of solar radiation is quite low. Greater magnitude of TEC was observed at 12:00 LT while it decays gradually and smoothly at 17:00 LT through the midnight until pre-sunrise hours and it is evident that the magnitude of TEC post-sunset variation is always greater than its pre-sunrise variation. Also, TEC decreases eastward across all latitudes as a result of reduction in the ionization at the east due to the relative position of the Sun as it sets around 17:00 LT.

Abstract ID: 33705

Final Number: SPA44C-0394

Title: Investigating Changes in Field Aligned Current Maps for Changing Solar Radiative Indices

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Co-authors: Daniel R Weimer, Virginia Tech, Blacksburg, VA

Abstract Body: Further developments have been made in the understanding of the interaction between solar wind and the interplanetary magnetic fields in the polar regions of the Earth's magnetic field. Previously, measurements using the Oersted satellite were used to develop field-aligned current (FAC) distribution mappings, and measurements from the ACE satellite was used to provide IMF data to study the changes of the FAC mappings during different solar wind conditions.

Magnetometer measurements from the CHAMP satellite have been used to develop maps for field aligned currents (FAC) based on previously developed techniques. This additional data from the CHAMP satellite has been used to provide further detail to this procedure and to study the effects of solar radiation on the auroral regions of the Earth's magnetosphere and ionosphere. These maps are then compared with four solar indices, F_10.7, S_10, M_10, and Y_10, to study the effects of solar radiation on the FACs. Initial investigation suggest that during equinox conditions the FAC tends to increase with solar radiation as expected, however winter and summer conditions do not completely agree with expected results.

Abstract ID: 34735

Final Number: SPA44C-0395

Title: Investigations on the Variations of Space Weather and Correlation Analysis with the GOCE Gradiometer Measurements

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Abstract Body: It is known that extreme variations in space weather and corresponding geomagnetic storms can affect satellite communication systems, disrupt electrical systems, damage hardware onboard the satellites and most importantly disturb the satellite measurements in an unusual way. In this study, we investigate the unexpected disturbances present in GOCE (Gravity Field and Steady-State Ocean Circulation Explorer) mission derived gravity gradients along the satellite track over the magnetic poles and its possible correlation with the magnetic storms occurred within the same time period. The interplanetary magnetic field and plasma flow velocity along with electric field data observed by the solar satellites ACE (Advanced Composition Explorer) and WIND are obtained from OMNI Website. Moreover, magnetic activity observations collected at CARISMA (Canadian Array for Real-time Investigations of Magnetic Activity) stations are included in our investigations for the comparison purposes. It is found that the CARISMA data are capable of monitoring the magnetic activity variations and agree well with the ACE and WIND observed datasets and can be useful for correcting GOCE mission gradiometer measurements due to their high resolution. By using these external and independent data we aim to understand the correlation between the disturbances observed in the GOCE gravity gradients and solar activity and eventually eliminate these effects from the gradiometer measurements.

TECTONOPHYSICS

Abstract ID: 34107

Final Number: T11A-01

Title: Partial melting, orogeny and crustal differentiation

Presenter/First Author: Olivier Vanderhaeghe, GET Géosciences Environnement Toulouse, Toulouse,

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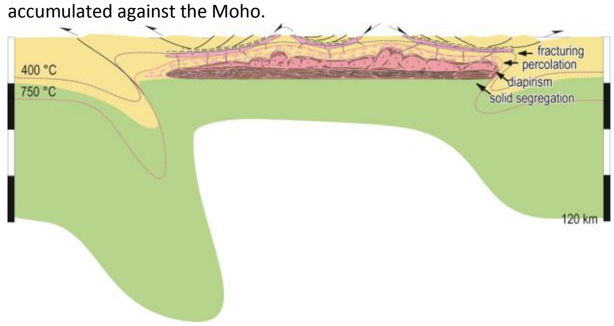
Published Material: The presented research is a synthesis of previously published papers (Vanderhaeghe & Teyssier, Tectonophysics, 2001; Vanderhaeghe et al., Journal of Geodynamics, 2003; Vanderhaeghe, Tectonophysics, 2009; Vanderhaeghe, Journal of Geodynamics, 2012) augmented with ongoing work.

Abstract Body: Partial melting of the crust plays a key role during orogenic evolution and leads to crustal differentiation as it impacts rheology and allows for melt/solid segregation and thus for magma transfer. These processes are controlled by (i) the dynamic balance among forces arising from plate-tectonic, gravitational potential energy, and buoyancy, (ii) the thermal balance between deformation-induced and radioactive heat production and heat advection related to subduction, orogenic deformation, and magma transfer. The strength decrease associated with partial melting leads to strain partitioning expressed by channel flow driven either by forces related to plate tectonics and/or buoyancy (vertical extrusion) or by the gravity force associated with lateral variations of crustal thicknesses (horizontal channel flow). Structural characteristics of migmatites point to the role of deformation in melt migration, but the emplacement of laccoliths of leucogranites above migmatitic terranes attests to the efficiency of the buoyancy force. The transition from partially-molten rocks to magmas is marked by another strength decrease allowing for settling of floating/sinking solids and favoring the development of gravitational instabilities (domal flow) evidenced by domes cored by diatexites (former heterogeneous magmas) mantled by metatexites (former partially-molten rocks). Melt/solid segregation and magma mobility during orogeny leads to the development of a crustal-scale horizontal layering. The middle crust is dominated by migmatites with domes cored by diatexites and mantled by metatexites that correspond to a partially-molten and magmatic zone, respectively. The granitic dikes and sills and the associated laccoliths of leucogranites correspond to an intrusive zone overlying the partially-molten zone. The refractory lower crust comprises residual and non-fertile material segregated and from the overlying heterogeneous magmas and partly accumulated against the Moho.



Abstract ID: 36531

Final Number: T11A-02

Title: What controls the geometry of large collisional orogens: insights from numerical modelling

Presenter/First Author: Katharina Vogt, Utrecht University, Utrecht,

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Co-authors: Liviu-Ciprian Matenco, Utrecht University, Utrecht, 3584, Netherlands; Taras Gerya, ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland; Sierd Cloetingh, Utrecht University, Utrecht, 3584, Netherlands

Published Material: These findings have been partly reported at the AGU 2014 Fall Meeting in San Francisco. These findings are not under review and have not been published by a scientific journal

Abstract Body: When continents collide mountain ranges with high topographies and complex geometries are formed. Compressional stresses during ongoing convergence result in crustal thickening, localized deformation, and material transport. Thus, crustal material is transported and redistributed within the orogen.

We use numerical thermo-mechanical models to investigate the physical processes of continent collision zones and its implications on crustal scale deformation and architecture. We demonstrate that compression of two continental blocks, separated by a rheologically weak suture zone can result in (i) double-vergent or (ii) single-vergent orogens, with distinct geometries, deformation and exhumation patterns. The transition between these different modes of collision is controlled by the rheology of the continental lithosphere and its temperature. Coupled crustal layers form double vergent orogens, while decoupled crustal layers result in single-vergent orogens.

Double vergent orogens are formed in response to the gradual accretion of crustal material along pro- and retro-shears (fore- and back-thrust). In these models, deformation is highly localized on the retro-side, where large off-sets are recorded. At Moho depth, the progressive decoupling of crustal material from the mantle lithosphere, leads to subduction of mantle lithosphere and accumulation of lower crust material at the plate interface. Typical examples include the collision recorded by the Swiss Alps and the Pyrenees.

In contrast, single-vergent orogens are characterized by large-scale lower plate deformation and are accompanied by the subduction of lower continental crust. In this situation, no significant retro-shear formation is observed, which is in agreement with recent physical modelling studies on deformation of the continental lithosphere. The resulting orogen is highly asymmetric and almost exclusively oriented towards the foreland. Natural examples of such single vergent orogens are common in the Mediterranean (Carpathians, Dinarides, Apennines, Betics) or the SE Asia subduction zones.

We conclude that deformation and exhumation in continent-continent collision zones may occur in foreland or hinterland settings, depending on the rheological structure of the continental lithosphere.

Abstract ID: 33393

Final Number: T11A-04

Title: Thermal Evolution of the Pamir Deep Crust Constrained using Lu-Hf and U-Pb Geochronology, and Garnet Thermometry

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Published Material: Smit, M.A., Ratschbacher, L., Kooijman, E., and Stearns, M.A., 2014, Early evolution of the Pamir deep crust from Lu-Hf and U-Pb geochronology and garnet thermometry, Geology, v. 42(12), 1047-1050.

Abstract Body: The large hot orogen exposed in the Pamir-Karakorum-Himalaya is a focal point of research into the links between active plate dynamics, magmatism, and tectonics. Extensive research accomplishment during the past three decades has allowed detailed reconstruction of Miocene exhumation, uplift and magmatism. Earlier orogenic processes, however, are still largely obscured, owing to an apparent scarcity of well-preserved assemblages and the general difficulty in resolving prograde histories from these. Recent research efforts demonstrated the widespread occurrence of Cenozoic deep-crustal rocks in the Pamir plateau. In this study, we investigated the timing and cause of prograde metamorphism of these rocks using Lu-Hf geochronology, U-Pb rutile thermochronology, and garnet thermometry. Regional prograde metamorphism and heating to 750-830 °C, as constrained by Zr-in-rutile and diffusion thermometry, occurred between 37-27 Ma. Prograde growth of garnet first occurred in the South Pamir at c. 37 Ma and spread to the Central Pamir during the following 10 Myr. By c. 27 Ma, the deep crust had heated beyond c. 750 °C and was partially molten on a regional scale. We attribute this thermal evolution to enhanced mantle heat flow following the c. 45-Ma slab break-off of Indian lithosphere underneath the Pamir. The history uncovered here confirms a long-lived thermal history of the Pamir deep crust and advocates a causal link between break-off, enhanced mantle heat flow, and heating of the deep crust along margins of large hot orogens.

Abstract ID: 35784

Final Number: T11A-05

Title: Crustal Structure Variation Across the Western Himalayas and Tibet

Presenter/First Author: Amy Gilligan, University of Cambridge, Cambridge,

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Co-authors: Keith F Priestley, University of Cambridge, Cambridge, United Kingdom; Steven W Roecker, Rensselaer Polytechnic Inst, Troy, NY; Vadim L Levin, Rutgers University, Piscataway, NJ; Shyam Sundar Rai, National Geophys Res Instt, Hyderabad, India

Published Material: Some of this work was presented at the AGU Fall meeting 2014 and a paper has just been submitted to JGR (awaiting reviewer asignment)

Abstract Body: We present new, high resolution, shear velocity models for the western Himalayas and West Tibet from the joint inversion of P receiver functions recorded using seismic stations from four arrays in this region and fundamental mode Rayleigh wave group velocity maps from 5-70s covering Central and Southern Asia. The Tibetan Plateau is a key locality in understanding large-scale continental dynamics. A large number of investigations has examined the structure and processes in eastern Tibet, however western Tibet remains relatively understudied. Previous studies in this region indicate that the western part of the Tibetan Plateau is not a simple extension of the eastern part. The areas covered by these arrays include the Karakoram and Altan-Tagh faults, and major terrane boundaries in West Tibet and the Himalayas.

We use the shear wave velocity models to obtain estimates of Moho depth. The Moho is deep (68-84km) throughout West Tibet. We do not observe significant steps within the Moho beneath West Tibet. A large step in Moho depth is observed at the Altyn-Tagh fault, where Moho depths are 20-30km shallower to the north of the fault compared to those to the south. Beneath the Lhasa Terrane and Tethyan Himalayas we observe a low velocity zone in the mid-crust. This feature is not interrupted by the Karakoram Fault, suggesting that the Karakoram Fault does not cut through the entire crust.

Abstract ID: 33713

Final Number: T11A-06

Title: Syn-Compression Normal-Sense Low-Angle Detachment in the Himalayan Foreland, Western Nepal: Implications for Orogenic Models

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Co-authors: Laurent Godin, Queen's University, Kingston, ON, Canada; John M Cottle, University of California Santa Barbara, Santa Barbara, CA

Published Material: Results were partially presented in: Soucy La Roche, R., Godin, L., and Braden, Z., 2014, Recognition of the South Tibetan detachment in the Karnali klippe, western Nepal: Implications for emplacement of Himalayan external crystalline nappes, in Montomoli C. et al., eds., proceedings for the 29th Himalaya-Karakoram-Tibet Workshop, Lucca, Italy, p. 155.

Abstract Body: The Himalayan metamorphic core, exposed between two opposite sense shear zones, is locally preserved in a series of foreland klippen. The upper shear zone, the South Tibetan Detachment (STD), is a key element in many competing tectonic models. One of these, the tectonic wedging model, requires that the STD merges with the reverse-sense basal shear zone towards the foreland. The Karnali klippe in western Nepal is a doubly-plunging synform underlain by a ca. 2 km thick folded reverse-sense shear zone. It comprises amphibolite metamorphic facies rocks overlain by greenschist to subgreenschist facies sedimentary rocks. Based on quartz recrystallization textures and crystallographic preferred orientations, the metamorphic units record both coaxial and reverse-sense non-coaxial strain at temperature increasing structurally upward from 550-600°C just above the basal thrust to ca. 750 °C in the middle and upper levels. In contrast, a ca. 1 km thick low-angle normal-sense shear zone, correlated with the STD, separates the metamorphic rocks in the footwall from low grade sedimentary rocks in the hanging wall on both flanks of the klippe. Temperature of deformation decreases abruptly to 580 °C and to 475 °C in the lower and upper part of the STD, respectively. Calcite twin types suggest that sedimentary units of the hanging wall were deformed at temperatures of 150-200 °C. In situ U-Th/Pb geochronology on monazite, combined with chemical characterization, suggests that prograde metamorphism occurred between 36 and 30 Ma in the immediate footwall of STD, followed by tectonic exhumation from 28 to <24 Ma, possibly starting as early as 30 Ma. Transport-parallel exposure of the STD in this area implies a minimum slip of 145 km. The presence of the STD on both flanks of the Karnali klippe contradicts previous interpretations that it merges at depth with the basal shear zone, thus weakening the argument for tectonic wedging in western Nepal.

Abstract ID: 36410

Final Number: T11A-07

Title: Crustal evolution of ca. 1.9-1.85 Ga collisional orogen associated with the massif-type anorthosite in the Yeongnam Massif, Korea

Presenter/First Author: Moonsup Cho, Seoul National University, Seoul,

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Co-authors: Yuyoung Lee, , Seoul, South Korea; Wonseok Cheong, , , ; Keewook Yi, Korea Basic Science Institute, Ochang, Chungbuk, South Korea

Published Material: Results were partially presented in Lee et al. (2014, *Terra Nova*, 26, 408–416).

Abstract Body: The North China Craton (NCC) including the Korean Peninsula has experienced episodic amalgamation and intracrustal reworking since its formation in the Archean. The Yeongnam Massif, Korea, situated at the eastern margin of the NCC, records prolonged crustal evolution characterized by an arc-related magmatism at ca. 2.0-1.9 Ga and subsequent collisional event at ca. 1.9-1.87 Ga, followed by a massif-type anorthositic magmatism at 1.86 Ga. An extensive occurrence of migmatites is well documented throughout this massif, but their temporal relationship and tectonic setting are poorly constrained. Zircon and baddeleyite grains separated from the anorthositic rocks were dated using a sensitive high-resolution ion microprobe (SHRIMP)[1]. The weighted mean $^{207}Pb/^{206}Pb$ age of zircon from two anorthosites is 1862 ± 2 Ma, corroborated by the baddeleyite age of 1861 ± 14 Ma. On the other hand, the ages of hornblende gabbro and granitic gneiss are 1873 ± 4 Ma and 1875 ± 5 Ma, respectively. In contrast, zircon rims from mafic granulite and migmatitic gneiss yielded ages of 1860 ± 5 Ma and 1858 ± 4 Ma, respectively, implying that the granulite-facies metamorphism and anatexis are associated with the anorthosite emplacement. Our preliminary P–T–t analyses based on pseudosections and microstructures of garnet–sillimanite–cordierite–K-feldspar–plagioclase–ilmenite–melt-bearing aluminous migmatites suggest a peak metamorphic condition at 800–850 °C and 4–7 kbar, followed by a near-isobaric cooling with melt crystallization in the range of 700–750 °C and 4–6 kbar. These results together with available Re-Os data are compatible with ca. 1.9–1.85 Ga collisional orogeny prevalent in the NCC, and suggest that orogenesis was accompanied by the mantle delamination beneath the craton. Taken together, we suggest that the Yeongnam Massif has experienced a prolonged orogeny characterized by late-orogenic anorthositic magmatism.

[1] Lee et al. (2014) *Terra Nova*, 26, 408–416.

Abstract ID: 34118

Final Number: T12A-01

Title: A 1 Ga Eclogite-bearing Hot Migmatitic Nappe in the Sveconorwegian Orogen – a Window into Depth beneath the Frontal Part of a Precambrian Himalayan-Tibetan-type Plateau

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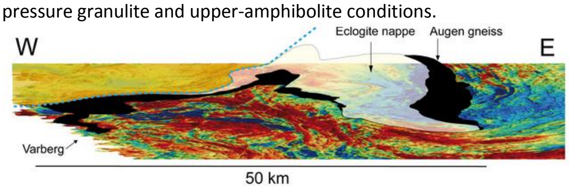
Co-authors: Jenny Andersson, Geological Survey of Sweden, Uppsala, Sweden

Published Material: Möller, C., Andersson, J., Dyck, B., Antal Lundin, I. 2014: Exhumation of an eclogite terrane as a hot migmatitic nappe,Sveconorwegian orogen, in: Castelli, D., Godard, G., Hirajama, T., Medaris, G. (Eds.), High- and ultrahigh-pressure metamorphism, from microscopic to orogenic scale. Lithos (Special Issue). DOI 10.1016/j.lithos.2014.12.013

Abstract Body: The Eastern Segment of the Sveconorwegian orogen exposes a formerly deeply (35-40 km) buried section of continental crust, corresponding to a setting beneath an orogenic plateau. A 75 x 50 km large eclogite-bearing nappe proves deeper burial (>55 km) of parts of the same crustal block. The eclogite-bearing nappe was exhumed by tectonic extrusion, melt-weakening assisted and foreland-directed translation of eclogitized crust, and stalled at 35–40 km depth within the collisional belt.

The Eastern Segment is semi-continuous with the continental foreland in the east (Baltica) but tectonically bound by a major crustal shear zone, the “Mylonite Zone”, at the contact to the Idefjorden Terrane in the west. Different lines of evidence indicate that this boundary is a deep collisional suture, where the Eastern Segment was down-thrusted “India-style” beneath the frontal part of a Himalayan-Tibetan-type plateau: 1) the eclogite-bearing nappe is located at the boundary; 2) the Eastern Segment and the Idefjorden Terrane both experienced metamorphism ≤ 0.98 Ga, but share neither pre-Sveconorwegian 1.7-1.1 Ga nor Sveconorwegian 1.05-0.99 Ga igneous and tectonic evolutions.

The eclogite-bearing nappe in the Eastern Segment demonstrates that extrusion of melt-weakened crust is a viable exhumation mechanism within hot and deep collision zones. The eclogites are structurally restricted to a regional recumbent fold in which stromatic orthogneiss with pods of amphibolitized eclogite make up the core. High-temperature mylonitic gneiss with remnants of kyanite eclogite compose a basal shear zone, <4 km wide. Heterogeneously sheared and partly migmatized augen gneiss forms a tectonostratigraphic marker in front of and beneath the nappe, and is in turn structurally enveloped by a composite sequence of orthogneisses and metabasites. The entire tectonostratigraphic pile underwent near-pervasive deformation and recrystallization under high-pressure granulite and upper-amphibolite conditions.



Abstract ID: 34953

Final Number: T12A-03

Title: Orogenic wedge or channel flow for the tectonic evolution of Parautochthonous Belt? New evidence from the Central Grenville Province

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Co-authors: Felix Gervais, École Polytechnique, Montreal, QC, Canada; Abdelali Moukhsil, Ministère de l'Énergie et des Ressources naturelles du Québec, Val D'Or, QC, Canada; James L Crowley, Boise State University, Boise, ID; Lars Eivind Augland, , ,

Published Material: Some part of this presentation where reported in Québec Mines meeting in 2012 and 2013. And some are reported in a MERN report (Minsitère de l'Energie et de Ressources Naturelles) and are under review.

Abstract Body: The tectonic evolution of the Parautochthonous Belt is controversial. An orogenic wedge model was proposed based on detailed fieldwork conducted in the eastern Grenville Province, whereas synconvergent and postconvergent heterogeneous channel flow modes were based largely on geometrical similarities between observed crustal structures and prediction from numerical models. This study presents new field-based structural and geochronological data from the southwestern part of Manicouagan reservoir (Central Grenville Province) that provides important constraints on these hypotheses.

In the Parautochthonous Belt, three deformation phases have been mapped. D_2 structures were developed by oblique-reverse, top-to-the-NNE shearing. Pre- to syn- D_2 axial-planar leucosomes yielded a weighted mean average $^{206}Pb/^{207}Pb$ age of 992 ±22Ma (LA-ICPMS on zircons) and, one analysis gives a concordia $^{206}Pb/^{238}U$ age of 986 ±4Ma (TIMS). A cross-cutting D_2 gabbro, co-magmatic with a pegmatite, has a D_2 lineation defined by retrograde hornblendes. This late D_2 pegmatite gives a weighted average $^{206}Pb/^{207}Pb$ age of 961 ±22Ma (LA-ICPMS on zircons). D_3 structures have been found locally at upper structural levels of the belt and were formed by oblique-normal, down-to-the-SW shearing. Syn-D_3 leucosome yielded a concordia $^{206}Pb/^{238}U$ age of 993 ±3Ma (TIMS on zircons). In the Allochthonous Belt, two deformation phases have been mapped. The main transposition fabric was developed by reverse, top-to-the-NNW shearing associated with the 1080-1030 Ma granulite-facies metamorphism of this belt, whereas the second deformation is the newly-identified Thachic shear-zone (TSZ) developed by oblique-normal, down-to-the-SSE or E shearing. Pegmatitic dykes cross-cutting TSZ but having normal kinematic indicators and a TSZ lineation, yielded a Concordia $^{206}Pb/^{238}U$ age of 988 ±3Ma (TIMS on zircons).

Normal-sense shearing at the upper structural level of the Parautochthonous Belt and along the TSZ, was, therefore, synchronous within error with D_2 reverse deformation in the structurally underlying Parautochthonous Belt. These characteristics imply extrusive ductile flow and are thus compatible with a form of channel flow rather than an orogenic wedge.

Abstract ID: 35180

Final Number: T12A-04

Title: Syn-orogenic High Fe-Ti Tholeiitic Magmatism in the Hinterland of Central Grenville Province: Implications for the Evolution of Large Hot Long Duration Orogens.

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Co-authors: Aphrodite Daphnee Indares, Memorial University of Newfoundland, St Johns, NL, Canada; Greg Dunning, Memorial University of Newfoundland, St John's, NF, Canada

Abstract Body: Late syn-orogenic (~1000 Ma) tholeiitic (high Fe-Ti) mafic rocks with granulite-facies assemblages and textures are documented for the first time in the hinterland of the central Grenville Province (Manicouagan area) where they form concordant or slightly discordant layers interleaved with felsic and mafic gneisses. Geochemically they are characterized by high FeO_t, TiO_2, P_2O_5 and HFSE ratios and low SiO_2, MgO, #Mg, Ni and Cr. Based on petrography, geochemistry and age they can be separated into two groups. The older group consists of granoblastic hornblende+ plagioclase+ clinopyroxene+ garnet+ ilmenite± orthopyroxene, and is characterized by $(La/Yb)_n$= 2.3-3.3, $(Nb/Th)_n$= 0.6-1.3, $eNd_{(1.0)}$= 1.5-2.8 and T_{DM1} = 1487-1523 Ma. One sample yielded a crystallization age of 1006±4 Ma and a metamorphic age of 1005.5±2.7 Ma (zircon U-Pb by CA-TIMS). The younger group consists of porphyroblastic garnet+ plagioclase+ orthopyroxene+ biotite+ ilmenite, large partially resorbed quartz grains, and minor K-feldspar, allanite, barite, thorite, monazite and apatite. A sample from this group has $(La/Yb)_n$= 5.3, $(Nb/Th)_n$= 2.4, $eNd_{(1.0)}$= 4.6 and T_{DM1} = 1131 Ma, and yielded a crystallization age of 997±2.6 Ma.

All samples plot in the within-plate or ocean floor basalt fields in tectonic discrimination diagrams, and the geochemical and isotopic characters of both groups indicate partial melting of a mantle source followed by fractional crystallization or assimilation-fractional crystallization along tholeiitic trend. The textural and age data suggest the rocks underwent medium-*P* granulite-facies metamorphism shortly after their emplacement. This record of late syn-orogenic magmatism and high-*T* metamorphism is compatible with delamination or convective thinning of the overthickened lithosphere beneath a large hot orogen (LHO) formed during the Ottawan phase of Grenvillian orogeny, followed by decompression melting of the rising asthenosphere and conductive heating of the thinned crust from below.

Abstract ID: 35426

Final Number: T12A-05

Title: Metamorphic Patterns of Aluminous Rocks from High and Mid-pressure Crustal Segments of the Central Grenville Province- a Review

Presenter/First Author: Aphrodite Daphnee Indares, Memorial University of Newfoundland, St Johns, NL

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Co-authors: Greg Dunning, Memorial University of Newfoundland, St John's, NF, Canada

Published Material: This is a review paper that summarizes work done ande published between 2005 and 1014

Abstract Body: Anatectic aluminous rocks in the Manicouagan area (central Grenville province) provide a record of partial melting, P–T evolution and the timing of metamorphism in granulite-facies crustal segments that were metamorphosed at different times and/or different depths during the Grenvillian orogeny: the southern part of the Parautochthonous belt (SPB), and the high-P and mid-P portions of the hinterland (HPH and MPH respectively).

In all segments the aluminous rocks consist of the assemblage garnet , ± biotite ± plagioclase, K-feldspar, and kyanite (in the HPH and in most of the SPB) or sillimanite (in the MPH), with textures suggestive of anatexis by breakdown of micas. The preservation of peak assemblages is consistent with melt migration, but widespread textural evidence of former melt at the sample scale suggests that a melt fraction was retained in most rocks at all levels. Textures and mineral chemistry, in conjunction with phase equilbria modeling, suggest that the rocks in the different segments followed contrasting P–T paths, with: (a) steep dP/dT gradients in the kyanite stability field, up to ~16 kbar and 850–900^{o}C in the HPH; (b) moderate dP/dT gradients limited between the ky-sil transition and the crd-in boundary with a peak at 9–11 kbar and 820–860^{o}C in the MPH; and (c) moderate dP/dT gradients in the kyanite field with a peak at 12–14 kbar and 800–850^{o}C in the SPB. In both the HPH and the SPB, the anatectic melt crystallized in the kyanite field. Monazite U-Pb data indicate that the granulite-facies metamorphism occurred during the Ottawan phase of the Grenvillian orogeny in the HPH (1.05–1.03 Ga) and the MPH (1.08–1.05 Ga; down to 1.02 Ga), and during the Rigolet phase (0.98–0.97 Ga) in the SPB. In addition, ages of 1.0–0. 98 Ga were also recorded by a texturally distinct generation of monazite rims in the SPB, and these ages are coeval with widespread ultrapotassic magmatism in the same crustal segment.

Abstract ID: 34471

Final Number: T12A-06

Title: The Supracrustal Rocks of the Escoumins Area: a Well-Preserved Pinwarian Arc-Backarc Sequence in the Central Grenville, Quebec.

Presenter/First Author: Pierre-Arthur Groulier, Memorial University of Newfoundland, St John's,

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Co-authors: Aphrodite Daphnee Indares, Memorial University of Newfoundland, St Johns, NL, Canada; Abdelali Moukhsil, Ministère de l'Énergie et des Ressources naturelles du Québec, Val D'Or, QC, Canada; Greg Dunning, Memorial University of Newfoundland, St John's, NF, Canada; Stephen J Piercey, Memorial University, St. John''S, Canada

Published Material: During the Quebec Mines congress in last november (2014).

Abstract Body: Well-preserved amphibolite-facies supracrustal rocks (Saint-Siméon Group) with primary textures is discontinuously exposed for over 100 km in the Escoumins-Petit Saguenay area of the central Grenville Province, and consists of metasedimentary (quartzite, meta-arkose, conglomerate, calc-silicate, greywacke, paragneiss and scarce marble) and metavolcanic rocks (mainly mafic to intermediate with few felsic). The latter are interpreted to represent flows and volcaniclastic deposits (hyaloclastite, breccia and different varieties of tuff) interbedded with sedimentary rocks, and suggests the Saint-Siméon Group is a volcano-sedimentary belt. The supracrustal rocks are located in synforms separated by antiforms of migmatite and orthogneiss with calc-alkaline continental arc signature (Tadoussac Group) in an overall domes and basins geometry. The geochemistry of the volcanic rocks from the Saint-Siméon Group range from those with E-type MORB-like REE patterns with negative Nb-Ta anomalies and enrichment in Th typical of back-arc basin basalts to those with more evolved arc signature and fractionation of LREE from HREE. A bomb-bearing dacitic tuff yielded a TIMS U-Pb zircon crystallisation age of 1493 ±3 Ma (Pinwarian) with a 1000 ±3 Ma metamorphic overgrowth. U-Pb analysis on titanite gave a similar age of 1000 Ma with a second cluster at 985 Ma. All metamorphic ages correspond to the Rigolet phase of the Grenvillian orogeny. These preliminary data add new insight on the makeup of the SE Laurentian margin and indicate the presence of a significant Pinwarian arc-back arc sequence in the southcentral Grenville Province.

Abstract ID: 33352

Final Number: T13A-01

Title: Muskoka Domain as a First-Order Detachment Zone during Exhumation and Orogenic Collapse: Support for a Core Complex Model for the Central Gneiss Belt, Western Grenville Province

Presenter/First Author: Toby Rivers, Memorial University of Newfoundland, St John's, NF

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Co-authors: Walfried Martin Schwerdtner, University of Toronto, Toronto, ON, Canada

Published Material: Paper is an overview. A small component of the information was reported by Schwerdtner et al (2014) in CJES. Other aspects were reported in a Field Trip Guide for Friends of the Grenville (FOG) in October 2014. This field trip guide has not been widely circulated. The overall message of the abstract has not been reported elsewhere.

Abstract Body: The Central Gneiss Belt (CGB) in the western Grenville Province of Ontario and Quebec is a large high-grade gneiss terrane with a surface area of >60,000 km^2. It consists of a crustal-scale stack of thrust sheets assembled during the Ottawan phase of the Grenvillian orogeny at ~1080 Ma, and is juxtaposed on its southeastern side against the lower grade Composite Arc Belt (CAB). Our work has focussed on the southern margin of the CGB (Ontario segment), where the granulite-facies rocks of the CGB (Algonquin domain) are separated from the CAB by a several km-thick, predominantly upper amphibolite-facies sheet known as the Muskoka domain.

On the basis of local, but widespread relict granulite-facies mineralogy and decompression textures, we infer that peak Ottawan metamorphic conditions in the Muskoka domain were comparable to those in the underlying Algonquin domain, and that the main amphibolite-facies mineralogy and high-strain planar gneissic fabrics characteristic of the Muskoka domain developed *after* the metamorphic peak during exhumation and retrogression. Post-peak exhumation and retrogression in the Muskoka domain began at ~1060 Ma while the rocks were still hot, and was associated with important ductile crustal thinning, orogen-perpendicular extension, transtensional folding and boudinage on all scales. Related fluid influx promoted widespread migmatization, which caused rheological weakening, with the result that the Muskoka domain became a mobile zone akin to a ductile glide horizon between two more competent units.

Collectively this evidence supports a core complex model for the exhumation of the CGB, in which the Muskoka domain formed a weak extensional detachment zone as the underlying hot granulite-facies mid crust rose into the thinned neck regions of the boudinaged overlying cooler amphibolite-facies upper crust during prolonged extensional collapse.

Abstract ID: 34403

Final Number: T13A-02

Title: Paleomagnetism: a Potential Avenue for Mapping the Allochthon Boundary Thrust and for Understanding the Development of the Grenville Orogen.

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Co-authors: Alan Lovette, University of Toronto, Toronto, ON, Canada

Abstract Body: Paleomagnetic data are presented for the ~2.47 Ga River Valley anorthosite (**RV**) and for 1.23 Ga Sudbury dykes **(SD)** which lie in the Grenville Province (GP) between the Grenville Front (GF) and the Allochthon Boundary Thrust (ABT). Both rock types yield high H_c/T_{ub} remanences with shallow down to the ESE directions. Their age is no more than ~ 980 Ma based on Ar-Ar plateaux on hornblende from the anorthosite. S of the ABT Dunlop & co-workers find multi-component remanences but one (**A**) with the highest H_c/T_{ub} has a steep up direction to the WNW. It may have an age close to the mean of U-Pb ages on titanite (T_b ~ 600-650°C) that range from ~1030±30 Ma, N=20 determinations in the Central Gneiss Belt (CGB) to 1100 ± 60 Ma, N=27, in the Central Metasedimentary Belt (CMB) (Tohver et al 2006). A large difference in magnetization direction across the ABT suggests that paleomagnetic data represent *a potential tool in mapping this thrust fault*. S of the ABT, Ar-Ar hornblende ages are similar to those closer to the GF; for the CGB the mean is 980±23 Ma (N=22); in the CMB, 970±40 Ma for N=23 (Tohver et al. 2006). They may date magnetic overprints, many of which are similar or antipolar to **SD** and **RV**. The **SD** and **RV** poles lie on, but the **A** pole lies to the west of, the Laurentian APWP. The **A** pole and the mean **SD** - **RV** pole lie on a great circle ~normal to the GF, and *could* suggest that the ABT is a thrust along which Grenville rocks, *already magnetized in response to an earlier collisional uplift and cooling*, have been transported to the NW. Further NW movement followed, utilizing deeper thrusts, one of which defines the GF, along which uplift and cooling produced the **RV** and **SD** poles. The collision causing **A** may have been the earliest (ca 1.2-1.3 Ga) of four which define the Grenville orogen. Collectively, they may have been responsible for transporting rocks of the allochthon 4000+/-1000 km to the NW, a distance based on that between the **A** and the mean **RV-SD** poles.

Abstract ID: 35971

Final Number: T13A-03

Title: Exhumation and cooling histories for high-pressure blocks above the western-most ABT: Potential insights from garnet zoning and rutile U-Pb depth profiling

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Co-authors: Andrew Smye, University of Texas at Austin, Austin, TX

Published Material: The zircon ages that will be discussed we published in Marsh & Culshaw, 2014. Lithos.

Abstract Body: Geodynamic models applied to the western Grenville Province predict a protracted period of high-temperature conditions (e.g. T > 700 °C for >70 Myrs) across the orogenic infrastructure during and after the Ottawan collisional phase. This is supported by ~50 Myr range in zircon ages from mid-crustal migmatites and hornblende ^{40}Ar-^{39}Ar cooling ages that are younger by another ~65 Myrs across much of the western Grenville. This type of long-duration high-T thermal history should result in complete diffusional re-equilibration of growth zoning in all but the largest garnet crystals and young ages in U-Pb thermochronometers with amphibolite-facies closure temperatures (T_c). However, exploratory thermal-chronological studies of HP mafic blocks within the Shawanaga Shear Zone (SSZ), the expression of the ABT along the Georgian Bay transect, show that prograde growth zoning (i.e. decreasing Mn and increasing Mg from core to rim) is well-preserved in ~4 mm garnet crystals and moderately preserved in many ~1 mm crystals. Given that these samples yield peak T estimates from 750-850 °C, the preservation of growth zoning suggests relatively short high-T durations (<5-10 Myrs at T_{char} = 750 °C and <7-30 Ma at T_{char} = 700 °C). Similarly, depth-profiled rutile crystals commonly show $^{207}Pb/^{206}Pb$ age progressions from ~1080 Ma in the cores to ~980 Ma along the rims, indicating core-to-rim migration of the intracrystalline diffusional closure front (associated with cooling from ~650 °C to ~500 °C) over this timeframe. The older ages preserved in the rutile cores (commonly within ~10 Ma of U-Pb zircon ages for the same samples (1085-1097 Ma)) suggests relatively rapid cooling within the interval of >750 °C to <650 °C following HP metamorphism. The rapid cooling (~10 °C/Myr) during the early Ottawan suggests syn-convergent exhumation to relatively shallow crustal levels followed by much slower cooling (~1.5 °C/Myr) during post-convergent residence in the thermally-matured middle-crust.

Abstract ID: 35056

Final Number: T13A-04

Title: 3D Visualization of the Large-Scale Crustal Structure in the SW Grenville Province

Presenter: Alan P Dickin, McMaster University, Hamilton, ON

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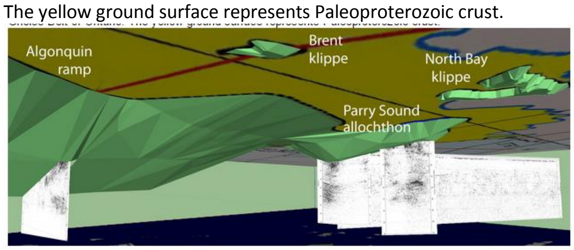
First Author Student?: No

Abstract Body: An accurate understanding of the three-dimensional structure of orogenic belts is a prerequisite to a correct understanding of their tectonic history. However, the complexity of crustal architecture in the SW Grenville province has obscured a correct understanding of its structure, and hence of its geological evolution. The recognised locus of Ottawan-age crustal stacking during the Grenville Orogeny is the Allochthon Boundary Thrust (ABT), which separates laterally translated terranes to the southeast from largely in-situ terranes to the northwest. In the central and eastern Grenville province, the ABT acts as a crustal-scale ramp, up which high grade gneisses were exhumed before further sub-horizontal transport to the northwest. In contrast, the 'standard' model for the Grenville Province in Ontario and western Quebec interprets the ABT as a very long ramp with gentle southeasterly dip, extending across much of the outcrop width of the Central Gneiss Belt. However, Nd isotope mapping suggests that parautochthonous crust extends much further south than previously recognized, such that salients and windows of

parautochthonous crust are recognised east of Whitney and south of Gravenhurst, between major allochthonous thrust sheets and erosional klippen. This implies a ramp-flat crustal structure in the SW Grenville Province, which can be understood with the aid of 3D visualization. This allows the complex three-dimensional shape of the ABT to be explored and compared with the attitude of other ramp surfaces of different ages, such as the Central Metasedimentary Belt Boundary Zone (CMBBZ) and the Grenville Front. The attached image shows a visualisation of the ABT surface (pale green) from a viewpoint in the mid crust, looking from Quebec towards the southwest, across the Central Gneiss Belt of Ontario. The yellow ground surface represents Paleoproterozoic crust.



Abstract ID: 35753

Final Number: T13A-05

Title: Chronology of the Torngat orogeny: duration and extent of crustal melting from combined U-Pb zircon and monazite geochronology and Lu-Hf and Sm-Nd garnet geochronology

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Co-authors: Carl Guilmette, Université Laval, Québec, QC, Canada; Daniel Bandyayera, Ministere de l'Energie et des Ressources Naturelles du Québec, Québec, QC, Canada

Abstract Body: The Torngat Orogen is a transpressional, hot, narrow, doubly-vergent orogenic belt part of the South-Eastern Churchill Province (SECP), located between the Superior and Nain cratons in north-eastern Canada. Exhibited as a tripartite structure, the SECP is composed of an Archean-Paleoproterozoic gneissic core, the Core Zone, surrounded by two NNW-trending orogens on its eastern and western margins, namely the Torngat (1.87-1.82 Ga) and the New-Quebec (1.82-1.77 Ga) orogens. Produced by the collision of the Core Zone and the Nain Province, the deeply eroded Torngat Orogen exposes granulitic roots dominated by ortho- and paragneisses and metaplutonic rocks, and lower-grade continental margin metasediments and orthogneisses. Although previous studies highlighted three tectonometamorphic phases associated with distinct regimes (i.e. crustal thickening, transpression, and exhumation-cooling), the understanding of the prograde to retrograde evolution of the Torngat orogeny in terms of dominant processes in the middle and lower crust – such as partial melting, melt extraction, crustal differentiation or crustal flow – is still embryonic. In this contribution, we present preliminary results from the application of multiple geochronology methods (i.e. U-Pb, Lu-Hf and Sm-Nd) to accessory and major metamorphic minerals (i.e. zircon, monazite and garnet) combined with microstructural analysis, mineral chemistry and multi-equilibria thermobarometry. Because of the different closure temperatures of the investigated isotopic systems and since metamorphic reactions producing these minerals occur at various phases through the orogeny, the new data provide insights in the evolution of the Torngat, from the onset of thickening to anatexis to the stabilisation and relaxation of the orogen. Preliminary results suggest that crustal thickening started as early as 1887 Ma, and that granulitic/anatectic conditions might have been sustained for tens of Ma.

Abstract ID: 35694

Final Number: T13A-06

Title: Is the Trans-Hudson Orogen a Large, Hot Orogen? Insights From Orogenesis and Cooling on Hall Peninsula, Baffin Island

Presenter/First Author: Diane Skipton, University of Ottawa, Ottawa, ON

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Co-authors: David A Schneider, University of Ottawa, Ottawa, ON, Canada; Marc R St-Onge, , , ; Dawn Kellett, Geological Survey of Canada, Ottawa, ON, Canada

Published Material: Some of the U-Pb monazite ages were reported at the Geological Soc. of America meeting in Denver, 2013. Some of the Ar-Ar ages were reported at last year's GACMAC meeting in Fredericton, 2014.

Abstract Body: The Trans-Hudson Orogen extends with a northeasterly strike for over 4600 km from the United States to northern Canada, and has an across-strike width of about 400-800 km. It has a long-lived accretionary history, beginning with amalgamation of crustal blocks in the upper Churchill plate during ca. 1.92 to 1.84 Ga, and ending with its terminal collision with the lower Superior plate at ca. 1.83-1.80 Ga. The orogen likely possessed a high heat flow, as it includes voluminous charnockitic batholiths and extensive granulite terranes. As such, in many ways it conforms to the definition of a large, hot orogen, comparable to the modern-day Himalayan orogen. Granulite-facies metasedimentary rocks on Hall Peninsula, southeast Baffin Island can be used to further explore this notion since they contain significant partial melt and host charnockitic plutons. The dominant deformation mechanism in the granulite facies terrane is km-scale east-vergent folding. Monazite U-Pb ages coupled with mica Ar-Ar geochronology on Hall Peninsula indicates cooling rates of ~1-2°C/Ma from peak metamorphism in the mid-crust at ca. 1.85-1.83 Ga to cooling through muscovite closure temperatures at ca. 1.67-1.64 Ga. This slow cooling rate and the lack of extensional structures suggest that this segment of the Trans-Hudson Orogen did not experience orogenic collapse despite a flat Moho and average crustal thickness of 43 km. In fact, much of the Trans-Hudson Orogen exhibits slow cooling rates and is missing many of the hallmarks of collapse, such as core complexes or significant detachments. The absence of these features sets the Trans-Hudson Orogen apart from other large, hot orogens such as the Grenville, Variscan and Himalayan orogens.

Abstract ID: 36577

Final Number: T13A-07

Title: The Paleoproterozoic Trans-Hudson Orogen: Large, Hot, but Only Moderately Thick?

Presenter/First Author: David Corrigan, Geological Survey of Canada, Ottawa, ON

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Published Material: Part of these findings are reported in Corrigan et al. (2009) Journal of the Geological Society of London and in "Tectonic Styles in Canada: The Lithoprobe Perspective" (Chapter 4: Paleoproterozoic crustal evolution and tectonic processes: Insights from the Lithoprobe Program in the Trans-Hudson Orogen, Canada, by D. Corrigan)

Abstract Body: The composite Trans-Hudson Orogen (THO), which locally reaches up to 1,500 km in width, compares in size as well as duration of collision with the Grenville Orogen. That being said, in detail they are quite different entities. The most striking difference, notwithstanding local exceptions, is the lesser degree of crustal thickening, as well as the apparent absence of core complex structures and related syn- to post-collisional extensional shear zones observed in the THO in contrast to the Grenville Orogen. Assuming that the thermal gradient of the continental crust and convergence rates were similar at ca. 1.83 Ga and 1.10 Ga, other

factors need to be considered in order to explain the observed differences. The most apparent empirical observation is the contrasting pre-collisional tectonic and magmatic accretion histories of both orogens. In the THO, widespread terrane and magmatic accretion shortly preceded terminal collision, resulting in structural and thermal weakening of the crust prior to collision. By contrast, in the Grenville Orogen, terrane and magmatic accretion predated collision by tens or hundreds of million years, allowing sufficient time for crust to cool prior to terminal collision. These contrasting starting conditions likely dictated how both orogens evolved with time, placing constraints on thermal and rheological boundary conditions. Another important factor, well constrained in the THO and much less so in the Grenville, is the size and shape of colliding continents and the presence of indenters, re-entrants, and oceanic freeboard. Particularly, the Ungava indenter (NE Superior Craton) was responsible for the highest degree of exhumation (by thrusting), as well as producing lateral escape of crustal blocks in the western Churchill Province, and southerly-directed crustal extrusion in the Core Zone, perhaps by tectonic overpressure.

Abstract ID: 34872

Final Number: T14A-0370

Title: Very-High Temperature Metamorphism and Deformation in the Footwall of an Eclogite-bearing nappe, Sveconorwegian Orogen: Meta-leuconoritic and Sapphirine-bearing Rocks of the Obbhult Complex, SW Sweden

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Co-authors: Jenny Andersson, Geological Survey of Sweden, Uppsala, Sweden; Gisella Rebay, University of Pavia, Pavia, Italy

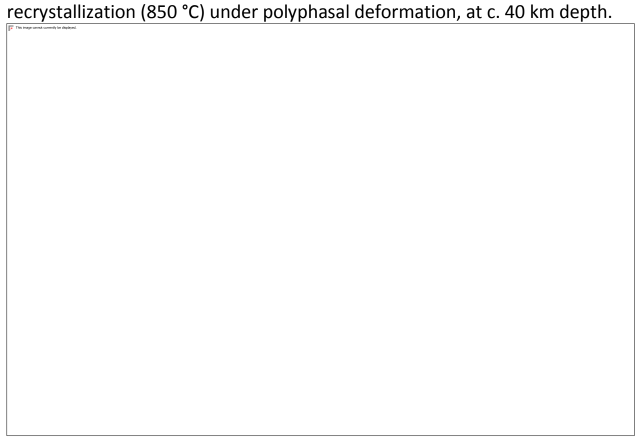
Abstract Body: The Eastern Segment, Sveconorwegian orogen, exposes a formerly deep section beneath the frontal part of a Himalayan-Tibetan type plateau. It hosts a 50 x 75 km eclogite-bearing nappe, which proves deep burial of continental crust and subsequent exhumation by extrusion of partially molten crust. The P-T-t-d evolution of the footwall beneath the eclogite-bearing nappe is characterized using a composite meta-igneous sequence (Obbhult complex).

Polyphasal deformation of the Obbhult complex involved isoclinal folding, E-vergent shearing, and refolding. Coarse-grained leuconorite–andesine anorthosite was heterogeneously mylonitized at very high temperature. The igneous assemblage (andesine plagioclase + orthopyroxene + Fe-Ti oxide) was recrystallized to metamorphic garnet + orthopyroxene + plagioclase + sillimanite + biotite + cordierite + quartz + hemoilmenite. Thermodynamic modelling (THERMOCALC) suggests PT conditions at 10.5-11.0 kbar and 850 °C for this assemblage. Si-poor, Mg-, Al-rich host rocks formed symplectite of sapphirine + garnet + corundum + hemoilmenite + plagioclase.

U-Pb SIMS zircon analysis dates the intrusion of anorthosite–leuconorite at 1.39 Ga, and the primary crystallization of intermediate-basic host rocks at 1.41 Ga. Thin secondary 0.98 Ga zircon rims formed in sapphirine-bearing and other deformed rocks.

Meta-leuconorites host four types of monazite: large, euhedrally zoned grains with resorbed margins, thin recrystallized rims on, and healed fracture zones within, large grains, and neoblasts in mylonitic deformation trails. EMP “chemical dating” demonstrates a Sveconorwegian age for recrystallization and neoblast formation; a primary igneous origin is indicated for large monazite grains.

The 1.4 Ga Obbhult complex demonstrates a non-complex 0.98 Ga Sveconorwegian metamorphic evolution for this part of the footwall beneath the eclogite-bearing nappe, involving very-high temperature recrystallization (850 °C) under polyphasal deformation, at c. 40 km depth.



Abstract ID: 35583

Final Number: T14A-0371

Title: Transpressional collision and post-orogenic deformation in the New Quebec Orogen.

Presenter/First Author: Deanne van Rooyen, Organization Not Listed, Sydney,

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Abstract Body: The New Québec orogen (NQO) is a Paleoproterozoic orogenic belt in the southeastern Churchill Province of the Canadian Shield. The NQO formed as a result of terrane accretion to the Superior margin at ca. 1.82 Ga, followed by terminal collision with the Core Zone in a SW-directed dextral transpressional regime at ca. 1.80 to 1.77 Ga. In the Kuujjuaq – Tasiujaq area on the SW margin of Ungava Bay, the NQO consists of three main zones. The foreland of the orogen, (the Knob Lake Group), contains autochthonous rocks deposited on the Archean Superior craton margin, shortened and imbricated in SW-verging thrust stacks. These domains are tectonically overlain by allochthonous metavolcanic and metasedimentary rocks of the Rachel-LaPorte Zone. These allochthonous rocks represent the hinterland of the orogen, and are juxtaposed against the Kuujjuaq Terrane, the northernmost part of the Core Zone. In the Kuujjuaq – Tasiujaq area there is evidence for multiple generations of structures, some of which are syn-orogenic. Greenschist to amphibolite facies rocks in the Rachel-LaPorte zone include metasedimentary rocks in which the main S_0-S_1 foliation dips moderately SE, overprinted by an F_2 crenulation with fold hinges plunging SW resulting in an S_2 cleavage dipping NW, in turn overprinted by an F_3 crenulation with fold hinges plunging N, resulting in an S_3 cleavage dipping W. In sheared metabasaltic units with strongly developed foliation dipping moderately NNE, there are overprinting folds with axial planes dipping steeply NW and fold hinges plunging NE. The fold vergence suggests a dextral, oblique, top-down-to-the-ESE shear sense. In both these examples the structural fabrics suggest at least one phase of deformation that post-dates the SW-directed transport that imbricated the rocks on the Superior margin. The Leaf Bay domain of the Kuujjuaq Terrane contains retrogressed garnet orthopyroxene granulite and tonalite with foliations dipping S that pre-date collisional deformation. The supracrustal assemblages include sheared mafic and semipelitic schists with foliations dipping shallowly E, overprinted by an S_2 cleavage dipping steeply SE. These fabrics could be a result of SE-directed transport post-dating orogenesis, suggesting that previously undocumented extensional deformation may be preserved in the NQO.

Abstract ID: 35259

Final Number: T14A-0372

Title: Metamorphic record of anatetic aluminous gneisses from the mid-pressure belt of the Grenvillian hinterland

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Co-authors: Aphrodite Daphnee Indares, Memorial University of Newfoundland, St Johns, NL, Canada

Abstract Body: A large portion of the hinterland of the Central Grenville Province is characterized by mid-pressure granulite-facies metamorphism. In the Manicouagan region, aluminous gneisses derived from hydrothermally altered volcanic and sedimentary protoliths provide a record of anatectic processes and of the pressure-temperature (P-T) evolution during orogenesis. Samples from these gneisses, collected in areas separated by several tens of kilometers, contain the same mineral assemblage: garnet, biotite, plagioclase, K-feldspar, quartz, sillimanite and locally, retrograde cordierite. However, they have a wide range of bulk compositions and textures, and may be grouped in two types: quartz-rich fine-grained fairly homogenous rocks, and relatively coarse-grained rocks of broadly pelitic composition. The later type shows microtextural evidence of partial melting, including pseudomorphed former melt inclusions in garnet, relict quartz surrounded by thin feldspar rims, and inter-granular films in the matrix. In addition, the presence of biotite-quartz symplectites and local replacement of garnet by biotite-sillimanite, are consistent with a melt crystallization reaction. However, the general preservation of the peak assemblage suggests that some melt has escaped. Phase equilibrium modeling with Thermocalc constrained the P-T field of the dominant mineral assemblage at 800-900ºC and 6-11kbar, with melt solidification in the range of 800-865ºC and 6-9kbar. The presence of sillimanite inclusions in garnet, and of only scarce, retrograde cordierite, is consistent with moderate dP/dT gradient 'hairpin' P-T paths. The data suggest that large parts of the mid-P hinterland in the central Grenville experienced a uniform metamorphic evolution, with large temperature variations relative to pressure. The high metamorphic temperatures recorded by these rocks are likely linked to syn-orogenic magmatic activity, and are consistent with the idea that the Grenville is a large hot orogen.

Abstract ID: 35218

Final Number: T14A-0373

Title: Insights into the Geology of the Central Metasedimentary Belt of the Grenville Orogen from Airborne Geophysical Data recently acquired by the Ontario Geological Survey

Presenter/First Author: Robert Michael Easton, Ontario Geological Survey, Sudbury, ON

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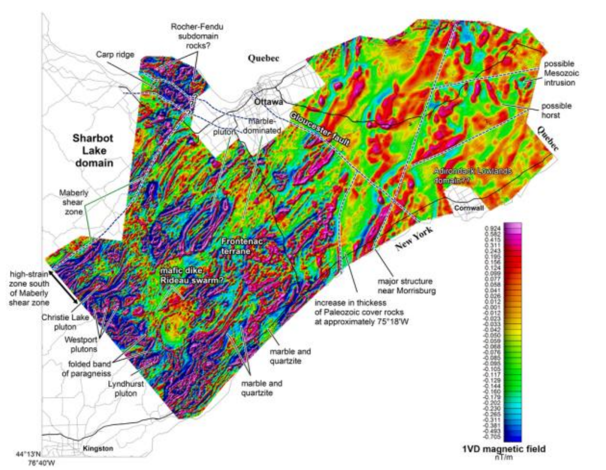
Published Material: Approximately 20% was presented at meeting of the Eastern Section of the American Association of Petroleum Geologists Meeting in London, Ontario on September 30, 2014.

Abstract Body: Most of the Ontario Grenville is covered by low resolution (800m line-spacing) 1950s and 1960s aeromagnetic data. In fall 2013, the Ontario Geological Survey (OGS) collected new high-resolution aeromagnetic and/or radiometric data over the eastern Central Metasedimentary Belt. The data were published in June 2014 as OGS Geophysical Data Sets 1074 (Renfrew) and 1075 (E Ontario) and as a set of hard-copy maps.

The Renfrew survey collected aeromagnetic and radiometric data at 200m line-spacing over an area of ~6 000 km². Highlights from this survey include 1) delineation of numerous E-trending mafic dikes of the 590 Ma Grenville dike swarm, many of which are buried by Paleozoic cover; 2) Paleozoic outliers in the survey area are locally sufficiently thick (>>100 m) to subdue the magnetic character of the underlying Grenville strata; particularly in the 1VD field; 3) confirmation of the subdomain-bounding N-trending Ross fault; 4) delineation of a new subdomain (Rocher-Fendu) in the Cobden area consisting of high P-T deformed gneiss (~9 kb based on corundum-hercynite assemblages) that structurally overlie only moderately deformed middle amphibolite facies marbles. Rocks of Rocher-Fendu subdomain are more abundant on the Quebec side of the Ottawa River, and may link with gneisses in the Otter Lake area. 5) the OGS radiometric data defines the same eU and eTh spectrometric highs as shown by existing GSC data, but anthropogenic anomalies for K and eU limit its use in areas of active farming or Leda clay.

The Eastern Ontario survey, at 400m line-spacing, collected aeromagnetic data only over an area of ~12 350 km². Highlights (see figure) include 1) Paleozoic cover in the western 2/3 of the survey area is thin (<400 m) allowing for the subsurface delineation of major Grenville rock units; 2) the Maberly shear zone is not readily apparent in the magnetic data, but a 10 to 20 km zone in Frontenac terrane immediately to the south characterized by strong linear magnetic trends is likely a high strain zone in the hanging wall of the Maberly shear zone; 3) in the Carp Ridge area, the Maberly shear zone is at least 10 km SE of previous positions. Rocks of the Rocher-Fendu occur beneath the Paleozoic on the north side of the Carp Ridge; 4) surprisingly, few faults and lineaments identified in the basement propagate into the overlying Paleozoic strata.



Abstract ID: 33711

Final Number: T14A-0374

Title: Tectono-Metamorphic History of the Eastern Taureau Shear Zone, Mauricie Area, Québec: Implications for the Exhumation of the Mid-Crust in the Grenville Province

Presenter/First Author: Renaud Soucy La Roche, University of Quebec at Montreal, Montreal, QC

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Co-authors: Felix Gervais, École Polytechnique, Montreal, QC, Canada; Alain Tremblay, GEOTOP, Montréal, QC, Canada; James L Crowley, Boise State University, Boise, ID; Gilles Ruffet, Géosciences Rennes, UMR CNRS 6118, Université Rennes 1, Rennes, France

Published Material: Soucy La Roche, R., Gervais, F., Tremblay, A., Crowley, J. L., & Ruffet, G. (2015). Tectono-Metamorphic History of the Eastern Taureau Shear Zone, Mauricie Area, Québec: Implications for the Exhumation of the Mid-Crust in the Grenville Province. *Precambrian Research 257*, 22-46.

Abstract Body: This study investigates the tectono-metamorphic history and exhumation mechanisms of the mid-crustal Mékinac-Taureau domain of the Mauricie area, central Grenville Province. Macro- and micro-structural analyses reveal the top-down-to-the-ESE sense of shear on the eastern Taureau shear zone, a major extensional structure that exhumed the mid-crustal Mékinac-Taureau domain and juxtaposed it against the lower grade rocks of the Shawinigan domain. Peak metamorphism in the Mékinac-Taureau domain, inferred to be the result of northwestward thrusting and regional crustal thickening, took place under P–T conditions of 1000–1100 MPa and 820–880°C prior to 1082 ± 20 Ma. Retrograde conditions varying from 775 to 675°C and from 800 to 650 MPa were registered in its upper structural levels prior to and/or during shearing along the eastern Taureau shear zone that was active at 1064 ± 15 Ma. The Shawinigan domain records P–T conditions ranging from 850 to 625 MPa and from 775 to 700°C, P–T values that are similar to or slightly lower than those for retrogressed samples from the upper structural levels of the Mékinac-Taureau domain, but clearly lower than the peak metamorphism values of the latter domain. Finally, the area cooled below 550–600°C at ∼1000–1030 Ma and below 450°C at ∼900–970 Ma on the basis of $^{40}Ar/^{39}Ar$ geochronology on amphibole and biotite. Structural and metamorphic characteristics of the Mauricie area are similar to those expected from a metamorphic core complex formed during post-convergence orogenic collapse in a gravity-driven fixed-boundary mode. The Mékinac-Taureau and Shawinigan domains were thus probably exhumed by a similar process, which supports the orogenic collapse model recently proposed to explain the exhumation of mid-crustal metamorphic core complexes in the Grenville Province.

Abstract ID: 33092

Final Number: T14A-0375

Title: Post-Peak Transtensional Buckling of High-grade Thrust Sheets in Western Central Gneiss Belt, Grenville Province of Ontario (Canada): A Signal of Orogenic Collapse

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Co-authors: Toby Rivers, Memorial University of Newfoundland, St John's, NF, Canada; Jack F Yang, , , ; Jason Tsolas, , , ; Gianluca Barbieri, , ,

Abstract Body: The Central Gneiss Belt (CGB) hosts a system of upright to inclined, horizontal to gently-plunging, noncylindrical cross-folds making high angles with the orogenic front. The cross-folds are multi-order features, visible at a range of scales from the outcrop to regional maps. We present new evidence that the cross-folds postdate the metamorphic peak and formed during retrogression and exhumation of the early-Ottawan thrust-sheet stack, in a tectonic regime of regional transtension and multi-layer buckling. Three-dimensional numerical *kinematic* models predict that typical transtensional folds be pervaded by hinge-parallel elongation lineations and L>>S strain fabrics. In the km-scale cross-folds of the CGB, however, such fabrics are generally restricted to the hinge zones, where they are locally accompanied by horizontal to shallowly-plunging sheath-like mesoscopic folds, apparently coeval with the host structure. By contrast, the limbs of cross-folds in the CGB are characterized by L<<S strain fabrics, quasi-cylindrical parasitic folds and tight intrafolial structures formed by coaxial refolding of the gneissic layering. On the other hand, our measurements and field observations are consistent with (1) the recent results of two-dimensional numerical *dynamic* modeling of multi-layer buckle folds and (2) empirical data from other classical metamorphic terranes that demonstrate the style and efficacy of regional transtension in exhuming high-grade rocks. Thus we conclude that the contrasting types of L-S fabrics and mesoscopic buckle folds observed in the km-scale cross-folds of the CGB are to be expected during post-peak exhumation of polydeformed gneisses in a regional transtensional regime.

A transtensional origin of the multi-order cross-folds removes the need to appeal to orogen-parallel regional shortening, a common but implausible requirement of previously favoured tectonic scenarios, and is compatible with our present understanding that much of the visible fabric and structure of the CGB developed during post-peak exhumation, retrogression and gravitationally-driven collapse of the thrust-sheet stack.

Abstract ID: 34578

Final Number: T14A-0376

Title: Nd Isotope Mapping of Large-scale Crustal Structure in the SW Grenville Province

Presenter/First Author: Alan P Dickin, McMaster University, Hamilton, ON

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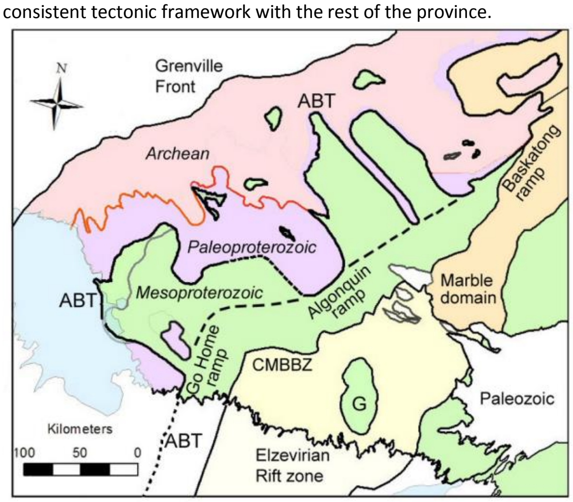
Abstract Body: The SW Grenville Province was an active continental margin for hundreds of millions of years before the 1 Ga Grenvillian terminal orogeny. This complex crustal evolution has for a long time obscured a correct understanding of crustal structure in the SW Grenville Province. However, crustal formation ages estimated from Nd isotope mapping can clarify the pre-collisional crustal history, and also characterize terranes that were displaced during crustal thickening, gravitational collapse, and exhumation associated with the Grenvillian collision. After the accretion of a Paleoproterozoic arc, an Andean-type ensialic arc was established on the composite Archean-Paleoproterozoic margin, causing extensive reworking, and also stepping ocean-ward to generate juvenile crust on the outboard edge of the continent. This complex crustal segment, displaying progressively younger Nd model ages southwards, was telescoped by Ottawan crustal stacking on the Allochthon Boundary Thrust (ABT). Basement exhumation occurred on a crustal-scale ramp, followed by sub-horizontal transport to the northwest, after which the allochthon was subjected to late buckle-folding. When this structure was denuded by erosion, it created a complex map pattern, consisting of large nappe lobes such as the Cabonga, Lac Dumoine and Parry Sound-Algonquin thrust sheets, interspersed with salients and windows of parautochthonous crust. In addition, at least six small allochthonous klippen have been recognised near North Bay, Mattawa, Lac Booth, Brent, Lac Perch and Lac Renzy. This ramp-flat crustal structure for the SW Grenville Province now places it in a consistent tectonic framework with the rest of the province.



Abstract ID: 34049

Final Number: T21A-01

Title: Early evolution of Earth-like planets

Presenter/First Author: Craig O'Neill, Macquarie University, Sydney,

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Abstract Body: The tectonics of Earth-sized planets is both a function of its thermal state and heating mode, and also its history. Even for similar heating trajectories, planets with different initial conditions may evolve down substantially different evolutionary paths. The rate of change of thermal conditions was greater in the Hadean than at any other time – extremely high heat productions rates were rapidly decaying, the young fully-molten core was losing heat to the mantle, substantial vestigial heat from planetary formation was being lost, and large impact fluxes were both decimating the early crust, and adding substantial heat to the mantle.

In many ways, though, the geodynamics of the Hadean may be seen as a response by the planet its initial, post-accretion, conditions. Here we use parallel finite element models developed in the community code ASPECT to explore the evolution of Earth-like planets, from an initial post-magma ocean state, till the end of the Hadean. We incorporate i) a parameterized, evolving core-model to track the evolution of core-mantle conditions; ii) rapidly evolving heat-production rates, and iii) a parameterization of the thermal effects of impact flux. We find there is a large-lag between the onset of post-magma ocean subsolidus convection, and active tectonics on the surface. We also find that tectonics is generally episodic, with a number of discrete tectonic overturn events anticipated for the Hadean. While there is a sensitivity to the heating mode (variable basal, decaying radiogenic, and impact-induced), we find a large sensitivity to the initial conditions, and suggest that one of the fundamental problems in understanding terrestrial planet evolution is constraining the state of a planet immediately post-accretion.

Abstract ID: 34956

Final Number: T21A-02

Title: Temporal Stress Patterns in Episodic Plate Tectonics Models with Implications for the Initiation of Plate Tectonics on Terrestrial Planets

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Abstract Body: Spherical shell mantle convection models are used to explore an episodic mode of plate tectonics. The time evolution of shear and normal stresses are tracked to determine how the stress levels vary coming into a global lithospheric failure event. The results indicate that an increase in convective mantle shear stress initiates lithosphere failure and an associated period were the lithosphere actively participates in convective mantle overturn (as is the case for the Earth's plate tectonics regime at present). The implication is that once the lithosphere is active, then normal stresses can exceed shear stress but it is not the normal stress itself that initiates the active lid mode of behavior. Based on our numerical results, we used 1D thermal evolution models to study the consequences of this shear-stress dominance for the initiation of plate tectonics. We find a reduced likelihood of initiating plate tectonics with increasing planet mass and interior heat. Moreover, our results indicate that for Earth an early (<500 Myr) or considerably later (0.5-3 Gyr after formation) start for plate tectonics are both possible. Once started, plate tectonics associated cooling of the interior can aid in its maintenance. In that situation, our thermal evolution models suggest the continuation for plate tectonics on Earth for the lifetime of the sun as a main sequence star.

Abstract ID: 35464

Final Number: T21A-03

Title: Evolving Lid-States, Bi-Stability, and the Evolution of Terrestrial Planets

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Published Material: Some early data has been presented, and further has been accepted to EPSL

Abstract Body: We use 3D mantle convection and planetary tectonics simulations to explore the links between tectonic regimes, lithospheric yield strength, the age of a planet, and thermal histories. At both high and low values of internal heating a single hot or cold stagnant-lid end state prevails. For lower initial and/or depleted radiogenics (e.g. thermal ageing) hot stagnant-lid states can yield through an episodic-lid, into a mobile-lid regime. Further reducing radiogenics leads the mobile-lid transitioning back into a (now) cold stagnant-lid. While high and low temperature tectonic end states may be fixed, the intermediate parameter range – a significant span of a planet's thermal evolution – may be governed by the thermal history of the system (e.g. initial conditions) allowing for regions of multiple stable tectonic states, or bi-stability. Within the bi-stability window, the tectonic regime becomes a function of a planet's specific geologic and climatic history. The timing of transitions in tectonic regimes is linked to internal temperature variations, which are a function of the lid-state evolution. Transitions from an initial stagnant-lid state are delayed (requiring a larger decrease in radiogenics) as a function of increasing yield strength and surface temperature, indicating that a system with a different thermal evolution has the potential to migrate through tectonic regimes at the same 'thermal time' (e.g. temperature), but very different 'temporal times'. Our results indicate that multiple modes of convection and surface tectonics can potentially operate on a single planetary body at different times in its evolution, as consequence of changing internal parameters, surface temperatures, and differing thermal histories, implying terrestrial worlds can alternate, and be offest between multiple tectonic states over giga-year timescales.

Abstract ID: 34318

Final Number: T21A-04

Title: The Feedback Between Surface Mobility and Mantle Compositional Heterogeneity: Implications for the Earth and Other Terrestrial Planets

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Published Material: This material was presented at the AGU Fall Meeting 2014 and was recently accepted to Earth and Planetary Science Letters (doi:10.1016/j.epsl.2014.08.019). Some of this material was also presented at the CIG meeting in Banff 2014.

Abstract Body: Planetary surface mobility depends on lithospheric stresses arising from the mantle's convective vigor. Using a model of thermochemical convection featuring force-balanced plates we examine the effect on surface mobility of different fractions of compositionally dense mantle material. Specifically, we introduce a uniform thickness compositionally enriched basal layer in a system with mobile-lid tectonics and monitor whether an active lid is subsequently maintained. We find that long-term surface mobility decreases when enriched material is present. High mobility is always maintained if the total material volume is no more than 1% of the mantle volume. For the inferred volume of the Large Low Shear Velocity Provinces (LLSVPs) in the present-day Earth, surface mobility is dependent on the buoyancy ratio of the enriched material. If the compositionally dense material self-organizes into provinces, both surface mobility and mantle upwelling vigor become more variable. Generally, upwellings that form at the edges of provinces are more buoyant relative to upwellings that form on the tops of provinces. If enriched material envelops the core, upwelling vigor is diminished so that plates are consumed more quickly than they can fragment, and surface mobility is eventually lost.

Abstract ID: 33085

Final Number: T21A-05

Title: Mantle Potential Temperature through time: Constraints from Greenstone Basalts and Komatiites

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Abstract Body: Basalts can be divided into three groups using incompatible element distributions: undepleted/enriched (UE), depleted (D), and hydrated (H). We have calculated mantle potential temperatures (Tp) for each of these groups and for komatiites (K) based on major element contents filtered for alteration and extreme fractionation. Median Tp for the H and D groups decreases with time from 1500°C in the Archean to 1380°C today, whereas the UE and K groups maintain high and relatively constant Tp values through time (UE,1500°C; K, 1650°C). Decreasing Tp in ambient mantle may be expected with time, but the rather constant Tp in UE and K mantle sources requires an explanation. One possibility is that before 2.5 Ga, most of the mantle was well stirred and low-viscosity and only near the core-mantle thermal boundary layer (CMB) was the thermal gradient large enough to give rise to mantle plumes. Although plumes may have existed throughout Earth history, only some of them (those that gave rise to komatiites) made it to the base of the lithosphere before 2.5 Ga due to smaller plume sizes resulting in rapid diffusive heat loss. Archean UE basalts may thus reflect partial melting of compositional inhomogeneities embedded in the D-H upper mantle rather than thermal plumes. Widespread plume production in the late Archean may be related to the onset of plate tectonics, where the accumulation of cool slabs at the CMB increased the thermal gradient, thus enhancing plume generation. Plume heads may have been more robust in this cooler mantle and survived to the base of the lithosphere, producing most of the post-2.5 Ga UE basalts. Supporting this interpretation are increases in Ti and Nb in UE basalts after 2.5 Ga. After 2.5 Ga, a maintained high Tp for UE and K mantle plume sources may reflect sustained high CMB temperatures, perhaps due to growth of the inner core.

Abstract ID: 33916

Final Number: T21A-06

Title: Origin and Evolution of Silicate Reservoirs in the Early Earth: an Archean Komatiite Story

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Co-authors: Richard J Walker, Univ Maryland, College Park, MD; Mathieu Touboul, University of Maryland College Park, College Park, MD; Janne Blichert-Toft, Ecole Normale Supérieure Lyon, Lyon, France

Abstract Body: Isotopic signatures created in early terrestrial silicate reservoirs *via* radioactive decay of short- and long-lived nuclides have been sampled by early magmas and preserved in crustal rocks. These isotopic signatures can be used to constrain the timing of formation and the nature of these, now likely vanished, reservoirs. Using the combination of $^{142,143}Nd/^{144}Nd$, $^{176}Hf/^{177}Hf$, $^{186,187}Os/^{188}Os$, and $^{182}W/^{184}W$ isotope systematics and highly siderophile element (HSE) abundances in Archean komatiite systems from around the globe ranging in age between 3.6 and 2.4 Ga, we attempt to place new constraints on specific processes that may have controlled mantle differentiation, on the timing of late terrestrial accretion, and the mixing times of the terrestrial mantle.

Our isotopic and HSE abundance data for the early to late Archean komatiite systems from around the globe are most consistent with formation and long-term isolation of deep-seated mantle domains, with fractionated time-integrated Sm/Nd, Lu/Hf, Hf/W, and Pt/Os ratios, within the first 100 Ma of Earth's history. These domains may have been generated as a result of crystallization of a primordial magma ocean, with Mg- and Ca-perovskite and Pt alloy acting as the fractionating phases. The inferred mantle domains remained isolated from the convecting mantle for more than a billion years, and, in some cases, may have never been completely re-homogenized, indicating very slow mixing times of the terrestrial mantle.

The absolute HSE abundances in the sources of early and late Archean komatiite systems studied are calculated to be generally similar and are within the range of those present in estimates for the modern primitive mantle, although at least some early Archean komatiite systems (e.g., 3.6 Ga Schapenburg, South Africa) were derived from mantle sources strongly depleted in HSE. Our combined isotopic and HSE abundance data indicate that late accretion of HSE to Earth may have been largely complete by the time the final terrestrial magma ocean had crystallized. Large HSE fractionations observed in some, mostly early Archean, komatiite systems may reflect rather sluggish mixing of diverse post-magma ocean domains characterized by variably fractionated HSE abundances.

Abstract ID: 34306

Final Number: T21A-07

Title: Zircon Evidence Reveals that Iceland is Not a Modern Analogue for Earliest Crustal Construction (Hadean, >4 Ga)

Presenter/First Author: Tamara L Carley, Lafayette College, Easton, PA

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Published Material: This conference submission is based on work published earlier this year: Carley, T.L., Miller, C.F., Wooden, J.L., Padilla, A.J., Schmitt, A.K., Economos, R.C., Bindeman, I.N., and Jordan, B.T. (2014) Iceland is not a magmatic analog for the Hadean: Evidence from the zircon record. Earth and Planetary Science Letters Vol. 405, pp. 85–97.

Abstract Body: Tangible evidence of Earth's earliest (Hadean; >4.0 Ga) crust, and the processes and materials that led to its formation, exists almost entirely in detrital zircon. Iceland's crust (hot, thick, juvenile, dominantly mafic, substantial silicic component) resembles what is often intuitively visualized for Hadean crust. Because zircon crystals provide a unique view of the >4.0 Ga world, a zircon-based comparison of Icelandic and Hadean zircon data is a first-order test of this model. We present the first extensive dataset for Icelandic zircon, with O isotopes and trace elements for samples spanning the island's history and tectonic settings. Comparison of isotopic and trace elemental data suggest fundamental differences in magmatic environments. Deviations from juvenile $\delta^{18}O$ reveal that surface waters interacted with magmatic source materials for many Hadean and most Icelandic zircons, but under very different circumstances. Preserved Hadean zircons have dominantly normal to high $\delta^{18}O$ (median value 6‰; 85% have $\delta^{18}O \geq 5.3$‰). Protolith material for host magmas may have been altered at low T by subaerial meteoric water or submarine seawater with $\delta^{18}O \geq 0$‰. Abundant low- $\delta^{18}O$ Icelandic zircons (98% ≤ 5.3‰; median 3‰) imply high T alteration of protolith by meteoric water. Titanium abundances in zircon are also distinct (Iceland median 12 ppm, Hadean 5 ppm), suggesting that Hadean zircons crystallized in cooler magmas (median difference ≥75°C). Other trace elements, e.g. MREE and HREE (Iceland >> Hadean zircons), are also consistent with distinct origins of zircon-bearing magmas. Perhaps Iceland-like settings and magmas existed in the early Earth, but evidence for this is very rare in >4 Ga zircons. Iceland is thus not representative of Hadean crust. Based on zircon, mid-ocean ridges, evolving continental rifts and continental hotspots are equally poor matches. Arc zircons provide a closer fit, although >4 Ga zircons appear to be from even cooler, wetter, magmas.

Abstract ID: 35048

Final Number: T21A-08

Title: An Iceland-like Setting for Generation of a ~4.02 Ga tonalite, Acasta Gneiss Complex, Canada

Presenter/First Author: Jesse Ray Reimink, University of Alberta, Edmonton, AB

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Co-authors: Tom Chacko, University of Alberta, Edmonton, AB, Canada; Richard A Stern, University of Alberta, Edmonton, AB, Canada; Larry Heaman, University of Alberta, Edmonton, AB, Canada; Joshua Davies, University of Geneva, Geneva, Switzerland; Graham D Pearson, University of Alberta, Edmonton, AB, Canada; Robert A Creaser, University of Alberta, Edmonton, AB, Canada

Published Material: A portion of the data and conclusions in this talk were presented in poster form at the Goldschmidt Geochemistry conference (2013) and in talk format at the Northwest Territories Geoscience Forum (2013) as well as published in Nature Geoscience (2014).

Abstract Body: The Acasta Gneiss Complex (AGC) contains the oldest known continental rocks on Earth with U-Pb zircon ages indicating crust formation between 3.6-4.03 Ga [Stern and Bleeker, 1997; Bowring and Williams, 1999; Iizuka *et al.,* 2007]. Here we discuss whole-rock elemental and isotope geochemistry along with SIMS U-Pb, trace element, Hafnium and O-isotope compositions of zircon from a >4.0 Ga tonalitic gneiss unit identified by Reimink *et al.,* [2014]. Unlike typical Archean TTG magmatism [Moyen and Martin, 2012], this unit is characterized by moderate silica contents (58-62 wt % SiO_2), strong Fe-enrichment (12-15 wt% FeO), and low Mg numbers (13-18). REE patterns are relatively flat with a significant negative Eu anomaly. These features strongly suggest that, unlike deep-seated Archean TTG magmas [Moyen and Martin, 2012], the evolution of this AGC tonalite was dominated by shallow-level fractionation processes involving plagioclase.

Zircons from this well-preserved unit document primary crystallization at ~4.02 Ga. Oxygen isotope compositions from zircon centers and mantles document a marked decrease in $d^{18}O$ from a mean of +5.6 ‰ to a mean of +4.7 ‰ that can be explained by processes occurring within a shallow magma chamber involving late-stage assimilation of hydrothermally altered crust.

The whole-rock and zircon data for the >4.0 Ga AGC tonalitic gneiss are similar to those of intermediate rocks from Iceland (e.g., icelandites), thought to be formed by shallow-level basaltic magma fractionation and assimilation of surface-water altered crust. Comparisons of zircon trace element data also compare favorably with Icelandic zircons [Carley et al., 2014]. We will present recently collected radiogenic isotope data and discuss these new findings in relation to the issue of crust formation on the Hadean Earth.

Bowring & Williams, (1999) *Cont. Min. Petro.* **134**, 3-16

Stern & Bleeker, (1999) *Geosci Can* **25**, 28-31.

Iizuka et al., (2007) *Precambrian Research* **153**, 179-208

Reimink *et al.* (2014) *Nature Geoscience* **7**, 529-533

Moyen & Martin, (2012) *Lithos* **148**, 312-336.

Carley *et al.,* (2014) *EPSL* **405,** 85-97

Abstract ID: 34567

Final Number: T22A-02

Title: Structure and dynamics of the North American lithosphere imaged using waveform inversion of global and USArray data

Presenter/First Author: Andrew J Schaeffer, Dublin Institute for Advanced Studies, Dublin,

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Co-authors: Sergei Lebedev, Dublin Institute for Advanced Studies, Dublin, Ireland

Published Material: Some results recently published in EPSL; some new results will be presented.

Abstract Body: The North American continent has had a long, eventful tectonic history. The assembly of the stable cratonic core has undergone numerous collisions and accretion at its boundaries, major rifting episodes within it, as well as the loss of ancient lithosphere beneath parts of it, all of which are examples of cratonic dynamics and evolution. Seismic tomography offers rich evidence on the structure and evolution of the cratonic lithosphere. With the continued deployment of the USArray during the last decade, the North American continent has now been densely sampled with broadband seismic data from west to east coast. We present a new high-resolution model of the upper mantle beneath North

America constrained by waveform fits of over 700,000 vertical-component broadband seismograms. Automated multimode waveform inversion was used to extract structural information from surface and *S* waveforms, yielding resolving power from the crust down to the transition zone, and improved resolution for a variety of features in North America.

We focus on central and eastern North America; in particular, the internal structure of the central cratonic core is resolved in detail, with clear delineation from the deformed continental margins. The northern and northeastern boundaries of the cratonic lithosphere closely follow the coastlines, with North America's and Greenland's lithospheric roots clearly separated. On the eastern margin of the continent, where multiple episodes of continental rifting are superimposed, the craton boundary coincides with the western extent of the Appalachian orogenic front, with significantly lower lateral velocity gradients than in the west.

Within the cratonic interior, the lithosphere surrounding the 1 Ga failed Mid-Continental Rift shows a reduction in wavespeeds compared to the surrounding craton, likely indicating thermo-chemical alteration of the sub-continental lithospheric mantle, in agreement with results from geochemical and petrological analyses of diamondiferous kimberlites and peridotites. We examine the spatial extent of the lithospheric mantle root and LAB variations across the continent, and compare them with respect to the spatial location of diamondiferous kimberlites. Finally, we discuss potential lithospheric control on the distribution crustal seismicity.

Abstract ID: 34272

Final Number: T22A-03

Title: On the Thermal Evolution of Archean Cratons : High-Grade Metamorphism, Granite Formation and Long-Term Cooling

Presenter/First Author: Claude P Jaupart, Institut de Physique du Globe de Paris, Paris,

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Abstract Body: High-precision geochronological and thermodynamic studies provide records of unprecedented detail on the thermal evolution of continents following major episodes of continental assembly and orogenesis in the Archean. Similar characteristics have been observed in all the major cratons worldwide. Metamorphic events affect very large areas quasi-simultaneously, indicating that the driving mechanism operates on a large-scale, but peak temperatures vary between terranes. The timing of high-grade metamorphism lags magmatism and tectonic amalgamation by several tens of million years. Final stage metamorphic events are associated with granite formation and emplacement. These events are followed by slow and long lasting isobaric cooling that persists for up to 1 Gy at rates of less than 1K/My. The source of the heat that is required to account for these phenomena remains controversial. The most common explanations are the underplating of basaltic melts due to a mantle plume or the instability of thickened lithosphere, which is also expected to generate basaltic melts, but they are not consistent with the significant time-lag that separates voluminous mafic magmatism and high-grade metamorphism.

We show that all these features are consistent with the thermal evolution of a new continental assemblage that adjusts to heat released by radioactive decay in crustal rocks. Quantitative results depend on the total amount of radioactive elements in the newborn crust, which can be determined by heat flow studies. Using heat flow and heat production data from the Archean Superior Province of the Canadian Shield, we show that peak temperatures of ≈ 800-900°C were reached a few tens of millions years after the final amalgamation event that occurred at ≈2.7 Ga. Lateral variations of peak metamorphic temperatures are accounted for by lateral changes of crustal heat production. We also show that peak temperatures are sensitive to the width of the newly accreted terranes. It is only after the final docking event that saw the width of the accreted belts exceed ≈400 km that the necessary conditions for high-grade metamorphism were met. The slow and long-term cooling that followed peak metamorphism is a straightforward consequence of the decay of heat producing elements in the crust.

Abstract ID: 34230

Final Number: T22A-04

Title: Investigating Precambrian Tectonics in Northernmost Hudson Bay: Insights from Joint Inversion of Receiver Functions and Surface Waves

Presenter/First Author: Amy Gilligan, University of Cambridge, Cambridge,

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Co-authors: Ian D Bastow, Imperial College London, London, United Kingdom; Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Laura Petrescu, Imperial College London, London, SW7, United Kingdom

Abstract Body: How tectonic processes operated and changed through the Precambrian still remains a matter of debate: when did plate tectonics as we observe on Earth today begin, and did different processes occur on the younger, hotter Earth? The Canadian Shield contains one of the largest exposures of Precambrian rocks on Earth, and the rocks of the northernmost Hudson Bay region span more than 2 billion years of Earth's history, from 3.9-1.8 Ga. This is thus an important locality for trying to understand the processes that may have occurred on the early Earth.

Previous geophysical work in northernmost Hudson Bay has shown interesting variations in crustal properties within this region. These variations appear to relate to differences in tectonic processes operating when distinct parts of the crust in northernmost Hudson Bay formed. In this study we use data from broadband seismic stations in northernmost Hudson Bay including from the POLARIS network to obtain new shear velocity models for the crust and upper mantle in northernmost Hudson Bay by jointly inverting P receiver functions and ambient noise surface wave dispersion measurements. A joint inversion for shear velocity reduces the inherent ambiguities in each individual method, while constructing a model that is consistent with both. These models are used to estimate crustal thicknesses within this region. Variations in crustal thickness and shear velocity are interpreted with respect to changes in tectonic processes over time.

Abstract ID: 33849

Final Number: T22A-05

Title: Precambrian Processes, the Trans-Hudson Orogen, and Cratonic Keels: Insights From Teleseismic Tomography in Northern Hudson Bay, Canada

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Co-authors: Ian D Bastow, Imperial College London, London, United Kingdom; Nicholas Rawlinson, Australian National University, Canberra, Australia; Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Amy Gilligan, Imperial College London, London, United Kingdom; Michael Kendall, University of Bristol, Bristol, United Kingdom

Abstract Body: Earth conditions in the Precambrian, and their effect upon the formation of cratons and orogenies from that era, are not fully understood. For example, the precise onset of modern plate tectonics remains ambiguous; it has been hypothesised to have begun anywhere from ~4.1Ga (Hopkins, 2008) to ~1Ga (Stern, 2005). Also, some cratons are associated with large geoid signatures and exceptionally deep fast wave-speed anomalies, pointing to the existence of thick "cratonic keels", the origin of which remains unexplained. To improve our understanding of the early Earth processes, geological evidence preserved within ancient plates that have remained largely unchanged since the Precambrian can be used. The rocks of northern Hudson Bay include Archean domains, the Paleoproterozoic Trans-Hudson Orogen (THO), and lie atop one of the largest cratonic keels on Earth (Bastow et al., 2013), making this region an ideal laboratory for study of Precambrian processes.

Here, we use seismological data recorded at Canadian POLARIS and Hudson Bay Lithospheric Experiment (HuBLE) stations to perform a relative arrival-time study of northern Hudson Bay region and the THO. Waveforms are aligned using the adaptive stacking routine of Rawlinson et al. (2004), and inversions are produced using the Fast Marching Tomography (FMTOMO) inversion code of Rawlinson et al. (2006). Our inversions provide an improved velocity model of the lithosphere and upper mantle of northern Canada and constitute new body-wave constraints on their structure. The results are used to address a number of outstanding questions regarding the processes that formed the THO and the Laurentian Keel of North America.

Abstract ID: 33552

Final Number: T23A-01

Title: The Canadian Shield in Southern Quebec – Some Outstanding Issues

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Published Material: This is partly, but not entirely a review, from several sources over the past decade. It was requested by the organizers.

Abstract Body:

Abstract ID: 33670

Final Number: T23A-04

Title: New Results of Earthquake Relocation in Charlevoix Seismic Zone, Eastern Canada and Implications for Regional Geological Structure

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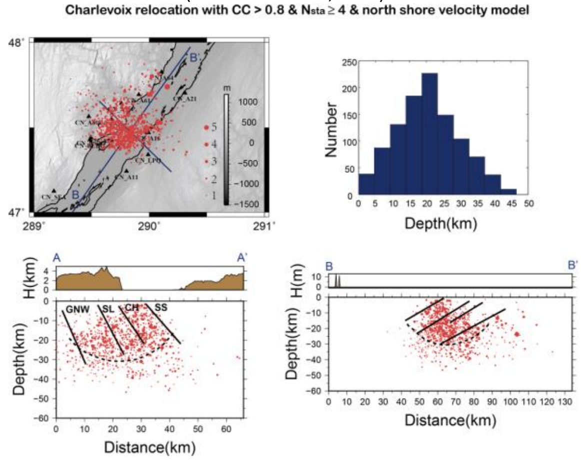
Abstract Body: The Charlevoix Seismic Zone (CSZ), located on the St Lawrence River about 100 km downstream from Quebec City, has the most active seismicity in eastern Canada. Historically there have been five magnitude 6 to 7 earthquakes in the CSZ, and about 200 events recorded by the Canadian National Seismograph Network (CNSN) every year. The high seismic hazard in this area is a result of its complex tectonic history, including the opening of Iapetus Ocean formed the St. Lawrence paleorift system (700 Ma), and a Devonian meteorite impact (350Ma) that shattered the plateau and created a highly fractured circular zone (56 km in diameter; Rondot, 1989) on the north shore of St Lawrence River (SLR).

In this study, we studied 1442 earthquakes that occurred in the CSZ area during January 1988 and October 2010, using the Double-Difference Hypocenter Locations (HYPODD, Waldhauser & Ellsworth (2000)) method. Broadband waveforms from 7 permanent CNSN stations are used in the relocation. We manually picked 11,525 P wave arrivals out of 29,737 recordings, with the reference of automatically picked P phases using the maximum kurtosis and κ-statistics criteria (C. D. Saragiotis et al., 2004). We used a layered CSZ velocity model from Lamontagne (1999). In total 1035 (71.8%) events have been relocated, by setting the cross-correlation coefficient (CC) to be greater than 0.8 at 4 or more stations.

The relocated earthquake hypocenters depicts the impact crater. Cross-section profiles also show a "bowl" shape envelope at the bottom of the seismicity. Events are more aggregated under SLR than under the north shore area, indicating that rifting faults beneath the SLR are probably weaker structures. The relocated earthquakes also define a series of SE steeply dipping faults, which are consistent with the surface traces of the Gouffre NW fault, the St-Laurent fault, Charlevoix fault and South shore fault. Finally, a series of SW low-angle dipping faults under SLR also agree with local compressive stress orientation implied by previous CSZ focal mechanism solutions (Zoback & Zoback, 1991).

Charlevoix relocation with CC > 0.8 & Nsta ≥ 4 & north shore velocity model



Abstract ID: 35477

Final Number: T23A-05

Title: Superior Layer-Cake: Gradual Lower Boundary and Textured Interior of the Lithosphere

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Co-authors: Benjamin Dunham, Rutgers University, Piscataway, NJ; Michael Klaser, Rutgers University New Brunswick, Highland Park, NJ; Andrea Servali, Rutgers University, Piscataway, NJ

Abstract Body: The lithosphere of Archean cratons reaches deeper than 200 km, and may be delineated by the distribution of elevated seismic wave speed in the mantle. The precise location of the decrease in speed that marks the lower boundary of the lithosphere has been difficult to define, leading to the inclusion of the Lithosphere-Asthenosphere Boundary (LAB) among the main challenges in modern seismological studies.

We investigate the properties of the mantle lithosphere beneath the Superior province of Quebec using teleseismic receiver function analysis. We rely on a data set spanning over 5 years from a number of long-running observatories in Quebec. Long duration of observations ensures excellent directional coverage at all sites we examine.

The appearance of a converted phase in a receiver function documents the presence of a vertical gradient in properties that takes place over a distance that is "short" relative to the wavelength of the phase. Our examination of the receiver functions from the Superior province fails to identify consistent P-to-SV converted phases with delay times ~20 s that would be consistent with the likely depth to the LAB. This is true for all frequencies down to 0.125 Hz, and implies that changes in isotropic seismic properties associated with the LAB take place over vertical distances similar to, or larger than the corresponding shear-wave wavelength (~36 km).

Interestingly, numerous converted phases are detected between 10 and 20 s at most sites we have examined. This range of delays corresponds to depths in excess of 100 km. On the transverse component of receiver functions these phases display directional polarity changes characteristic for conversions from boundaries that have significant dip, or else have anisotropic seismic velocity adjacent to them. On the Radial component the interval between 10 and 20 s delays is overprinted by crustal multiples that are excited well by the sharp Moho of the Superior province crust. Directional patterns of SH-polarized (transverse) phases are distinct from those of the crustal multiples. As we do not find corresponding SV-polarized phases, we favor an interpretation in terms of the abrupt changes in mantle rock texture, as might result from episodes of shearing, delamination or underplating, all likely to have affected the long-lived lithosphere of the craton.

Abstract ID: 34160

Final Number: T24A-0377

Title: Lithospheric Structure of Greenland and the Northwest Atlantic from Rayleigh Wave Group Velocities

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Published Material: Approximately 30-40% of material was presented at the 2013 AGU Fall Meeting.

Abstract Body: Greenland is largely thought to be underlain by Precambrian lithosphere, including Archean cratons and Proterozoic mobile belts. The margins of the continent are characterised by extensive orogenic belts, and by magmatic extrusives and intrusives related to breakup of the North Atlantic region.

Most detailed studies of crustal structure have been carried out at the edges of the continent and its margins, using controlled-source experiments. However, the establishment of broadband seismographs across Greenland, principally from the GLATIS and GLISN initiatives, has permitted an increasing number of passive-source studies such as receiver function analysis.

We investigate the crust and uppermost mantle structure of Greenland and the Northwest Atlantic, using Rayleigh wave group velocities from regional earthquakes recorded at the GLATIS and GLISN seismograph stations on Greenland, as well as permanent stations in the eastern Canadian Arctic. Dispersion data for periods from 10 to 80 seconds are combined in a tomographic inversion that solves simultaneously for group-velocity heterogeneity and azimuthal anisotropy. For each grid-point in the group-velocity maps, we extract a 1D dispersion curve, which is inverted for 1D shear-wave velocity structure using a probabilistic modelling scheme. The results are combined to create a pseudo-3D model of the crust and uppermost mantle across the region.

The resulting models indicate crustal thicknesses ranging from ~30 km to almost 50 km beneath mainland Greenland. At shallow depths, the extensive and deep sedimentary basins on the northwest and northeast margins are clearly imaged. Beneath the continental margins and the ocean basin, crustal thickness decreases significantly. In the uppermost mantle, the Greenland mainland region is characterised by high seismic wavespeeds, consistent with a cratonic structure, whereas the Northwest Atlantic shows wavespeeds lower than the global average, likely related to processes at and around the Mid-Atlantic ridge and Iceland hotspot.

Abstract ID: 34553

Final Number: T24A-0378

Title: Variations in Seismic Anisotropy Across the Canadian High Arctic

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Co-authors: Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Abstract Body: The Canadian High Arctic is a complex and little-studied area made up of the northern edge of the Canadian Shield plus several orogenic belts and basins. Each geological province has its own characteristics, from the NW-SE thrust fault and fold structures of Ellesmere Island to the NE-SW structures and diapirism of the Sverdrup basin. This great variation in surface geological structure likely reflects tectonic complexity at the scale of the entire lithosphere, but the role of past and present mantle processes in the development of the region is still poorly understood. One of the signatures of mantle tectonic processes is seismic anisotropy, the directional dependence of seismic wave propagation speed. This seismic anisotropy can arise from 'fossil' fabric in the lithosphere, related to past tectonic processes, and from present-day mineral alignments due to sub-lithospheric mantle flow. We use measurements of shear-wave splitting to investigate the anisotropy beneath the Canadian High Arctic. Our seismic data come from permanent seismograph stations (the Global Seismograph Network and the Canadian National Network) across the region, and a temporary installation on Ellesmere Island (the 'ELLITE' project). Data timespans range from 2 years for the temporary installations to 24 years for the longest-running permanent stations. Both SKS and SKKS waveforms are used in the analysis. Preliminary shear-wave splitting measurements, showing the dominant directions of seismic anisotropy across the High Arctic, are presented and interpreted in the context of tectonic structure and present-day mantle flow. The results show significant variability in splitting parameters across the region, including variations in fast-polarisation orientation at short spatial wavelengths. This and the correspondence between large-scale tectonic structure and fast orientation (e.g. E-W at

station ALE and WNW-ESE at station RES) suggests that lithospheric anisotropy plays a significant role.

Abstract ID: 34259

Final Number: T24A-0379

Title: What is the Driving Mechanism of Earthquakes in the New Madrid Seismic Zone? – A Study of Shear Wave Splitting and Tomography.

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Co-authors: Christine Ann Powell, Center for Earthquake Research and Information, Memphis, TN

Published Material: Preliminary results of part 1 (tomography) of this work was presented at the annual AGU 2014 meeting in San Francisco California. The results are still being improved with addition of more data from the Flex Array Deployment and in preparation to be submitted to a journal in the near future. The second part (Shear wave splitting study) has not been presented anywhere else.

Abstract Body: Seismicity in the New Madrid Seismic Zone (NMSZ) remains an enigma with no agreed upon driving mechanism hypothesis. In order to address this issue we present detailed P and S wave velocity models for the crust and upper mantle structure of the NMSZ. We also use the SplitLab processing environment to measure shear wave splitting of teleseismic SKS phases recorded at seismic stations in the NMSZ to map the orientation and strength of the mantle fabrics beneath this region.

We use data from January 2011 to date recorded by the broadband USArray Transportable Array (TA), Northern Embayment Lithospheric Experiment (NELE) project stations and Cooperative New Madrid Seismic Network broadband stations. NELE is a lithospheric-scale passive array experiment. Fifty stations of the TA form the basic grid. 51 Flex Array (FA) broadband stations are used to form three profiles over a two-year deployment (July 2013 to June 2015) and an additional 6 FA broadband stations are moved to fill in the TA grid in six month intervals in order to increase the background spatial resolution in velocity structure from 70km to about 35km.

For the tomographic study, we use arrival times from local earthquakes and travel time residuals from teleseismic earthquakes recorded by the three networks. We perform a joint local and teleseismic inversion using the TOMOG3D inversion code of Zhao et al., (1994) to determine the velocity structure. Our results indicate a consistent low velocity anomaly in both the Vp and Vs solutions at about 200-300 km depth. Checkerboard tests show that the spatial resolution is high in the upper mantle especially for the Vp model and fairly high in the crust for most of the study area.

For the SKS splitting study we select events (Mw ≥ 6.5) from the global centroid moment tensor catalog recorded by the three networks. We compare three inversion techniques simultaneously: the rotation-correlation method, minimum energy on the transverse component and the eigenvalue criteria. Preliminary results indicate a complex pattern of anisotropy beneath the study region. We combine the splitting results with the new, detailed P-wave and S-wave velocity models for the upper mantle to further our understanding of the driving mechanism of the NMSZ intraplate earthquakes and allow us to better assess the associated seismic hazard.

Abstract ID: 34305

Final Number: T24A-0380

Title: Superior Layer-cake: An Investigation of the Mid-Lithospheric Discontinuity in the Superior Craton in Quebec, Canada

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Co-authors: Vadim L Levin, Rutgers University, Piscataway, NJ; Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC, Canada; Huaiyu Yuan, Macquarie University, Kensington, WA, Australia

Published Material: Most of the data was presented at the AGU Fall 2014 meeting, though an investigative focus of the MLD (and geologic interpretation) is new.

Abstract Body: The Superior craton has some of the thickest lithosphere on the planet, extending as deep as ~250 km, as suggested by elevated shear wave speed, considerations of heat flow, petrology of xenoliths, electrical resistivity etc. However, in the Superior the most significant decrease in shear wave speed with depth (over 10 m/s per 1 km of depth) does not correspond to the expected lower limit of the lithosphere. Rather, the continent-scale shear-wave velocity model of Yuan et al (2014) puts it at depths of ~125 km within the Superior. In the velocity model, the vertical extent of this region of large negative shear wave speed gradient is approximately 50 km.

P-to-S converted waves from teleseismic earthquakes offer a way to detect abrupt changes in seismic properties in the upper mantle, and may be used to determine the depth and the vertical extent of such abrupt changes.

We produced P-to-S receiver function (RF) gathers for 5 long-term seismograph stations, utilizing 5.0 and greater magnitude teleseismic earthquakes from the period 2000-2013. For each station, we constructed RF gathers arranged by back-azimuth and epicentral distance, to identify phases that can be associated with horizontal discontinuities within the crust and upper mantle. We also use newly collected data from a portable seismic array between Lake Mistassini and James Bay to augment the data from the permanent stations.

We detect clear negative P-S conversions consistent with an abrupt decrease in shear wave speed. Their delays range from 6 to 9 s, corresponding to the depths between 60 and 90 km. Similar observations are found in most cratons, and give rise to the concept of a Mid-Lithospheric Discontinuity (MLD). Conversions from the MLD in the Superior craton appear clearly in RFs with frequencies up to 0.5 Hz, suggesting a relatively abrupt boundary with a vertical extent of ~2 km or less.

We use seismic velocities from the model of Yuan et al (2014) and the timing of pulses in our receiver function time series to develop more precise estimates of the depth to the MLD in the Superior. Also, we use synthetic seismogram computations in simple layered models to evaluate vertical profiles of seismic properties within it.

Abstract ID: 35309

Final Number: T24A-0381

Title: Seismic constraints of the crustal structure of the Appalachian Front: An investigation of the St. Lawrence River Valley

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Co-authors: Vadim L Levin, Rutgers University, Piscataway, NJ; Andrea Servali, Rutgers University, Piscataway, NJ; Michael Klaser, Rutgers University New Brunswick, Highland Park, NJ

Abstract Body: Lithosphere beneath the present day Appalachian Front (AF) experienced three major tectonic events over the last 1.5 Ga. First, the crust to the west of the AF was formed and consolidated by the Grenville Orogeny. At ~620 Ma the Iapetus Ocean began to open, leading to rifting and possible thinning of Grenville crust. Subsequently, the closure of Iapetus and the Taconic, Acadian, and Allegenhian orogens sutured the Applachian crust onto pre-existing Grenville crust.

Most reconstructions of the Appalachian orogeny envision a thin-skin tectonic regime, where thrust sheets of relatively small thickness are emplaced onto the pre-existing continental margin of the thick-skinned Grenville tectonic regime. In this view, the crustal structure on the opposite sides of the modern AF should be very similar, specifically in the deep crust. Alternatively, if the Iapetan rifting event broke up and separated blocks of Grenville basement, then the deep crustal structure of the Appalachians, Iapetan rift and Grenville terrain should have features that reflect their individual geologic setting. The underlying basement of the Appalchians and Iapetan rift does not have to be similar to the Grenville's, and we would expect a major difference in deep crustal structure on the opposing sides of the AF.

We use seismic data from a group of long-operating seismometers on the banks of the St Lawrence River, and also data from recently installed portable observatories in the region. We employ teleseismic receiver function analysis methodology to construct detailed descriptions of seismic properties in the crust on opposite sides of the AF.

Our preliminary results show that while the thickness of the crust is similar (~50 km), on both sides of the AF, the internal structure of the crust is highly variable on lateral scales of ~20 km. Our density of observations in the St. Lawrence region helps us relate this complexity to the tectonic events that shaped the lithosphere.

Abstract ID: 35388

Final Number: T24A-0382

Title: Detailed study of the Moho boundary in the Superior province of Quebec.

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Co-authors: Michael Klaser, Rutgers University New Brunswick, Highland Park, NJ; Benjamin Dunham, Rutgers University, Piscataway, NJ; Vadim L Levin, Rutgers University, Piscataway, NJ

Abstract Body: Our project focuses on the description of the Moho discontinuity beneath the Superior Province in Quebec. We determine the depth to the Moho, its sharpness, and investigate such attributes as inclination, and relationships with the other discontinuities within the crust.

Our highly descriptive observations are facilitated by a large amount of clear data collected over a decade from long-operating seismic stations in Quebec. Also, we include data gathered by a temporary seismic array placed between Charlevoix and James Bay. We use teleseismic P wave data and carry out receiver function analysis to identify P to S converted waves.

To investigate the sharpness of the Moho we examine the shape of the P-to-S converted phase associated with it at different frequencies, from 0.25Hz to 2-3 Hz. To determine whether there is a systematic dip in the Moho we use directional changes in the timing of this pulse.

In the northern part of the Superior Province the Moho is very sharp. Converted waves with frequencies up to 2Hz are observed, suggesting a vertical change in seismic properties over a few hundred meters. This is not the case close to the Grenville Front, where a complex signature at high frequencies suggests a more diffuse crust-mantle boundary.

A very clear signature of the regional dip in the Moho is found at a site close to James Bay, while sites further south show a relatively flat Moho boundary. The finding of a dipping Moho in the oldest part of the Canadian Shield is surprising, and documents long preservation of the signature of past tectonic events.

Abstract ID: 34636

Final Number: T24A-0383

Title: Appalachian Front is a Shallow Feature: Insight From Studies of Seismic Wave Speed in the Mantle

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Co-authors: Vadim L Levin, Rutgers University, Piscataway, NJ; Trevor Neitz, University of Maine at Farmington, Farmington, ME; Brandon Schow, Stanford University, Monument, CO; Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC, Canada

Published Material: 20% at 2014 Fall AGU Meeting

Abstract Body: The Appalachian Front (AF) is a major feature in the surface geology of eastern North America, separating 0.4 Ga old Appalachian terranes from the 1.2 Ga Grenville Province. North of Quebec City, it strikes northeast-southwest, and is approximately collocated with the St. Lawrence River. We use a group of long-operating seismic observatories that straddle the AF in Charlevoix region of Quebec, and a new portable array of observatories extending northwest and southeast from it, to investigate the seismic wave speed in the upper mantle beneath a region extending from the Archean craton near James Bay, across the AF, to the Appalachian terranes of coastal Maine.

Travel time delays of teleseismic P waves indicate that although the mantle tends to be faster in the craton 100-200 km northwest of the AF and slower in the Appalachian terranes 100-200 km southeast of the AF, there is no significant vertical boundary in the uppermost mantle (100-150 km) directly beneath the AF. Furthermore, the cross-strike variability (relative to the AF) is not in a form of a uniform decrease of mantle P velocity from James Bay to coastal Maine, but instead has two en echelon gradients (neither of which aligns with the AF). The Appalachian upper mantle is very heterogeneous (much faster in New Brunswick and northern Maine than in southern New England), and these heterogeneities are not aligned with the strike of the AF.

Stations on both sides of the AF in the Charlevoix region detect strong birefringence in SV-polarized teleseismic shear waves. The nature of birefringence is complex, with considerable scatter in individual observations. There is, however, no systematic difference in birefringence observed by sites on the "Grenville" and "Appalachian" sides of the AF, confirming that this tectonic boundary does not extend into the upper mantle. We detect a distinct pattern of birefringence in shear waves arriving from a narrow range of north-western back-azimuths (330-360NNW). Directional limits of this anomalous birefringence pattern, and the strength of the teleseismic P wave travel-time delay offset suggest a presence of a distinct upper-mantle feature to the NW that is faster, and has distinct rock fabric. A good candidate for such a feature would be an underplated oceanic slab preserved within the body of the craton since the time of its formation.

Abstract ID: 34416

Final Number: T24B-0384

Title: Glacial erosion during orogenesis: A study of the intraplate Eurekan Orogeny of Ellesmere Island.

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Abstract Body: The Eurekan Orogeny of northeastern Ellesmere Island in the Canadian arctic was formed as a result of mountain-building processes in the Paleogene. The orogen developed relatively distant from any active convergent plate boundaries making it a representation of a class of intraplate mountain-building. In this work we investigate the geodynamics of the Eurekan and in particular focus on the potential role of glacial erosion in modifying the orogenesis. The study is motivated by important recent research that has demonstrated a significant interaction between (climate-controlled) surface processes and solid Earth tectonics at collision. Glacial erosion is thought to have the capability of eroding at a rate which matches with that of rock uplift in active orogens, referred to as the “buzz saw” effect of glaciers. Using the geodynamic modelling code of SOPALE we developed forward 2D models of the idealized Ellesmerian lithospheric structure and imposed shortening to explore Eurekan-style orogenic deformation. In the numerical experiments, we modified the erosional algorithm in the model such to investigate various implementations of the glacial buzz saw. The model results show how the surface topography and internal lithospheric structure of the orogeny are modified by variable glacial erosion. In addition to illustrating how the Eurekan orogeny may have evolved, the results provide insight into how the generic orogenic zones may develop in a glacial environment.

Abstract ID: 35912

Final Number: T24B-0385

Title: Computational Modelling of the Continental Collision near South Island, New Zealand

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Abstract Body: Among tectonic plate boundary types, the process of continental collision is poorly resolved, especially compared to the evolution of subduction, spreading, and transform plate boundary systems. There is still debate about the first-order response of the mantle lithosphere (sub-crustal lithosphere), such as whether there is distributed pure shear-type thickening, subduction-like consumption of the sub-crustal portions of the plate, or a combination of these two. This work explores in more detail a number of questions regarding the dynamics of the coupled crust and mantle lithosphere at continental collision. It focuses on the active continental convergence occurring at the South Island of New Zealand as a natural prototype for collision. The modest amount of shortening in this collision and relative abundance of observational constraints make this an ideal locale for studying the geodynamic processes of early orogenesis — a key step in understanding continental collisions generically. An important feature of the South Island tectonics is the highly oblique nature of the plate collision meaning high rate of along-strike material transfer. The oppositely verging subduction zones bounding the collision likely have their own influence on the deformation. However, previous studies on modelling the dynamics of the South Island collision have not included these important factors in the direction parallel to the plate boundary; instead considering this as a two-dimensional problem. In the scope of the research, we are conducting 3D geodynamical modelling to explore these tectonic questions for the collision. Here, we present the first results of forward computational modelling of the transpressional lithospheric system demonstrating the influence of rheology and varied rates of strike-slip versus convergent plate motion on the structures formed.

Abstract ID: 36557

Final Number: T24B-0386

Title: Sharp Mantle Tansition from Cratons to Cordillera in Southwestern Canada

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Abstract Body: The Western Canada Sedimentary Basin (WCSB) marks the transition from the old North American continental lithosphere to young accreted terranes and Cordillera. Earlier studies in this region have suggested a large number of intricate basement domains as well as major seismic velocity gradients in the mantle. To investigate the effect of the accretion and subduction on the mantle structure beneath the western margin of the North American craton, we analyze P-to-S converted waves from upper mantle discontinuities from Canadian Rockies and Alberta Network (CRANE). The depths of the 410 and 660 km seismic discontinuities are correlated and are, on average, 9 km and 7 km greater than the respective global estimates. The largest depression is observed beneath the Rocky Mountain foreland belt in southern Alberta, which highlights a steep south/westward structural gradient from cratons to Cordillera at lithospheric mantle depths. The severity of the depressions, especially in the southernmost Alberta, may be triggered by diffuse partial melt or increased water content above the mantle transition zone. This result is jointly corroborated by locally increased impedance contrast across the 410-km discontinuity and a strongly depressed 660-km discontinuity. The existence of, and the mantle processes associated with, a Mesozoic slab fragment may be responsible. Overall, the availability of local arrays, particularly the CRANE network, offers a new window into the history of the lithosphere and upper mantle beneath the southern WCSB.

Abstract ID: 33237

Final Number: T24B-0387

Title: The Gravity and Magnetic Field Characteristics of North China Area and Its Tectonic Significance.

Presenter: Xiaohong Meng, China University of Geocsience, Beijing,

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Abstract Body: The Bouguer gravity and aeromagnetic anomaly data sets of North China Craton are finely processed and the method such as anomaly separation, reduction to equation pole by varying declination angles, tectonic feature extraction are used to obtain enhancing and comparative results. With comprehensive understanding of MT and other geological results, the identification of tectonic units and faults by gravity and magnetic field are preformed and the 3D distribution of density contrast and equivalent susceptibility in the scale of lithosphere are obtained.

The framework of regional gravity field in North China can be summarized as “East high and west low for regional gravity field, three vertical and two horizontal for gradient gravity zone”. The magnetic field has high amplitude, complex for negative and positive characteristics and also has different kinds of trends.

From the northeast to southwest four orogneic belts and eight tectonic units can be identified according to the corresponding gravity and magnetic field. Four orogneic belts include central Asian orogneic belt, Yinshan orogenic belt, central orognic belt and Qinling orogenic belt. Eight tectonic units consist of Alashan block, Qinlian block, East Kulun block, Songpan block, Eastern block， Western block, Yangtze Block and Sulu block. In addition, eleven main faults can be recognized by gravity and magnetic lineament.

The 0-40km and 0-15km 3D subsurface distributions of density contrast equivalent susceptibility in North China Craton are obtained by 3D gravity inversion and 3D correlation for gravity and magnetic data respectively. The analysis shows that the central orogenci belts region has an overall low density contrast. With increasing depth, density contrast changes by a larger range. The south, north, middle abnormal variations are not identical. This discrepancy may be illustrated by the south, north and central orogneic belt experienced different geological process, and also implies that the lithosphere destruction in North China may have extended from the eastern block to the area. Similarly, the magnetic distribution of North China Craton is not uniform for shallow to deep region in each block units. The boundaries of most tectonic belts are approximately located at the transitional belts of high and low magnetic distribution.

Abstract ID: 34913

Final Number: T31A-02

Title: Experimental Characterisation of Slip Properties in Similar and Dissimilar Volcanic and Sedimentary Rocks during Flank Motion at Mount Etna (Italy)

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Published Material: They will be presented in-part at EGU2015

Abstract Body: The edifice of Mount Etna (Italy) is structurally unstable, exhibiting near-continuous ESE sliding along a set of faults that results from interplay between regional tectonics, gravity instability and magma intrusion. Ground deformation and seismic monitoring reveal large-scale flank motion at variable rates. However, the mechanisms controlling this faulting remain poorly constrained. Examination of the fault zones reveals a range of rock types along the different fault segments: fresh and altered basalt, sandstone, clay and limestone. Here, we experimentally investigate the frictional properties of these rocks using rotary shear tests on similar and dissimilar rocks, to better understand episodes of slow flank motion as well as potential rapid and catastrophic sector collapse events.

Experiments were performed at velocities up to 1.2 m/s and at normal stresses up to 1.5 MPa, commensurate with depths of the contacts in the Etna edifice. Friction experiments on solid rocks show a wide range of mechanical behaviour. At high velocity (>0.6 m/s) volcanic rocks tend to melt whereas the clay and limestone do not; rather they decarbonate, which prevents the rock from achieving the temperature required for melting. Experiments on dissimilar rocks clearly show that shear resistance on the slip zone is intermediate between the shear resistances of each component rock individually. Host rock composition affects the composition and viscosity of the resultant frictional melt, which causes fault weakening or strengthening depending on the combination of host rock samples. Friction experiments on clay gouge show the strong rate-weakening dependence of slip in this material as well as the release of carbon dioxide. The range of lithologies encountered by the fault system at Etna serve to complicate the model for flank instability, but these results provide important insights to realistic slip behaviour.

Abstract ID: 35222

Final Number: T31A-03

Title: Joint Electrical-Elastic Properties of Berea Sandstone

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Abstract Body: The aim of this research is to investigate the cross-property relationships between electrical and elastic properties of sandstone to improve the joint inversion of seismic and electromagnetic monitoring surveys in a CO_2 sequestration context. We conducted a laboratory study of the impact of pressure change on the P and S wave velocity, attenuation and electrical conductivity of Berea sandstone. Measurements were obtained varying both the confining and the pore pressure in the 0-40 MPa range. Similar measurements were performed on a porous alumina rod with different petrophysical properties as a comparison. The four properties mentioned above are found to follow the exponential equation Z(P)=A+BP+Cexp(-DP) where the parameter D is universal for the properties under consideration.

Abstract ID: 33472

Final Number: T31A-04

Title: Seismic Properties from EBSD Data and Receiver Function Analyses: Results from a Crustal-Scale Detachment System, Aegean Region

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Published Material: Only part of the results were previously reported, at the Geological Society of America Annual Meeting (Denver, CO) in 2013. These findings are not yet submitted to any journal.

Abstract Body: The crystallographic preferred orientations were measured on a suite of samples representative of different structural depths along the West Cycladic Detachment System of Greece. Electron backscatter diffraction (EBSD) analyses were conducted on calcitic and mica schists, impure quartzites, and a blueschist, and average seismic properties of the rocks were calculated with the Voigt-Reuss-Hill average of the single minerals' elastic stiffness tensor. The calcitic and quartzitic rocks have P- and S-wave velocity anisotropies (AVp, AVs) averaging 8.1% and 7.1%, respectively. The anisotropy increases with depth as represented by the blueschist, with AVp averaging 20.3% and AVs averaging 14.5%, due to the content of aligned glaucophane and mica, which strongly control the rock seismic properties. Localised anisotropies of high magnitudes are caused by the presence of mica schists as they possess the strongest anisotropies, with values of 26.6% for AVp and 23.9% for AVs. The direction of the fast and slow P-wave velocities occurs parallel and perpendicular to foliation, respectively, for most samples. The fast propagation has the same NE-SW orientation as the lithospheric stretching direction experienced by the Cyclades since the Late Oligocene. The maximum shear wave anisotropy is subhorizontal, similarly concordant with mineral alignment that developed during extension in the Aegean. Our results strongly favour radial anisotropy in the Aegean mid-crust over azimuthal anisotropy. Receiver functions (RF) for several stations in the Cyclades have been calculated to characterize the underlying crustal structures, such as anisotropy. We present preliminary results of RF post-processing, which will be used in conjunction with velocities and anisotropies from our EBSD data to build a seismic velocity model. This model, based on rock textures and seismic observations, will be helpful for understanding the crustal structure of an extensional province.

Abstract ID: 36514

Final Number: T31A-05

Title: Experimental Determination of the Elastic Anisotropy of Shales: Comparison of Static and Dynamic Measurements

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Published Material: Similar material presented at the Geoconvention in Calgary that is running at the same time as this meeting.

Abstract Body: Interest in the physical properties of unconventional reservoir rocks, which are often all characterized as 'shales', has accelerated due to the rapid growth in the use of hydraulic stimulation for the recovery of hydrocarbons. Similarly, it has long been known that such rocks are anisotropic and this has significant implications for proper seismic imaging. We are currently making measurements of the elastic anisotropy of such materials under the assumption they are transversely isotropic. An array of strategically oriented P- and S-wave PTZ ceramics are mounted directly to a specially machined prism of the core material in order to capture the wave speeds in a number of different directions. The measurements are conducted under hydrostatic confining pressures. Strain measurements are simultaneously obtained to allow for comparison of static to dynamic moduli. We observe high levels of anisotropy of up to 25% or more in both P- and S-wave speeds. More interestingly, we see that the physical properties parallel to layering are nearly independent of pressure while those perpendicular to layering show significant nonlinearity with pressure. Heuristically, this is likely a result of the preferential layering of both minerals and pore shapes.

Abstract ID: 34637

Final Number: T31A-06

Title: Seismic Properties and CPO Relationships of a Crustal Scale Shear Zone in Granodiorite, Serifos, Greece

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Co-authors: Élise Cossette, University of Ottawa, Montréal, Canada; David A Schneider, University of Ottawa, Ottawa, ON, Canada; Bernhard Grasemann, University of Vienna, Vienna, Austria

Abstract Body: Serifos island is the southern-eastern terminus of the West Cyclades Detachment System, where a late-tectonic granodiorite pluton exhibits ductile to brittle structures due to ongoing extension accommodated by the shear zone. The crystallographic preferred orientations (CPO) of samples collected across a strain gradient were measured using electron backscatter diffraction and seismic properties were calculated using Voigt-Reuss-Hill averaging. All samples show bulging quartz grains with brittle fractures and the weakly deformed granodiorite exhibits feldspars with straight, sharp boundaries. Quartz in the moderately deformed samples is recrystallized, feldspar grains have serrated boundaries and mica crystals are bent. In the mylonite, the magmatic quartz grains recrystallize by a combination of dislocation glide and bulging resulting in a smaller grain size, suggesting a significant component of shear strain. Quartz CPO is very strong in the weakly deformed sample recording prism <a> slip and is very weak in the mylonite. Orthoclase and anorthite possess a weak CPO in all samples suggesting that temperatures were too low for feldspar to deform by dynamic recrystallization (450-500°C for Fsp, compared to 250°C for Qz). All but the less deformed samples have similar directions for fast P-wave velocity and slow P-wave velocity for anorthite. Orthoclase P-wave and S-wave velocities are similar for only the highly deformed samples. Also in highly deformed samples, there appears to be a relation between the maximum P-wave velocity and the CPO of anorthite. The S-wave anisotropy of the weakly deformed granodiorite is the highest of all samples (maximum anisotropy: 8%), and the anisotropy of the mylonite is the weakest of all samples (maximum: <3%). Texture analysis provides

information on the seismic anisotropy of variably deformed granodiorite, which can be considered as a good approximation of bulk crustal material.

Abstract ID: 36602

Final Number: T31A-07

Title: Magnitude and symmetry of seismic anisotropy in schists and geophysical implications

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Abstract Body: We have calibrated the magnitude and symmetry of seismic anisotropy in various schists by laboratory measurements at pressures up to 600 MPa and analyses of EBSD fabrics in order to evaluate whether seismic properties of the schists can be reasonably well approximated by a transverse isotropic (TI) symmetry. The average bulk anisotropy values for chlorite schists, mica schists, phyllites and sillimanite-mica schists at 600 MPa are 12.0±4.1%, 12.8±5.6%, 12.8±9.0% and 18.4±4.4%, respectively. These schists show much higher V_p anisotropy (13.1±6.1%) than other categories of metamorphic rocks such as granitic gneisses, felsic mylonites, granulites and peridotites. V_p anisotropic pattern of the schists depends mainly on the interference effects between mica and quartz. Basal slip of mica causes $V_p(X) \approx V_p(Y) >> V_p(Z)$ while prism <a> slip of quartz increases $V_p(Y)$ but decreases $V_p(X)$. Accordingly the quartz-mica schists display $V_p(Y)>V_p(X)>V_p(Z)$. However, schists containing considerable volume fractions of quartz deformed by prism <c> slip show $V_p(X)>V_p(Y)>V_p(Z)$. Mica schists containing amphibole, kyanite and sillimanite are of orthorhombic symmetry due to the needle minerals whose fast c-axes are aligned preferentially parallel to the lineation. The average polarization direction of fast split SKS and SKKS waves (ϕ) between the Ailao Shan-Red River fault zone and the Nabang Fault zone in west Yunnan is 110±19°, which is approximately parallel to the absolute plate motion (APM) of the region but at high angles with the strikes of the crustal fault zones. The average delay time is 1.58±0.44 s. However, Pms phases, which are generated at the Moho and their wave path are confined within the crust only, display their fast polarization directions parallel essentially to the strikes of the fault zones and splitting times of up to 0.45 s with typical values of 0.30 s. Hence, S-wave anisotropy in the west Yunnan is consistent with a model of two anisotropic layers: the upper layer related to frozen fabrics of mica-rich and amphibole-bearing rocks within the crust, which deformed during folding and strike-slip shear, whereas the lower layer related to present-day APM-driven flow in the lithospheric mantle and asthenosphere. The data indicate that mechanical decoupling occurs between the crust and mantle of the region.

Abstract ID: 34000

Final Number: T33A-03

Title: The Grabens, Canyonlands National Park, Utah: Gravity Slide of the Paradox

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Abstract Body: The Grabens, Canyonlands National Park, Utah is an area of arcuate horsts and grabens formed by extending and gliding Pennsylvanian and Permian brittle rocks down dip towards the Colorado River over the Pennsylvanian Paradox salt. Dissolution and deformation of salt enhanced the extensional fracture system, widening individual fractures. Slumped blocks that constrict river flow and create rapids are evidence that gravity gliding is still active.

Scaled analogue models were constructed with sand and silicon to recreate brittle layer extension as the underlying salt deforms on a slightly inclined sliding plane. During the early stages, deformations within the ductile layer resulted in unequal thickness, exhibiting areas of spreading and compression where deep-seated, normal or reverse faults bounding the horsts and grabens form. During spreading, shallow-penetrating faults developed within existing horsts and grabens in the distal and medial areas and propagated towards the source area. Extensional features in the analogue slide translation and source zones are similar to the Grabens area and its vicinity east of Shay Mountain.

We suggest that a large, multi-stage and slow-moving gravity driven slide affects the Canyonlands area west of the Shay Mountain up to the Colorado River. It is caused by a deforming salt layer underneath. Deformation factors including basement faults; sinking basin; and sediment overburden were present by the end of Middle Pennsylvanian. The slide was triggered by Shay Mountain intrusion during the Cretaceous as evidenced by uniform thicknesses of Late Triassic overburden in the Bridger Jack and Boundary Butte. The sliding translated the upper brittle layer initially towards the northwest and eventually to the west due to thicker and stronger sedimentary confinement to the north. When the Colorado River in the west started eroding the toe of the translating mass during the Middle Miocene, retrogressive failure started, forming The Grabens.

Abstract ID: 34071

Final Number: T33A-04

Title: Two earthquake sequences along the Selaha and Zheduotang branches of the Xianshuihe fault, southwest China, and implication for aseismic transient slip on continental transform faults

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Abstract Body: During one week since 22 November 2014, over 900 earthquakes of $M<6$ struck the northwest of Kangding within a distance of ~30 km on the Xianshuihe fault in southwest China. This intense seismicity are two earthquake sequences initiated by two large events: November 22 (UTC 08:55:25) Mw 5.9 and November 25 (UTC 15:19:07) Mw 5.6, along the Selaha branch and the Zheduotang branch respectively. The inversion results of slip distribution from InSAR images taken between September 26 and December 5, 2014, show the optimal dip angle of the seismogenic fault is ~84°, and the maximum slip of the first earthquake sequence is 0.5 m. Using a rigidity of 30 GPa, the geodetic moment is 2.45×10^{18} N m, which is about two-fold the total seismic moment (equivalently Mw 6.0) accumulated during the same time period. This implies that there was probably aseismic slip between these two earthquake sequences. The along-strike migration velocities of seismicity in the first ~5 hours after two large events are both ~ 5 km/hr, which is on the order of the propagating speed (km hr^{-1}) of seismicity driven by aseismic slip on tectonic transform faults [Roland and McGuire, 2009]. However, the occurrence of two

earthquake sequences does not completely decrease the seismic risk of a big earthquake on this Kangding segment of Xianshuihe fault, which has accumulated seismic moment up to 7.15×10^{18} N m since the 1955 M7(1/2) event [Jiang et al., JGR, 2015; under review].

Abstract ID: 34619

Final Number: T33A-05

Title: AMS Investigation in the Pingluoba and Qiongxi Anticlines, Sichuan, China: Implications for Deformation Mechanism of the Qiongxi Structure

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Published Material: This research has been recently published in Tectonophysics.

Abstract Body: Stratigraphic attitude is one of the most important field data for structural geology research. However, it is difficult to measure directly sometimes, especially in weak deformed sediments with low dip angle. Pingluoba anticline, mainly consisting of medium-high dip angle strata, is located on the Longmen Shan fold-and-thrust belt front. Qiongxi anticline is located in the southwestern Sichuan Basin, and it is mainly composed of sub-horizontal to low dip angle strata. An investigation of the anisotropy of magnetic susceptibility (AMS) in 78 sites has been carried out in these two folds. Stepwise demagnetization of three orthogonal isothermal remanent magnetization suggests that hematite is the main magnetic carrier mineral in the Qiongxi anticline, meanwhile, hematite and magnetite are both existing in the Pingluoba anticline. It reveals three types of magnetic fabrics: sedimentary magnetic fabic, initial deformation magnetic fabric and pencil structure magnetic fabric, which indicate weak deformation. Throughout AMS theoretical analysis and example test in the Pingluoba anticline, magnetic fabric is a suitable technique to confirm the stratigraphic attitude in weak compressional deformed sediments. For the sedimentary magnetic fabric, initial deformation magnetic fabric and one atypical initial deformation magnetic fabric developed in the weak deformed tectonic superposition region, dip direction of bedding plane = pitch direction of K_3＋(or－) 180°, and dip angle of bedding plane = 90°－pitch angle of K_3. 38 stratigraphic attitudes with low dip angle in the Qiongxi anticline have been rectified by magnetic fabric results. Qiongxi structure is a weak tectonic superposition deformation anticline. The deformation mechanism of Qiongxi structure may contain two stages: NW-SE compression stage started from the latest Cretaceous-early Cenozoic and nearly E-W shortening stage in the Late Cenozoic.

Abstract ID: 35251

Final Number: T33A-06

Title: 3-D seismic velocity structure of Kumaon-Garhwal Himalaya: Insight in to Main Himalayan Thrust and earthquake occurrence

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Abstract Body: We present a detailed three-dimensional *P*- wave velocity (V_p) and *Vp/Vs* structure for the Kumaon-Garhwal Himalaya generated by inverting arrival times of 1180 local earthquakes recorded by 50 broadband stations operated during April 2005 - June 2008. The upper crust (< 20 km) show heterogeneous structure in this region. In the near surface (upper 5 km), south of Main Frontal Thrust (MFT) is characterised by low V_P (~5.2 - 5.4 km/s) and low V_P/V_S (~1.67 - 1.72) that could be impression of unconsolidated sediments. We observe that the earthquakes are localized in the regions of low V_P (~ 5.3 - 5.7 km/s) and low V_P/V_S (~1.6 - 1.72) in the upper crust (< 20 km) possibly due to the presence of quartz-rich rocks. To the north of Main Boundary Thrust (MBT) a low velocity (V_P ~5.7 km/s) layer is observed at 10-15 km depth. This could be signature of the Main Himalayan Thrust (MHT) in this region. At the depth of 18 - 25 km beneath the Main Central Thrust (MCT) zone an isolated zone of anomalous V_P ~5.7-6.0 km/s and V_P/V_S ~1.75.1.85 is observed. This is just below the maximum concentration of seismicity and coincides with the low resistivity zone reported by magneto telluric studies. This could be interpreted as possible presence of fluids due to metamorphic dehydration reaction during underthrusting of the Indian crust. The presence of fluids around and below the seismogenic zone can influence the activity of the fault system; it can affect the long-term structural and compositional evolution of the fault zone, and can alter the fault-zone strength and local stress regime. As fluids enter the active faults in the crust (such as the MCT zone), fault zone friction decrease facilitating the stress concentration in the seismogenic layer leading to mechanical failure. We, speculate that the earthquake occurrence in the Kumaon-Garhwal Himalaya is not only due to stress caused by collision tectonics, but also associated with the lithology of the region.

Abstract ID: 34878

Final Number: T34A-0396

Title: Stress state of the central part of the Zagros Foreland Folded Belt, Iran

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Abstract Body: NW-SE trending of the Zagros Foreland Folded Belt (ZFFB) developed during Mio-Pliocene Arabia-Eurasia convergence. Tectonic convergence is still ongoing and intense seismicity in the ZFFB. Our study area covers the Eastern Zagros (Fars area) with significant set of nearly N-S trending right-lateral strike-slip and several NW-SE trending thrust faults. These lateral fault zones play a major kinematic role by matching the change in shortening state through the study area. Multiple detachment levels (e.g. Hormuz Salt) allow decoupling of deformation between the basement and the cover. Such decoupling of deformation controls the stress conditions between different units within the cover sequence and the brittle crust. In order to reconstruct the paleo and recent stress conditions, we analyzed fault slip and focal mechanism data sets using stress inversion method. Our results show the compressional regimes from Miocene to recent with an anticlockwise change in the direction of main compression stress through time, consistent with variation in Arabia–Eurasia convergent path. Based upon the evidence of pre-syn-folding stage of faulting, it suggests a general NE-SW trending of σ1 axis with no significant change in long term seismicity through the study area. On the other side, the inversion of earthquake focal mechanism shows NNE to N-S compression with a low ratio between differential stresses. It suggest that not only the shortening within the thick sedimentary cover of the Zagros

(~12 km) completely decouples from the brittle crust deformation, but our results also mention to a possible non-completely-aligned decoupling due to the obliquity of the shortening directions in the sedimentary cover with respect to the basement.

Abstract ID: 33315

Final Number: T34A-0397

Title: Evolutionary model of oblique rift basins-Study of Central African Rifts

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Abstract Body: The geometry of oblique-rifting basin has relationship with the acute angle – α-between the rift trend and trend of tensile stress. In this study, we simulated the formation of oblique-rifting basin by Particle Flow Code 3-Dimensions-(PFC 3D) and drew a comparison between the simulation results and the evolutional models of Doba basin, Doseo basin and Salamat basin in Central African Rifts. The main theory of PFC 3D is based on the Discrete Element Method (DEM) which a whole model framework is established by applying different parameters to the every particles in the model.

There are two big-model sets in this study, Model-set1 and Model-set2. Model-set1: The model is divided into two blocks according to the rift trend. Both blocks are applied two tensile stresses parallel to the y-axis. Model-set2: Set the plate below the model. The plate is divided into two plates according to the rift trend. A fixed -tensile velocity parallel to the y-axis is applied to the both plates. The α is set at 90°, 75°, 60° and 45° in both model-sets. The study results indicated that 1. The en echelon faults in the rifting basins are sub-vertical to the trend of tensile stress. 2. The density of en echelon faults in rift basins decrease gradually when α is close to 45°. 3. By comparison with the α value of the Central African Rifts, we reckon that the α of the Doba Basin, Doseo Basin and Salamat Basin are 60°, 60° and 75°, respectively. 4. The Doba basin- wide and shallow- is a mesoscale rift basin, while the Doseo basin and the Salamat basin- narrow and deep- are megascale rift basins. We proposed that the petroleum systems of Doba basin and Doseo-Salamat basin are different.

Abstract ID: 34404

Final Number: T34A-0398

Title: Structural, geochronological, and geochemical analysis of a Cycladic detachment system II: Results from the Lavrion Unit, Greece

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Abstract Body: The West Cycladic islands comprise the footwall of the West Cycladic Detachment System (WCDS), characterized by a system of high and low angle normal faults that cuts different structural levels of the Cycladic Blueschist Unit (CBU). Whereas the hanging wall has mostly been eroded on the islands, the Lavrion peninsula preserves the Lavrion Unit, interpreted to be the upper structural levels of the WCDS. The main foliation is a compressional crenulation cleavage with ENE-WSW to NE-SW stretching and intersection lineations. Kinematic indicators reveal top-to-SSW sense of shear, and along the detachment both units are overprinted by cataclastic deformation and high-temperature metallic ore mineralization. Glaucophane and chlorite pseudomorphs of glacophane are preserved. New single-crystal Ar-Ar geochronology on muscovite from the Lavrion Unit yields ages between 35-28 Ma, and together with published zircon (U-Th)/He dates of 16-12 Ma and preservation of glaucophane suggests these rocks did not witness the dominant Miocene greenschist facies deformation that characterizes the WCDS. One muscovite sample along the west coast at Thimari yielded an Ar-Ar age of c. 175 Ma and maybe part of the Sub-Pelagonian Berzekos Unit. Moreover, the geology of Lavrion peninsula is strikingly similar to Serifos island on the southeast termination of the WCDS. Pinning the ends of the detachment system, the geology of Lavrion and Serifos both include late-tectonic granodiorite plutons intruded at c. 10 Ma into the low-angle normal fault that cuts different structural levels of the CBU, which preserves an Eocene-Oligocene cooling signature and ENE-WSW trending lineations. The western Cyclades including the Lavrion peninsula can be resolved into a coherent and uniform tectonic progression commencing in the Eocene involving ENE-WSW to NNE-SSW ductile to brittle extension through the Miocene, localized plutonism at the tips of the detachment system, and relatively rapid cooling of the footwall.

Abstract ID: 34630

Final Number: T34A-0399

Title: Structural, geochronological, and geochemical analysis of a Cycladic detachment system I: Results from the Kamariza Unit, Greece

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Abstract Body: The Lavrion peninsula of Greece marks the northern terminus of the West Cycladic Detachment System (WCDS), a low-angle normal fault system accommodating extension under ductile-brittle condition. The Kamariza unit comprises the lowest structural levels, and is composed mainly of greenschist facies marble and schist recording SSW-directed kinematics. We have collected samples to conduct Ar-Ar geochronology on white mica in an attempt to better understand the thermal history of this extensional terrane. In the schists, white mica is abundant, defining the main foliation and locally forming a secondary SC foliation with mica fish structures; in the marble samples, white mica is rare. In all samples, the quartz and calcite crystals are recrystallized and quartz often has bulging grain boundaries. Chemical maps show that the white mica has a dominant muscovite composition and is strongly zoned within samples yielding younger cooling ages. Mica from the Kamariza unit yields Early to Middle Miocene Ar-Ar ages, and coupled with Late Miocene zircon (U-Th)/He ages and top-to-SSW shear sense, suggests these rocks experienced the same extensional tectonism as the other WCDS footwall exposures on Makronisos, Kea, and Kythnos. Relatively rapid exhumation initiated decompressional melting in the Late Miocene generating the Plaka pluton as well as attendant hydrothermal fluids. Fluid infiltration along the brittle detachment metasomatized the host marbles resulting in high-temperature Mississippi Valley Type deposits. Some of our mica ages may reflect reheating associated with mineralization. Similar to the tectonic history on Serifos, the final extensional movements along the low-angle normal faults took place at rather shallow depths, postdating the intrusion and illustrating the >10 m.y. evolution of the detachment system.

Abstract ID: 33521

Final Number: T34A-0400

Title: Magma production rate along the Ninetyeast Ridge and its relationship to the Indian plate motion and the Kerguelen hot spot activity

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Abstract Body: The Ninetyeast Ridge (NER), a linear trace of the Kerguelen hot spot in the Indian Ocean, was emplaced on a rapidly drifting Indian plate. Magma production rates along the ridge track are computed using gravity-derived excess crustal thickness data. The production rates change between 2 and 15 m3/s over timescales of 3-16 Myr. Major variations in magma production rates are primarily associated with significant changes in the Indian plate velocity with low production phases linked to high plate velocity periods. The lowest magma production rate (2m3/s) at 62 Ma is associated with the rapid northward drift of Indian plate under the influence of the Reunion mantle plume. The contemporaneous slowing of the African plate coincides with increase in magma production rate along the Walvis Ridge in the Atlantic Ocean. The present study suggests that variations in the Indian plate motion and frequent ridge jumps have a major role in controlling the magma production, particularly on long period cycles (~16 Myr). Short-period variations (~5 Myr) in magma productions may be associated with intrinsic changes in the plume, possibly due to the presence of solitary waves in the plume conduit.

Abstract ID: 34736

Final Number: T34A-0402

Title: Thick sediments in the central Ganga basin: evidence from magnetotelluric investigations

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Abstract Body: The collision of the Indian and the Eurasian plates around 55 million years ago and flexing of the Indian plate created a foreland basin south of the Himalaya, named as the Indo-Gangetic basin. The sedimentation in the basin by the giant Himalayan Rivers and their tributaries has led to the deposition of a thick sequence of sediments masking the underlying rocks and tectonic features of the Indian plate. Mapping of the thickness of these sediments is of immense importance for the assessment of earthquake hazard potential due to amplification of seismic waves. Since a large population lives in this basin, it is necessary to quantify the thickness of sediments in the basin and use this information in site amplification studies. We have carried out a magnetotelluric (MT) investigation along a 285 km long profile across the central Ganga basin to delineate the sedimentary thickness in this part of the basin. MT time series processing and transfer function analysis of the data of 39 sites in the frequency range of 0.001-1000s has been carried out for this purpose. The subsurface electrical resistivity section obtained after the inversion of MT data reveals a significant contrast in the geoelectric structure along the profile. The sedimentary thickness at the northern end of the profile, close to the Himalayan foothills, is estimated to be more than 9 km, which is considerably thicker than the average thickness of 4 to 5 km used in flexural modeling studies. The high conductivity of sediments together with the high Vp/Vs ratio obtained by a seismological study in the Ganga basin implies poorly consolidated nature of the sediments and, thus, high seismic hazard potential.

Abstract ID: 35839

Final Number: T34A-0404

Title: Geometrical and Kinematic Setting of L-tectonites in the Tongbai Orogenic Belt, Central China

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Abstract Body: L-tectonites are well developed and widely distributed in the Tongbai orogenic belt in central China. The orogenic belt as a whole has an antiformal geometry and the hinge of the antiform is subhorizontal and trends west-east. The L-tectonites occur in the core of the antiform, in a zone that is ~20-40 km wide and over 100 km long. Lineations in the L-tectonites are subhorizontal, parallel to the hinge of the antiform. Sheath folds are also well developed associated with the L-tectonites, with the hinges parallel to the lineations.

The L-tectonite zone is bounded by two ductile shear zones, on the north and south side, respectively. Well-developed shear sense indicators indicate that the southern and northern shear zones have a dextral and sinistral sense of shear, respectively. The L-tectonite zone is capped by a sub-horizontal shear zone with the hanging wall moving west relative to the footwall. These geometrical and kinematic data indicate that the three shear zones are likely part of a single shear zone that wraps around the L-tectonite zone. The L-tectonite zone in the core moves east relative to the hanging wall. The development of the tectonites is interpreted to be a result of this special geometry and kinematics. Available geological and geochronological data indicate that this took place in Early Cretaceous. Magmatism in late Cretaceous affected but did not significantly change the overall geometry.

Abstract ID: 34888

Final Number: T34A-0405

Title: Transpression vs. simple shear superimposed on inherited pure shear – methodology for a more refined kinematic analysis

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Abstract Body: Determination of the extent of shortening that accompanies simple shearing in transpressional shear zones is of great importance to regional deformation studies. A kinematic method is developed here to discriminate between combined pure and simple shear deformation (i.e. general shear - transpression/transtension), and cases where the simple and pure shear occurred at distinct times in a specific lithology within the shear zone. The following assumptions should be valid for the selected lithology: (i) the non-coaxial shearing is the last deformation event; (ii) the strain field prior to this last shearing event was homogeneous; (iii) no strain recovery has occurred during or after the last deformation event; and (iv) the last shearing event operated at constant

strain rate. The method involves determination of the states of finite strain at different locations within the selected sheared lithology as input parameters. The finite incremental strain is then calculated from the finite strain using any standard methodology, e.g. Horsman & Tikoff (2006). Thereafter, assuming constant strain rate, more precise estimates of the *infinitesimal incremental* strain can be obtained by taking roots of the *finite incremental* strain. Restriction of finite strain determination to a specific lithology eliminates errors arising from the presence of pre-shearing finite strain inhomogeneities in lithologies of varying competencies. Thus, this method can be used to distinguish whether the last shearing event within a lithology of a particular shear zone was one of general shear, or a case of simple shearing superimposed on earlier, inherited pure shear deformation. This method has been applied to a quartzite unit in a major, crustal-scale shear zone in the eastern Indian shield, to demonstrate that shortening features in the unit are temporally unrelated to the later, dominantly simple shear strike-slip event.

Abstract ID: 33037

Final Number: T34B-0406

Title: Earth evolution as a thermal system

Presenter/First Author: Chunan Tang, Organization Not Listed, Dalian,

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Abstract Body: After fifty years of plate-tectonic theory, the reasons why the Earth sometimes froze as a snowball or sometimes became lethally hot resulting in mass extinction remain enigmatic. Here we propose a new model on the Earth evolution as a thermal system. The unbalance of heat between input and output is considered as the driving force for the Earth evolution, the lithospheric expansion and associated uplift are the triggers, the self-organized progressive failures following certain scale law in terms of fracture spacing leading to the crust collapse of the Earth (CCE) are the amplifier, and the global scale response in terms of volcanism and magmatism is the globalizer. These shallow processes of lithosphere may reach a critical state with a positive feedback loop, and result in the formation of Large Igneous Provinces (LIP) in a top-down pattern. Endothermic phase changes during de-compressive melting remove heat from the inner Earth and cool their surroundings, including the upper parts of the lithosphere. The huge loss of the Earth's heat during eruption of LIPs, together with the endothermic cooling, may put the thermal cycle to an end and a new start of the thermal cycle initiates. In summary, Earth drives itself to evolve in terms of thermal cycles. Global cooling and warming are the two stages of many cycles during the Earth evolution. The LIPs are the extreme results of global warming, whereas glaciations are the extreme results of global cooling, with a long recovering age, the interglacial stage, between them. They come and go as thermal cycle evolves, with climate warming, being caused by the Earth itself rather than by external forces or human activities, as the most attractive prediction.

Abstract ID: 33130

Final Number: T34B-0407

Title: Nuclear Planetology

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Abstract Body: Earth-like planets, like free-floating planets of few Jupiter masses or ultra-cool Y dwarfs, may be regarded as the low-mass extension of the stellar population. Nuclear planetology is a new research field, which aims at constraining the evolution of such ultra-substellar objects in the light of nuclear astrophysics and particle physics. For example, based upon findings from ^{187}Re-^{187}Os nuclear geochronometry [1-2], it is argued that the Earth's core contains Re-Os isotopic signatures of at least two rapid (r) neutron-capture process events: The 13.78 Ga old component, represented by the signature of a komatiitic basalt [5085 BasKom] [3] from the BGB, South Africa, is assigned to the Earth's inner core. The other signatures identified so far within pyroxenites/komatiites [2] are assigned to its outer core, due to the gravitational collapse of the old component ≈ 3.48 Ga [1]. Supporting evidence comes from recent SCP measurements showing increasing paleointensities of the Earth's magnetic field from 3.55 Ga to 3.45 Ga [4]. Hence, the following conceptual model is suggested: A gravitational core collapse ≈ 3.48 Ga would compress matter and pre-existing magnetic field lines, thus increasing field strength and magnetic pressure. The latter, together with nuclear repulsive forces, centrifugal forces and thermal expansion prevents the core from collapsing further; the bounce fractures the Achaean crust, thus initiating the transformation from stagnant lid to plate tectonics. If this conceptual model can be further constrained, it may be concluded that those planets within the habitable zone going through a gravitational core collapse with subsequent nuclear element synthesis and increasing magnetic field strength are suitable candidates for carrying life.

[1] Roller (2014), *GSA Abstr. with Programs*, **46**, 323. [2] Roller (2014), *Abstr. S51B-4444*, Fall Meeting, AGU. [3] Birck *et al.* (1994), *EPSL* **124**, 139 – 148. [4] Cottrell *et al.* (2014), *Abstr. GP53A-3752*, Fall Meeting, AGU.

Abstract ID: 34121

Final Number: T34B-0408

Title: Secular cooling and crystallization over 1Ga of partially molten Archaean felsic crust

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Co-authors: Célia Guergouz, , , ; Cecile Fabre, University of Lorraine Nancy, Nancy Cedex, France; Stéphanie Duchene, , ,

Abstract Body: Archaean cratonic nuclei, with an average thickness of about 40 km, are dominated by gneisses exposed in the core of crustal-scale domes delineated by greenstone belts. The emplacement of komatiites implies partial melting in a mantle with a temperature 200-300°C higher than the present-day one. Similarly, the widespread occurrence of high-temperature metamorphic mineral assemblages, and of former partially molten rocks (migmatites) attest for a high geothermal gradient within the crust. The geochronological record of the oldest cratonic nuclei typically span over a billion years which is classically interpreted as reflecting a succession of continental growth/reworking events associated to lithospheric scale dynamics. In contrast, geophysical data combined with the petrological analysis of xenoliths from the subcontinental mantle suggest that the formation of a depleted relatively buoyant lithospheric mantle root allowing for the stabilization of these cratons, occurred at the early stage of the Archaean crust accretion. In this contribution, we use present-day thermal and lithologic structure of Archaean cratons to calculate its thermal evolution considering solely the effect of secular exponential decrease of HPE (^{238}U, ^{235}U, ^{232}Th, and ^{40}K) with time, and discuss the implications in terms of Archean dynamics and crustal differentiation. This modelling shows that Archaean cratonic nuclei, characterized by an initially high geothermal gradient at 4.0 Ga with a Moho temperature close to 1000°C and a thickness for the thermal lithosphere limited to 130km, remained partially molten for about a billion years after their formation, despite a potential rapid stabilization at the lithospheric scale. This result provides a new key for the understanding of the peculiar tectonic evolution of Archaean cratons marked by (i) widespread deformation characterized by crustal-scale structural domes, and (ii) protracted (polyphased?) high-temperature metamorphism and magmatism.

Abstract ID: 34586

Final Number: T34B-0409

Title: Implications of Surface Boundary Conditions on Evolution of Mantle Thermal Structure

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Published Material: Glišović, P., and Forte, A. M., 2014. Importance of initial buoyancy field on evolution of mantle thermal structure: implications of surface boundary conditions, Geoscience Frontiers, DOI: 10.1016/j.gsf.2014.05.004

Abstract Body: It is now understood that the dynamic impact of plates plays a crucial role in the evolution of the Earth's mantle flow - organizing and modulating cold downwellings and hot upwellings. The use of a plate-like boundary condition over very long geological time intervals, however, requires consideration of which geological era were likely characterized by modern plate-tectonic activity dominated by motions of a few large plates. Differing interpretations of the geological record suggest that modern-style plate tectonics began to operate either at around 2.7 Ga or at around 1 Ga. Some evidence also suggests the possible presence of a stagnant or sluggish lid at the top of the mantle during pre-plate tectonic period. This leads us to explore the use of a rigid surface to model surface mechanical conditions during the Archean (or in terrestrial planets without plate tectonics: Mercury, Venus, Mars). To carry out this modelling we use a dissipative and compressible 3-D pseudo-spectral method for calculating mantle convection with Earth-like vigour. We find the rigid-surface boundary condition yields remarkably stable and long-lived convection patterns that are therefore dependent on the starting configuration (i.e., a long-term "mantle memory") and that the dominant wavelength of mantle flow is also sensitive to the depth variation in rheology. Models with a plate-like boundary condition demonstrate that the most stable (i.e., steady-state) pattern of downwellings is dominantly hemispherical. However, the evolution of subduction zones may be influenced by the mantle-wide flow driven by deeply-rooted and long-lived superplumes since Archean time.

Abstract ID: 34703

Final Number: T34B-0410

Title: Mapping the Transition to the Stagnant-lid Regime in Variable Core Size Spherical Shell Convection with a Temperature-dependent Viscosity

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Co-authors: Julian Philip Lowman, University of Toronto, Toronto, ON, Canada; Frederic Deschamps, Academia Sinica, Taipei, Taiwan; Paul J Tackley, ETH Zurich, Zurich, Switzerland

Abstract Body: Many features of the behaviour of mantle convection in the terrestrial planets are dependent on the relative sizes of the core and planet surface areas. In previous studies implementing Cartesian geometry models, convection in strongly temperature-dependent viscosity fluids was investigated for a range of viscosity contrasts and Rayleigh numbers. The viscosity contrasts give rise to convective regimes widely described as mobile-lid, transitional (or sluggish)-lid, and stagnant-lid. For systems with small core-to-planet radii ratios, f, the combinations of Rayleigh number and viscosity contrast required for stagnant-lid convection differ substantially from what is found for f values greater than 0.5. Accordingly the first challenge in modelling stagnant-lid convection with small cores is to find parameter combinations that will yield surface stagnation. In the present study, a series of isoviscous convection calculations with rigid top boundary conditions were performed, to model the steady state characteristics of stagnant-lid convection in a spherical annulus. Utilizing existing parameterizations, the mean temperatures of these calculations are then used to predict surface Rayleigh number and viscosity contrast parameters for the stagnant-lid regime as a starting point for a search for finding the parameters (surface Rayleigh number and viscosity contrast) associated with the delineation of mobile surface and stagnant-lid convection in small core planets ($f < 0.5$). Geotherms are used to distinguish between convective regimes characterized by a stagnant-lid versus mobile systems. Findings from several full 3D spherical shell calculations are compared to the 2D model results to test whether our method of determining the appropriate viscosity contrast and Rayleigh number is accurate.

Abstract ID: 36504

Final Number: T34B-0411

Title: Ophiolite obduction in the Precambrian

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Abstract Body: Ophiolites are and not recognized in the geological record before 1 Ga and only become abundant after 800 Ma. Hence, different hypothesis have been proposed to explain this major shift in plate tectonics.

In a recent study on modern subduction zones, Vogt and Gerya (2014) have proposed that serpentinized mantle may provide a mechanically weak horizon along which basal detachment of oceanic crust is feasible. It has been suggested that deformation of this serpentinized layer may lead to decoupling and separation of oceanic crust from the downgoing slab. Subsequently, the oceanic crust is broken and obducted onto continental crust.

However, conditions for subduction were different in the past. The oceanic crust has been thicker and mantle temperatures have been higher. The resulting oceanic lithosphere was, therefore, more likely to resist subduction. Thus, bending-related fractures may have been less common for water to be transmitted downwards.

In a series of experiments using a 2D petrological–thermomechanical numerical model of oceanic subduction (Gerya and Yuen, 2003) we have systematically investigated the dependence of ophiolite obduction along serpentinized fracture zones in relation to upper-mantle temperatures and oceanic-crust thickness. First results indicate that detachment of oceanic crust from the downgoing slab becomes less likely with increasing temperatures and increasing crustal thickness. The transition from a hot to a cool subduction zone after 1Ga could therefore be a major factor controlling ophiolite obduction along partially serpentinized fracture zones.

Vogt, K. & Gerya, T. (2014). Deep plate serpentinization triggers skinning of subducting slabs. Geology, 42, 723-726.

Gerya, T.V., Yuen, D.A. (2003) Characteristics-based marker-in-cell method with conservative finite-differences schemes for modeling geological flows with strongly variable transport properties. Phys. Earth Planet. Interiors, 140, 293-318

Abstract ID: 33935

Final Number: T41A-01

Title: Lithosphere Temperature Constraints and the Thermal Control of Lithosphere Thickness

Presenter/First Author: Roy D Hyndman, Geological Survey of Canada Sidney, Sidney, BC

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Abstract Body: The lithosphere thickness, as defined by the boundary between conductive and underlying convective asthenosphere heat transport, is directly related to the thermal regime. Although local variations, thermal regimes and thicknesses are strongly bimodal; cold strong cratons (Can. Shield) with thicknesses of 200-250 km and hot weak backarcs (Cordillera) with thicknesses of about 60 km. Intermediate thicknesses appear to be transient. I first summarize the temperature constraints, and then discuss time variations in lithosphere thickness and their possible origins. Good temperature-depths require more than one estimator; the three principal are: (1) Heat flow-heat generation; upper crust radioactive heat is important; increasing temperature uncertainty with depth. (2) Mantle seismic velocity; temperature is the primary control of mantle velocity; some composition effects. (3) Upper mantle xenoliths; rocks torn off the conduit walls by kimberlites in cratons and volcanics in bacarcs that preserve insitu P-T. Continents divided into: (1) Hot backarcs like Cordillera (<50 Ma); (2) Cold cratons like Canadian Shield (thermotectonic age >500 Ma); asymptotically approach adiabatic below 200-250 km. (3) Transient conditions: Intermediate (50-500 Ma) cooling and thickening from hot backarcs following subduction termination (e.g., Appalachia); and second, rapid lithosphere thinning from cold-thick to thin-hot backarc regimes (e.g., Colorado Plateau). Some questions: Lithosphere thickness and the thermal regime are directly related, but which is the primary control? Why are craton lithospheres thick and backarcs thin? Craton upper mantles may be refractory so convection is limited to below ~200 km, but how was a special mantle formed if the lithosphere thickens with age from a formerly hot backarc? Vigorous backarc convection may result from viscosity reduction by subducted water, but how does it start? i.e., abrupt thinning of the lithosphere?

Abstract ID: 33810

Final Number: T41A-02

Title: Thermochemical Structure of the Hudson Bay Lithosphere, Northern Canada: Evidence from Multi-Observable Probabilistic Inversions

Presenter/First Author: Fiona Ann Darbyshire, University of Quebec at Montreal UQAM, Montreal, QC

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Published Material: About 30-40% of material was presented in an article: Darbyshire et al., 2013 (EPSL). About 80% was presented as an Invited talk at Fall AGU 2014.

Abstract Body: The Paleoproterozoic Trans-Hudson Orogeny (THO) was a Himalayan-style collision at ~1.8 Ga that brought together two of the largest North American cratonic blocks. The geometry of the collision is difficult to ascertain from surface geology, as much of the structure is concealed beneath the Paleozoic Hudson Bay intracratonic basin. However, seismographs placed around the periphery of the Bay have provided a wealth of data in recent years, allowing for regional-scale studies of lithospheric structure.

We use multi-observable probabilistic inversions to investigate the thermal and compositional structure of the Hudson Bay lithosphere. A joint inversion of Rayleigh wave phase velocities, geoid anomalies, elevation and surface heatflow is performed, giving a pseudo-3D model of the upper mantle.

Broadly, the Hudson Bay lithosphere is characterised by pervasive low temperatures and a high degree of chemical depletion. The thermal lithosphere is at least 250 km thick across the entire region, and may extend to 300 km depth in the centre of the Bay. The phase-velocity data are best explained by a stratified lithosphere, in which the upper layer is highly-depleted and the lower layer shows a slightly more fertile character (though still depleted compared to the average non-cratonic lithosphere). Within the upper layer, a relatively narrow zone of lower depletion is visible across the Bay and the Hudson Strait, coinciding with the inferred location of the THO collision zone. This zone likely preserves the signature of juvenile material trapped between the cratonic cores at the end of the THO collision.

Some outstanding issues remain; in some areas beneath the cratons, there is evidence from intermediate-period phase-velocities for anomalous mid-lithospheric structure. Variations in long-period phase velocities also suggest the presence of localised thermal heterogeneities in the sublithospheric mantle and transition zone beneath the region.

Abstract ID: 35197

Final Number: T41A-03

Title: Lithosphere Structure of Canada: Constraints From Ambient Seismic Noise Tomography

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Abstract Body: The continental lithosphere of Canada contains a record of the events that have shaped its formation and evolution over the last 4 Gyr. In this study, we provide an updated assessment of the crust and uppermost mantle structure of Canada using shear wave velocities (Vs) from a recent continental-scale ambient noise tomography model (Kao et al., J. Geophys. Res., v. 118, p. 5865-5887, 2013). The model is derived from Rayleigh waves recorded from 2003 to 2009 at 788 seismic stations throughout Canada and adjacent regions. The more uniform data coverage and higher frequency content of ambient noise provides better resolution of crustal structure than images based on earthquake waveforms. The ambient noise tomography model shows both regional and local spatial variations in Vs, with generally high crustal and mantle velocities in the Canadian Shield and lower velocities in surrounding areas, especially in the Cordillera. In many areas, the Moho is characterized by a velocity increase over ~2 km depth, but in some places (e.g., the southern Western Canada Sedimentary Basin, WCSB), a 6-8 km thick velocity gradation is observed, suggesting that this may be a zone of mixing between crustal and mantle

rocks or an area where the lowermost crust is partially eclogitized. Moho depth varies between 30 and 55 km, with the thinnest crust below the Cordillera and thickest crust below the southern WCSB. Within the Canadian Shield and Cordillera, the Moho depth exhibits significant relief over 100-500 km spatial scales, which is not reflected in the surface topography. Such Moho relief may be compensated by lateral variations in crust/mantle density structure. We are currently inverting the Vs model for lithosphere thermal and density structure to examine the implications for lithosphere composition, strength and surface topography.

Abstract ID: 35294

Final Number: T41A-04

Title: Temporal Evolution of the Lithosphere-Asthenosphere Boundary and its Effect on the “Diamond-Window” in the Western Superior Craton

Presenter/First Author: Karen Smit, Gemological Institute of America, New York, NY

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Co-authors: Graham D Pearson, University of Alberta, Edmonton, AB, Canada; Thomas Stachel, University of Alberta, Edmonton, AB, Canada; Michael Seller, , ,

Published Material: Findings in the abstract have been accepted as part of two scientific papers: in Journal of Petrology (2014: 55, 9, 1829-1863) and Contributions to Mineralogy and Petrology (2014: 167, 962).

Abstract Body: The Attawapiskat area of the Superior craton provides the ideal opportunity to evaluate the thermal and compositional effects of a rifting event on the cratonic lithospheric mantle. Rather than being a stable entity since Archaean craton amalgamation (2.7 Ga), the lithospheric keel records evidence for significant thinning, melt impingement and diamond destruction, all related to the impact of the Midcontinent Rift.

Kimberlites in the Attawapiskat area of the western Superior sample the lithospheric mantle at two time periods, i) during the Mesoproterozoic, concurrent to the 1.1 Ga Midcontinent Rift and ii) during the Jurassic.

Thermobarometry studies of peridotite xenoliths and xenocrysts from the two kimberlitic age groups reveal a temporal evolution of the lithospheric mantle beneath Attawapiskat. The Palaeoarchaean lithospheric keel was thinned to less than 180 km at the time of Midcontinent rifting. The rifting resulted in higher heat flow into the base of the lithosphere and appears to have caused diamonds residing in the deep lithosphere to be destroyed.

Small-degree rift-related melts infiltrated and refertilised the lithospheric mantle as evidenced by (1.) enrichment of incompatible trace elements in clinopyroxene, (2.) the generation of Mesoproterozoic Re depletion (T_{RD}) ages, and (3.) decreased Mg# in olivine (89 – 91).

After the thermal and igneous effects of the Midcontinent Rift subsided, the lithospheric root cooled and thickened, such that xenoliths erupted in Jurassic kimberlites define P-T arrays close to ‘typical’ cratonic geotherms - that correspond to crustal heat flow of ~ 40 mW/m^2. This thermal thickening of the lithospheric mantle led to the lithosphere-asthenosphere boundary being extended to depths of 200 km. This new stable, cooler and thickened cratonic root provided the optimum conditions for post-Midcontinent Rift diamond formation at Attawapiskat.

Abstract ID: 35165

Final Number: T41A-05

Title: Electrical Resistivity Structure of the Proterozoic Grenville Province Lithosphere

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Co-authors: Alan G. Jones, Dublin Institute for Advanced Studies, Dublin, Ireland

Published Material: This work forms part of a PhD thesis and a manuscript based on this presentation is still under review with Geophysical Journal International.

Abstract Body: The large-scale lithospheric resistivity images structure of the Proterozoic Grenville Province and its margin with the Archean Superior Province in southern Ontario is investigated with 84 MT sites, distributed across southern Ontario. Dimensionality analysis indicates dominantly 2-D resistivity structure below the Grenville Front and northwestern Grenville Province, with more significant 3-D responses to the southeast. It allows the division of the lithosphere into upper (45-150 km) and deeper (>200 km) mantle layers with regional strike azimuths of N85^{o}E (±5^o) and N65^{o}E (±5^o) respectively. The entire Grenville Province in southern Ontario is characterized by large-scale, laterally extensive, resistive lithosphere. The top of this feature is at about 45 km depth and the geometry of its base shows that the true thickness of the lithosphere in this region is about 280 km. This resistivity anomaly extends for about 300 km southeast of the GF from the exposed Superior Province and along strike for at least 800 km. This feature is interpreted to be Superior Province lithosphere and the corresponding N85^{o}E geoelectric strike to be associated with the fabric of the Superior Province. This Archean lithospheric root provided the stable basement for the Grenville orogen. A large region of enhanced conductivity in the lower lithosphere is attributed to the refertilization of the mantle lithosphere by fluids associated with the Cretaceous kimberlite magmatism. The results provide evidence for refertilization of a large volume of the lower mantle lithosphere by the passage of fluids. The enhanced conductivity is interpreted to be associated with the presence of water in nominally anhydrous minerals. A water content of 50 wt ppm was estimated based on average crustal heat flow, average resistivity at 180 km depth and temperature of 1220^{o}C. It is hypothesized that the strike direction measured in the deeper mantle of the study area was established in the Cretaceous and potentially records the plate motion at that time.

Abstract ID: 34439

Final Number: T41A-06

Title: The role of the temperature and stress fields for evolution of asthenospheric layers

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Published Material: Parts of results were presented in EGU 2014. No part is presently under review. Na part was recently accepted by a scientific journal

Abstract Body: The boundary between the lithosphere and the asthenosphere (LAB) is usually defined by a difference in response to stress. The reology of rocks depends on many factors but the basic differences of lithosphere and asthenosphere properties could be explained as a result of the temperature and pressure. The effective viscosity is proportional to C exp(A *q*), where *q* is the ratio (melting temperature/temperature), C and A are positive constants. The mantle is not molten, so *q*>1. In asthenosphere *q* is close to 1 and effective viscosity is low (e.g. 10^{18} Pa s).

In upper part of lithosphere *q* is high, but the temperature gradient in the lithosphere is high. Below the lithosphere, the gradient is low and the melting temperature is increasing with depth faster than true temperature. Hence, *q* and the viscosity reach minimum value below LAB and are increasing with depth. It is a typical situation..

Another important factor determining rheological properties is a stress tensor T. Generally viscosity is proportional to the power of the invariant of the stress tensor: I(T)^(1-n) where n is probably in the range from 3 to 5.

We investigate the processes of formation and evolution of low viscosity layers ("asthenospheric layers") in the upper mantle. The time scale of the temperature changes is of the order of 10 Myr. The characteristic time of stress changes could be much shorter depending on tectonic processes. Eventually processes of formation and vanishing of low viscosity layers is very dynamical. In a relatively short time (below 1 Myr) the pattern the viscosity distribution and velocity gradient could change substantially.

Using results from deep seismic sounding and surface wave tomography we have found that below some regions there are structures in the mantle that could be a forming/vanishing low viscosity layers. Reflectors in the lower lithosphere are observed beneath Trans-European Suture Zone between Precambrian and Palaeozoic platforms. In a thick Baltic shield lithosphere (200 km or more) low velocity zones and seismic reflectors are observed in the depth range 60-100 km, which could be interpreted as mechanical low Vp velocity zones, in contrast to thermal velocity zone in deeper asthenosphere.

Acknowledgments: This work was partially supported by the National Science Centre (grant 2011/01/B/ST10/06653).

Abstract ID: 36544

Final Number: T41A-07

Title: On the History and Integrity of the Cratonic Lithosphere in Western Canada

Presenter/First Author: Yu Jeffrey Gu, University of Alberta, Edmonton, AB

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Abstract Body: The crystalline basement beneath the Western Canada Sedimentary Basin (WCSB) exemplifies a complex tectonic assembly of welded lithospheric fragments during the Paleoproterozoic era. Earlier studies have suggested extensive subduction, magmatism and accretion, especially along the boundaries of major tectonic blocks such as the Hearne and Rae provinces, Wabamun domain, Medicine Hat Block (MHB) and Trans-Hudson orogen. The existence and the state of the lithosphere beneath southern WCSB remain largely speculative, however, due to the thick Phanerozoic sedimentary cover and relatively few regional broadband seismic stations prior to 2006. In this study we combine teleseismic travel time data from the USArray, the Canadian National Seismographic Network (CNSN) and a recently established Canadian Rockies and Alberta Network (CRANE) to invert for a new P-wave velocity model of the mantle lithosphere beneath the craton-Cordillera transition region. We adopt finite-frequency kernels during the inversions to account for 3D finite-volume sensitivity to model and improve data coverage surrounding the geometrical ray paths. The P wave velocity decreases by more than 1 percent from Alberta Basin to the foothills of the Rocky Mountains at lithospheric depths, which suggests a sharp mantle gradient along the Cordillera deformation front. The stable cratonic lithosphere appears to extend down to a maximum depth of ~180 km beneath the Archean Loverna Block ---- the core of the Hearne craton. High mantle velocities are further observed beneath the controversial Medicine Hat Block (MHB) in southern Alberta. The complex shape of the lithospheric root beneath the MHB could be an indication of considerable erosion. Distinct high velocity anomalies beneath the Loverna Block and MHB, which are separated by lower crustal and average mantle velocities beneath the Vulcan structure (VS), suggest different Archean formation and collision histories between these two tectonic regimes. Overall, the mantle lithosphere beneath the craton-Cordillera transition region in southwestern Canada appears to be relatively intact down to 120-150 km depths.

Abstract ID: 33953

Final Number: T43A-01

Title: Pockets, conduits, channels, and plumes: structures beneath and within the continental lithosphere beneath western Mediterranean

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Abstract Body: Detailed upper mantle and lithospheric structure from the Canary Islands to Iberia have been imaged with data from recent temporary deployments and select permanent stations from over 300 broadband seismometers. The stations extended across Morocco and Spain as part of the PICASSO, IberArray, and Morocco-Münster experiments. We present results from S receiver functions (SRF), shear wave splitting, waveform modeling, and geodynamic models that help constrain the tectonic evolution of the westernmost Mediterranean, including orogenesis of the Atlas Mountains and occurrence of localized alkaline volcanism. Our receiver function images, in agreement with previous geophysical modeling, show that the lithosphere is thin (~65 km) beneath the Atlas, but thickens (~100 km) over a very short length scale at the flanks of the mountains. We find that these dramatic changes in lithospheric thickness also correspond to dramatic decreases in delay times inferred from S and SKS splitting observations of seismic anisotropy. Pockets and conduits of low seismic velocity material below the lithosphere extend along much of the Atlas to Southern Spain and correlate with the locations of Pliocene-Quaternary magmatism. Waveform analysis from the USC linear seismic array across the Atlas Mountains constrains the position, shape, and physical characteristics of one localized, low velocity conduit that extends from the uppermost mantle (~200 km depth) through the lithosphere up to the volcanoes in the Middle Atlas. The shape, position and temperature of these seismically imaged low velocity anomalies, topography of the base of the lithosphere, morphology of the subducted slab beneath the Alboran Sea, position of the West African Craton and correlation with mantle flow inferred from shear wave splitting suggest that the unusually high topography of the Atlas Mountains and isolated recent volcanics are due to active mantle

support that may be from material channeled from the Canary Island plume.

Abstract ID: 35257

Final Number: T43A-02

Title: Deformation within continental plates: Surface deflection and magmatism induced by lithosphere removal

Presenter/First Author: Huilin Wang, University of Alberta, Edmonton, AB

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Abstract Body: Many localized pulses of deformation have been found in the interior of continental plates, and in some cases, these can not be readily linked to regional tectonics. Further, beneath many regions, the lithosphere is found to be abnormally thin, and there is evidence for detached lithosphere material located at 100-200 km depth. One hypothesis is that the lower lithosphere has been gravitationally removed and been replaced by upwelling asthenosphere. This sudden removal abruptly changes the stress and temperature field in crust and mantle, which may generate localized transient basins/orogens and pulses of volcanism. Thus, studying this surficial evidence provides a window to investigate the deep mantle dynamics. 2D thermal-mechanical numerical models are used to explore the surface deflection and magmatism induced by gravitational lithosphere removal. We find that topography and magmatism are primarily controlled by lithosphere structure. In hot lithosphere (e.g., a back arc), the lithosphere is removed through small wavelength (<50 km) instabilities. Magmas can be generated through conductive heated of sinking lithosphere and through decompression melting of upwelling asthenosphere. Lithosphere destabilitization causes thickening of warm and weak crust, producing in isostatic uplift. The resulting surface topography either has small subsidence (<0.5 km) or generate a topographic high during the removal. In warm lithosphere (e.g., average Phanerozoic lithosphere), lithosphere foundering occurs on longer wavelengths (50-100 km). In this case, the only melts are from asthenosphere. The surface subsides, followed by a partial uplift as the instability detaches. In cold lithosphere (e.g., craton), the lithosphere removal has the longest wavelength (>100 km), and the surface can subside >1 km; however, no magmas are generated. In most models, lithosphere removal and the associated surface deflection and magmatism occur on time scales of a few Myr. After this, stress relaxation and surface cooling erase these expressions. Observational data from a number of regions (e.g., Sierra Nevada in California, Tibet in China, Puna plateau in the central Andes) are consistent with our models, suggesting that pulses of deformation and magmatism in these areas are related to local lithosphere removal.

Abstract ID: 33614

Final Number: T43A-04

Title: Plate Tectonics Beyond Plate Boundaries: The Role of Ancient Structures in Continental Lithosphere on Intraplate Orogenesis

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Abstract Body: The development of orogens that occur at a distance from plate boundaries (i.e., 'intraplate' deformation) infers a more complex argument for lithospheric and mantle interaction than the conventional plate tectonic theory allows. One hypothesis is the amalgamation of continental micro-plates leaves inherent scars on the crust and mantle lithosphere. Previous studies into continent-continent collisions identify a number of scenarios from accretionary tectonics that affect the crust and mantle (namely, the development of a Rayleigh-Taylor instability, lithospheric underplating, lithospheric delamination, and lithospheric subduction). Any of these processes may weaken the lithosphere allowing episodic reactivation of faults within continental interiors. Hence, continental convergence at a time after continental collision may cause the already weakened crust and mantle lithosphere to produce intraplate deformation. In order to better understand tectonic processes away from plate boundaries, we present suites of numerical models to identify the preferred style of deformation during continental shortening. Ancient structures are modeled by applying weak subduction scarring, changing the rheological conditions, and modifying the thermal structure within the lithosphere. The effect of climate-driven erosion and deposition on the tectonic structure of intraplate deformation is also addressed. We explore the relevance of the models to previously studied regions of intraplate orogenesis (including the Pyrenees in Europe, the Laramide and Eurekan orogenies in North America, Tien Shan orogen in Central Asia, and Central Australia). Our findings indicate that there exists a number of tectonic environments that can be produced relating to continental accretion, and that specific observational constraints to the local area (e.g., geological, geophysical, geodetic) are required to be integrated directly into the analyses for better interpretation. The models show that although rheological changes to the lithosphere can produce a range of deformation during continental convergence (i.e., crustal thickening, thinning, and folding), mantle weak zones from ancient subduction can generate more localized deformation and topography.

Abstract ID: 33075

Final Number: T43A-05

Title: Lithospheric and Upper Mantle Stratifications Beneath Colombia: Using Receiver Functions from S Waves.

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Abstract Body: The knowledge of the structure of the lithosphere is an important parameter to understand the evolution of the Earth and plate tectonics behavior. Seismic recordings of RSNC*/IRIS** stations are processed with S receiver function (SRF) technique to determinate the asthenosphere lithosphere boundary (LAB). The technique uses distant seismic events, 65° to 85° from the station, to detect the S wave and its Sp wave conversion at broadband-three component stations. To isolate the recorded phase is necessary to apply a rotation process to the components; this process takes the ZNE into the ZRT components through the back azimuth of the event, and then is necessary an extra rotation through the incident angle to obtain the LQT components. The L-component is almost free of the transverse energy from the S-wave and it is de-convolved from the Q-component to obtain the SRF. Once the FRS are gotten for all the events, it is performed a migration and move out correction to be able to stack the FRS. According to the distribution of the seismological stations, the structure of the lithosphere obtained is expected to be highly inhomogeneous; in fact the LAB depends on the azimuthal orientation. The results show that the LAB in Colombia is found between 90 and 120 km, the shallower is found under the stations located at the Caribbean Ocean and the subduction zone, whilst the deeper are on the continent. Also for each FRS appears two lobes in the records, showing two different structures that could be the Moho and the Conrad discontinuities.

Abstract ID: 34748

Final Number: T43A-06

Title: India's Fast Mesozoic Drift Linked to Continental Mantle Lithosphere Delamination: New Insights From (U-Th)/He Thermochronology of Dharwar Craton Kimberlites

Presenter/First Author: Sebastian Tappe, University of the Witwatersrand, Johannesburg,

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Abstract Body: Periods of significant continental uplift and erosion are believed to be caused by processes that operate within Earth's mantle. Among these processes are strong thermochemical upwelling and convective erosion of mantle lithosphere. Peninsular India is comprised of a collage of Archean cratonic blocks bounded by Proterozoic mobile belts. The basement blocks are overlain by remnants of thick sedimentary successions of Proterozoic basins ranging from 1.9 to possibly 0.7 Ga. Basin formation was accompanied by pronounced kimberlite magmatic activity across Peninsular India between 1.4-1.0 Ga. However, the tectonic setting of the Proterozoic basins and associated kimberlites remains poorly understood. In particular, the relationship to the coeval mobile belts, for which subduction processes have been invoked, is enigmatic. We are studying the (U-Th)/He systematics of a variety of kimberlite-derived minerals from across the Dharwar craton in an attempt to understand the burial and unroofing history of these small diamond-bearing magmatic bodies. Whereas previous studies suggested that basin inversion occurred during the Late Proterozoic, our novel perovskite (U-Th)/He thermochronology results suggest that the Dharwar craton crust was affected by nearby tectonothermal events during the Early Paleozoic assembly of Gondwana. Our apatite (U-Th)/He results indicate that diatreme root-zones of the once-buried 1.1 Ga Dharwar craton kimberlites were unroofed to within ~1 km of the Earth's surface during the Mesozoic, most likely during the Early Cretaceous. This timing corresponds to the break-up of Gondwana after which the Indian plate drifted for several hundred kilometers with record speed toward its current position. India's fast drift during the Mesozoic has been explained by significant plume-related delamination of its cratonic mantle lithosphere, which also appears to be the root-cause for km-scale uplift and erosion across Peninsular India during the Mesozoic.

UNION

Abstract ID: 33891

Final Number: U23A-01

Title: Hydraulic Fracture Growth Geometries in Unconventional Reservoirs: Closing Gaps among Perceptions, Predictions, and Reality

Presenter/First Author: Andrew Bunger, , ,

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Abstract Body: One of the challenges to informing the current discussion on the economic and environmental sustainability of the process of extracting hydrocarbons from unconventional reservoirs is the preponderance of gaps among our perceptions, model predictions, and the real geometries of hydraulic fractures. The basic problem starts with the fact that real geometries are never fully observed at reservoir scale. However, a synthesis of mapping data from mine-through experiments, monitored field experiments, natural and laboratory analogues, and coupled models that account for the role of the pre-existing fracture network on hydraulic fracture growth do provide an emerging picture, albeit still far from complete, of the basic drivers that lead to complex, network-like hydraulic fracture geometries in some cases but not in others. A similar synthesis is able to give at least a rudimentary understanding of conditions in which hydraulic fractures are expected to be well-contained within the targeted reservoir layer. Furthermore, there is a growing, yet far from complete, understanding of the dynamics that determine whether the idealized uniform division of injected fluid among multiple possible entry points can be achieved. But in spite of what is understood, or at least thought to be understood, about the drivers of various hydraulic fracture geometries, idealized and/or artistically-rendered sketches dominate the images of hydraulic fracture geometry that underpin not only the current public and technical discussions, but in many cases also the fracture geometries that are used as inputs to reservoir simulators upon which well design and production decisions hinge. This talk will synthesize data with modeling results with the aim of bringing closer alignment between the perceived and actual growth geometries achieved in hydraulic fracturing stimulations of unconventional reservoirs.

Abstract ID: 33948

Final Number: U23A-02

Title: AN OVERVIEW OF INDUCED SEISMICITY IN NORTHEAST BRITISH COLUMBIA: REGULATOR RESPONSE AND LESSONS LEARNED

Presenter/First Author: Dan Walker, British Columbia Oil and Gas Commission, Victoria, BC

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Co-authors: Jeff Johnson, British Columbia Oil and Gas Commission, Victoria, BC, Canada

Published Material: Some of this presentation has appeared in the British Columbia Oil & Gas Commission's December, 2014 report 'Investigation of Observed Seismicity in the Montney Trend'. Parts of this report were picked up by the media.None of this presentation has been submitted for publication to scientific journals.

Abstract Body: Since 1985, northeast British Columbia has experienced induced seismicity triggered by waterflood injection, waste water disposal and fluid injection during hydraulic fracturing. In December, 2014, the British Columbia Oil & Gas Commission (Commission) published its 'Investigation of Observed Seismicity in the Montney Trend'. This report summarizes induced events recorded since August 2013 and covers seven areas in northeast British Columbia currently being monitored for induced events. Two of these areas have clusters triggered by waste water disposal in the Mississippian Debolt zone. The other five areas, all within the Triassic, Montney shale gas trend, have event clusters triggered by fluid injection during hydraulic fracturing. The Commission's response to induced events has varied with the causal mechanism. Eagle waterflood induced events were successfully mitigated when the operator reduced injection rates. For the two waste water disposal wells currently triggering events in northeast British Columbia, the Commission is working with operators to reduce injection rates and find alternative disposal zones and locations. Hydraulic fracturing induced events present a unique mitigation problem. Injection pressure is much greater than at disposal wells and flowback is not practical until the well is put on production. Responding immediately to hydraulic fracture induced events is limited to avoiding known active faults, altering hydraulic fracture parameters or suspending operations. From a regulatory perspective, lessons learned since 1985 would include the following: 1) Sufficient regional and localized seismograph monitoring must be in place to characterize the events 2) Effective event reporting and mitigation strategies should be formalized and implemented. 3) The seismic history for operational areas should be

reviewed and the seismicity risk assessed 4) Procedures should be in place for the collection, sharing and release of seismological data 5) Research partnerships should be set up and supported to study the relationship between the operations and seismicity 6) Areas considered to be high risk for induced seismicity should be considered for exclusion from development.

Abstract ID: 34344

Final Number: U23A-03

Title: Shale Gas and Tight Oil Potential in Eastern Canada: Some Numbers and What Lay Behind Them

Presenter/First Author: Stephan Sejourne, Organization Not Listed, Montreal,

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Abstract Body: Unconventional reservoirs with variable potential for shale gas or tight oil have been identified in most provinces of eastern Canada. The resources are hosted primarily in onshore Late Cambrian to Early Carboniferous rocks although some speculative offshore potential also exists.

Where resource estimates have been proposed the numbers are invariably large, but in the absence of production history this potential is always qualified as an undiscovered, initially-in-place resource rather than a discovered reserve. While these estimates are based on strict geological, petrophysical and geophysical criteria, considerable uncertainties remain due to the scarcity of data and their possible lack of representativeness as it is often the case in initial stages of exploration. Beyond the initial resource assessments, key prospectivity drivers include the recovery rates, the geographical and regulatory constraints, the energy market and the political and social stability. Of course none of these parameters should be considered constant through time.

Overall, the current understanding of the shale gas and tight oil potential in eastern Canada is a necessary step forward but must be considered as a preliminary, semi-quantitative appraisal and should not bear an excessive weight in the debate over the pros and cons of a possible development of these unconventional resources. Regional, provincial-scale estimates convey the misleading impression that an entire basin will be ultimately covered with drill-holes while in practice only a few specific areas will prove to be worth developing in the long-term. Other – indirect – potentials are also part of the equation and have the benefit to strengthen the overall competitiveness of the provincial economies.

Abstract ID: 34371

Final Number: U23A-04

Title: Assessment of Potential Impacts of Shale Gas Development on Shallow Aquifers in the St. Lawrence Lowlands, Quebec, Canada

Presenter/First Author: Christine Rivard, Natural Resources Canada, , ON

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Published Material: Preliminary data have been presented in other conferences.

Abstract Body: The Upper Ordovician Utica Shale in the St. Lawrence Lowlands has a shale gas production potential, which was assessed by the industry between 2007 and 2010, until a *de facto* moratorium was imposed on shale gas exploration in Quebec. A total of 29 wells were drilled in this shale, of which 18 were subjected to hydraulic fracturing. Due to this limited number of wells, the Utica Shale is considered a frontier play and, therefore, the St. Lawrence Lowlands are viewed as a “virgin” area with regards to fracking. The Geological Survey of Canada initiated a project in 2012 in the St-Edouard area, 65 km south-west of Quebec City, to investigate whether this region is geologically at risk before drilling and fracking activities resume. This area was selected because the Talisman St-Édouard well is the most promising one drilled in the Utica Shale and it is also located in a region where several faults are present. Multi- source data are being used for this study and extensive fieldwork has been carried out, including sampling of groundwater, soil, core and drill cuttings, shallow seismic surveys (~800 m), borehole geophysics in shallow wells (30 to 150 m deep) and hydraulic tests in sediments and bedrock. Furthermore, geomechanical lab tests and chemical lab analyses, as well as interpretation of acoustic logs and deep seismic profiles are being done.

The anticipated outcomes of this work are two-fold. First, this work will provide a better understanding of potential impacts of shale gas development on shallow aquifers through the identification of possible natural connections between deep and shallow geologic formations. Second, the development of a methodology for the estimation of aquifer vulnerability relative to activities occurring at depth will be initiated based on this work. This methodology could serve as a basis for permit allocation and regulations to insure that needed studies are being conducted by the industry along with exploration activities.

Abstract ID: 34866

Final Number: U23A-05

Title: Induced seismicity from hydraulic fracturing and large volume wastewater injection: Revising the assessment criteria using results from recent swarms

Presenter/First Author: Katie M Keranen, Cornell University, Ithaca, NY

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Co-authors: Cliff Frohlich, Univ Texas, Austin, TX

Published Material: This presentation summarizes results of recent published studies in a number of journals, and discusses the need for revised criteria for induced seismicity.

Abstract Body: The United States midcontinent has experienced a dramatic increase in seismicity over the past seven years, led by Oklahoma, and accompanied by unusual earthquakes in England and Canada. During this time frame, the new technologies (and the expanded use of existing technologies) used to increase hydrocarbon production have significantly increased the fluid volume injected into the subsurface both for hydraulic fracturing and for wastewater disposal. Studies of these recent earthquake sequences have increased our understanding of fluid triggering. Rare cases also motivate modification of the commonly used criteria (Davis and Frohlich, 1993) for induced seismicity, specifically in the expectations for temporal and spatial correlations between injection rates, well locations, and seismicity. Recent potentially-triggered swarms have grown to cover hundreds of square kilometers: In the well-documented case of seismic triggering in the Paradox Valley region of Colorado, earthquakes occur up to 16 km from injection wells (King et al., 2014). Similarly, hydrogeologic models for central Oklahoma indicate that the region affected by increased pore fluid pressure (sufficiently high to trigger earthquakes) likely extends tens of kilometers from disposal wells (Keranen et al., 2014). Earthquakes in both cases have migrated and continued over 24 and 7 years, respectively. These swarms deviate substantially from existing criteria, though the majority of other cases of apparently triggered earthquakes near disposal wells and hydraulic fracturing operations are more closely aligned. Rapid, near-well seismic responses near hydraulic fracturing operations (e.g., Skoumal et al., 2014; Holland et al., 2012) imply high

hydraulic connectivity between the fault zone and injection wells. In contrast, sustained fluid injection at disposal wells, without accompanying fluid extraction, can create a migrating zone of perturbed fluid pressure capable of either activating seismogenic faults near the well on similarly short time frames, or at greater distances over years. Though challenging to compose criteria to encompass both scenarios, modifying to include long-term effects and net volume changes will aid regulators and be relevant for seismicity in regions of production, gas storage, and carbon sequestration.

Abstract ID: 33712

Final Number: U33A-01

Title: The new Science Plan of ICDP: Achievements and Challenges in Continental Scientific Drilling

Presenter/First Author: Uli Harms, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam,

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Abstract Body: Understanding the complex System Earth is despite great progress in deep geophysical sounding and modeling advances depending on samples and observations at depth. The rocks and fluids of our ever-changing planet contain matter, heat, energy, and life as well as archived records of what has gone before. These precious relicts and living systems need to be probed and monitored in situ and need to be collected and analyzed. The scientific results obtained by scientific drilling cover the spectrum of the earth sciences from climate change, natural hazards and earth resources to the origins and evolution of life on Earth. The need to drill has never been greater and requires addressing the needs of our growing population for energy, sustenance, and quality of life.

The International Continental Scientific Drilling Program, ICDP addresses these questions in terrestrial environments. It is an infrastructure for scientific drilling that facilitates outstanding science at globally important sites bringing together scientists and stakeholders from 24 nations. The new science plan for the ICDP addresses five scientific key topics including: Active Faulting and Earthquakes, Global Geodynamics, Global Cycles Effecting Climate And Environmental Change, Heat And Mass Transport, The Ubiquitous Hidden Biosphere, and Cataclysmic Events. Each of these themes is tackled with respect to socioeconomic relevance, past achievements are described and fundamental open issues, future scientific targets and recommendations are presented. Potential future science goals include man-made earthquakes, borehole observatories in active environments, drivers, feedback and tipping points of Earth climate, deep time studies of global cycles, harvesting magmatic geothermal heat at shallow depth, deep hard-rock and geothermal microbiology, basin-size impact craters. In addition, ICDP is planning to cooperate closely with other programs to open new joint targets such as land-sea drilling transects.

Abstract ID: 33620

Final Number: U33A-02

Title: Scientific Achievements of the Integrated Ocean Drilling Program (2003-2013) and International Ocean Discovery Program (2013-present)

Presenter/First Author: Keir Becker, Univ Miami - RSMAS, Miami, FL

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Published Material: Overview of results of first IODP in chapter by presenter in late 2013 Elsevier Book on IODP highlights, book title "Earth and Life Processes Discovered from Subseafloor Environments: A Decade of Science Achieved by the Integrated Ocean Drilling Program (IODP)", editors R. Stein, D. Blackman, F. Inagaki, and H.-C. Larsen

Abstract Body: This talk will present an overview of scientific and programmatic highlights of the Integrated Ocean Drilling Program (IODP, 2003-2013) and initial results from the first two years of the follow-on Integrated Ocean Discovery Program (also IODP). Results from the first IODP will be summarized with respect to the three main themes and eight initiatives of the IODP Initial Science Plan (ISP) “Earth, Oceans and Life.” The first IODP made significant contributions in the ISP objectives related to past greenhouse climates, rapid climate change and sea level history in the current icehouse world, subseafloor hydrogeology and biosphere, subduction zone seismogenesis, and accretion of oceanic crust formed at slow and fast spreading rates. The Science Plan for the second IODP, “Illuminating Earth’s Past, Present, and Future,” builds on the ISP to define four main themes with thirteen important scientific challenges to be addressed over the ten-year period 2013-2023. It is still early in that period, but proposal pressure is already strong across these themes and challenges. Expeditions early in the second IODP have made or will make a strong start at addressing two specific challenges: the role of subduction zones in generating continental crust and the control of regional precipitation exemplified by the Indian Ocean monsoon system. In addition, the new IODP is cooperating closely with ICDP to define a coordinated approach to “amphibious” drilling projects that require both at-sea and on-land drilling to be fully addressed.

Abstract ID: 33976

Final Number: U33A-04

Title: Integrating IODP-ICDP Drilling On The Mid-Atlantic U.S. Margin With Deep Sea Isotopic Records: Tectonics Or Eustasy?

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Co-authors: Gregory S Mountain, Rutgers Univ, Piscataway, NJ; Michelle A Kominz, Western Michigan Univ, Kalamazoo, MI; James V Browning, Rutgers University, Piscataway, NJ; James D Wright, Rutgers University, Piscataway, NJ; Robert E Kopp, Rutgers University New Brunswick, New Brunswick, NJ

Abstract Body: Drilling on the mid-Atlantic U.S. “passive” continental margin (New Jersey to Virginia) by ocean (DSDP/ODP/IODP Legs 150, 174A, & Exp. 313) and continental scientific drilling (Legs 150X, 174AX, and the Chesapeake Bay Impact Structure; funding by ICDP, NSF-EAR, NSF-OCE, the USGS, and various state surveys) has provided unprecedented recovery of Upper Cretaceous to Holocene sequences. Ocean drilling has provided a global array of deep sea coreholes allowing application of the $d^{18}O$ and Mg/Ca proxies for ice volume. Together, margin and deep sea cores allow two approaches for estimating sea-level changes:

1) backstripping of coreholes from the onshore coastal plain and continental shelf, progressively accounting for the effects of compaction, loading, and thermal subsidence; and 2) scaling deep-sea $d^{18}O$ records using Mg/Ca to remove temperature effects. Comparison of the two methods addresses the long-standing debate about the roles of global average sea-level change (eustasy) and tectonism on the stratigraphic record. Our scaled-isotopic and onshore backstripped sea-level estimates changes are remarkably similar on the Myr scale for the past 34 Myr and testify to the importance of glacioeustasy. The dominant beat in the icehouse world of the past 34 Myr is the 1.2 Myr tilt cycle; forcing for the greenhouse world of the Cretaceous-Eocene appears to be the 2.4 Myr eccentricity cycle. However, there are differences between the onshore and offshore and between New Jersey, Delaware, and Virginia on the 1+ Myr scale that we attribute to the influence of mantle dynamics, including effects of the subducting Farallon slab. The amplitudes of the offsets are

consistent with models of mantle dynamic topography that predict observed differences. Such changes in continental elevation explain the patchwork preservation of sequences and regional differences on this passive-aggressive margin; they also complicate estimates of the absolute position of globally averaged sea level, though glacioeustatic changes are well-constrained (better than ±10 m).

Abstract ID: 33526

Final Number: U33A-05

Title: IODP-ICDP Expedition 364: Drilling Chicxulub, the K-Pg impact structure.

Presenter/First Author: Richard A F Grieve, Natural Resources Canada, Ottawa, ON

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Co-authors: Joanna V Morgan, Imperial College London, London, SW7, United Kingdom; Sean Gulick, University of Texas at Austin, Austin, TX; Jaime Urrutia Fucugauchi, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico; Ligia L Perez-Cruz, UNAM National Autonomous University of Mexico, Mexico City, Mexico; Mario Rebolledo-Vieyra, CICY, Merida, Mexico

Published Material: Abstract submitted to 2015 Lunar and Planetary Science Conference.

Abstract Body: Joint IODP-ICDP drilling of the Chicxulub impact structure, Mexico is scheduled for early 2016. The current team of multi-disciplinary co-proponents team consists of some 28 researchers from 9 nations. Chicxulub is unique in the terrestrial impact record in that its formation is associated with a mass extinction event (K-Pg) and it has a (albeit buried) preserved peak ring structure. Although peak ring structures occur on the other terrestrial planets, there is no consensual agreement on either the formational mechanism or the nature of the rocks that form a topographic peak ring. A 1.2-1.5 km hole will be drilled offshore that will penetrate the crater's peak ring; thus, providing the first ground-truth data on a peak ring. Geophysical data indicate that the peak ring at Chicxulub is characterized by relatively low velocity and density material, suggesting that the rocks are highly fractured. Numerical models of large impacts require that target rocks behave temporarily in a fluid-like manner to facilitate the dramatic modification of a large bowl-shaped transient cavity resulting from the cratering flow-field to form a broad, flat final complex craters. Competing hypotheses for weakening include so-called thermal softening and acoustic fluidization. Sampling material at Chicxulub will allow the first study of the actual rocks of a peak ring, and better constrain the weakening mechanism and large crater formation. Other science goals include: detailed lithology and porosity of the target rocks, which are fundamental input parameters to models of ejecta interaction with the atmosphere and volumes of soot, dust and climatically-active gases essential for evaluating post-impact environmental change; mineralogical and geochemical studies related to post-impact hydrothermal systems and identification of the impactor type; and a series of biological and sedimentological studies of both the impact and post-impact lithologies.

Abstract ID: 36700

Final Number: U33A-06

Title: The Paleomagnetic Record of Continental and Ocean Drilling: The Only way Forward

Presenter/First Author: Joseph Stephen Stoner, Oregon State Univ, Corvallis, OR

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Published Material: I will summarize our present understanding of the field and then I will present new ideas on how we can move the field forward.

Abstract Body: Drilling provides the unique opportunity to sample otherwise inaccessible archives, acquiring otherwise unobtainable information. Paleomagnetism is often used to date such records, yet from a paleomagnetic perspective often the most exciting results are the information it provides on the past history of the geomagnetic field. These paleo-geomagnetic observations provide fundamental models of the core and the geodynamo, telling how and possibly even why the geomagnetic field changes. Because geomagnetic change is what all paleomagnetic stratigraphies are based upon, an improved understanding of the geomagnetic field influences how we can use it to tell time, as well as improving the precision and accuracy of standard techniques. Because sediment paleomagnetic records preserve only a low pass filtered version of the geomagnetic field and the largest extreme events only occurred in the more distant past, critical observations needed to study the geomagnetic field such as long, high-resolution, directional and intensity time series and expanded intervals of polarity transitions (reversals, excursions), can only be routinely obtained through drilling. Here I will discuss this symbiotic relationship between paleo-geomagnetism and drilling; outlining opportunities for future understanding, strategies for improved stratigraphies, and how such records will allow a more complete understanding of the geomagnetic field and all the processes that it governs.

Abstract ID: 35862

Final Number: U33A-07

Title: From Patagonia to Tasmania: Paleo- and Environmental Magnetism of Long Continental Records in the Southern Hemisphere

Presenter/First Author: Agathe Lisé-Pronovost, La Trobe University, Fitzroy,

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Co-authors: Michael-Shawn Fletcher, , , ; Guillaume St-Onge, University of Quebec at Rimouski UQAR, Rimouski, QC, Canada; Andy IR Herries, La Trobe University, Bindoore, VIC, Australia; Pierre Francus, Inst Nat Recherche Sci, Québec, QC, Canada; Bernd Zolitschka, University of Bremen, Bremen, Germany

Published Material: Published work on PASADO: Lise-Pronovost et al. 2013, 2014 and 2015.

Abstract Body: The sedimentary archive from Laguna Potrok Aike (52°S), Argentina, is the only continuous paleoenvironmental record from continental Patagonia that reaches back to the Last Glacial Period (106 m; 51,200 cal BP). On the other side of the hemisphere, Darwin Crater (42°S) in Tasmania, Australia, contains another long lacustrine sediment sequence (60 m) that spans several glacial cycles (< 780,000 cal BP). These two sites are critically located at the northern and southern limit of the Southern Hemisphere westerly wind belt, thus providing a unique opportunity to reconstruct past changes in aeolian activity and paleoclimate at both regional and hemispheric scales. Here we present rock-magnetic proxies of dust and wind intensity from the recent Potrok Aike Maar Lake Sediment Archive Drilling Project (PASADO) within the framework of the International Continental Drilling Program (ICDP). We also discuss preliminary results for a future continental drilling project at Darwin Crater in Tasmania. We will overview how the magnetic properties and physical grain size data from the PASADO record were used to develop magnetic proxies of dust and wind intensity in Patagonia. We will then evaluate the potential of using similar magnetic proxies in Tasmania by presenting preliminary data from Lake Selina, a low-resolution lacustrine

record that is proximal (50 km north) to Darwin Crater and which spans several glacial cycles. Preliminary results from the Lake Selina sedimentary archive reveal two magnetic mineral components: one of low coercivity (likely iron oxides such as magnetite) and one of high coercivity (likely iron sulfides). The high coercivity component is likely to reflect environmental changes, suggesting an excellent potential for paleoenviromental reconstruction based on the magnetic properties. Importantly, the low coercivity component displays a strong and stable magnetization with a geomagnetic inclination varying around the geocentric axial dipole value, indicating a likely genuine geomagnetic record that will significantly bolster the development of a robust and independent chronology at the site using an integrated dating strategy.

Abstract ID: 35014

Final Number: U33A-08

Title: Geophysical Studies of a Deep Borehole in the Canadian Shield in NE Alberta

Presenter/First Author: Douglas R Schmitt, University of Alberta, Edmonton, AB

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Published Material: Parts of this talk will be given at the DGG conference - Hannover, Germany in March. The VSP component has been published in the Int. J. of Geosciences.

Abstract Body: With the support of the German-Canadian Helmholtz-Alberta Initiative we were able to obtain support to carry out an extensive suite of geophysical investiations of a nearly 2.4 km deep borehole drilled through the sedimentary cover into 1.9 km of metamorphic rocks of the Taltson Magmatic Zone in NE Alberta. This geological unit is primarily a biotite gneiss. This work was motivated as part of geothermal reconnaissance studies in the search for low-enthalphy geothermal resources in Alberta. Regrettably, the temperature at the bottom of the well is only about 50 °C. Despite this, however, there are a number of pertinent findings of more general interest. Geophysical logging and borehole seismic investigations were jointly conducted by the GFZ-Potsdam and the University of Alberta, withadditional data provided by the owner of the borehole and in later commerical logging. Logs acquired are resistivity, magnetic susceptibility, full waveform sonic, dipole sonic, density, neutron, and ultrasonic televiewer. High resolution zero offset VSP data were obtained with a receiver spacing of 2.5 m from 1800 m to surface. A number of walk-a-way VSP measurements were also obtained simultaneous to surface seismic acquisition. A number of fracture zones are encountered along the borehole and correlate well with normal electrical logs, full waveform sonic logs, and image logs. These fractures, too, appear to be filled with highly saline brines as they correspond to sharp peaks in the electrical conductivity. These fractures may provide pathways for fluid flow in an engineered geothermal system. The fracture zones may be related to dipping seismic reflectors seen in deep profiles adjacent to the borehole site. An alternative explanation could be the existence, on the basis of high magnetic susceptibility, of mafic sills with differing impedance contrasts. Analysis of this exceptional geophysical data set is still underway. This includes detailed analysis of the walka-way VSP data to measure seismic anisotropy of the crust and of the image logs to provide measures of in situ stress directions and possibly magnitudes. We hope in future to develop this site into a long term deep observatory.

Abstract ID: 35123

Final Number: U34A-0001

Title: The solidification of obsidian glass during drilling of the IDDP-1 drill hole

Presenter: Donald B Dingwell, Ludwig Maximilian University of Munich, Munich,

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Co-authors: Felix W. von Aulock, University of Liverpool, Liverpool, L69, United Kingdom; Yan Lavallée, University of Liverpool, Liverpool, United Kingdom

Published Material: European Geosciences Union General Assembly 2015 Vienna | Austria | 12 – 17 April 2015

Abstract Body: Understanding the thermal fate of magmatic rocks during scientific high temperature drilling represents a contribution to their interpretation in terms of magmatic state and their mechanical response to the drilling process.

Chips of black crystal-poor unfoamed calc-alkaline rhyolitic obsidian have been obtained from a depth of 2100m in the IDDP-1 borehole. Five samples (20-40 mg) have been subjected to scanning calorimetry in order to evaluate the glass transition temperature, viscosity and cooling history of these obsidians that are believed to have been quenched by the drilling process. In addition to scanning runs on the raw glasses, their controlled cooling/heating cycle behavior has been determined at 5, 10 and 25K/min.

The glass transition temperatures of the raw samples lie in the range of 500-525°C. The glass transition temperature shifts with controlled cooling/heating rates yields an activation energy of 335 kJ/mol. The absolute value of the glass transition temperature has been compared with the Hess and Dingwell (1996) viscosity model for calc-alkaline rhyolite. The comparison allows the inference that the obsidian contains water contents consistent with those reported by Elders et al. (2011) Furthermore, the activation energies obtained from the Tg peak shift with cooling/heating rate are entirely consistent with those water contents. The cooling rate estimated for the raw samples are higher than 25K/min. A relatively high cooling rate for a “natural” obsidian.

These glasses have been interpreted to have been quenched from temperatures of 940-760°C (based on water content). From the present glass transition analysis it would appear that the first 200-400K of cooling of these magmas occurred above the glass transition in a plastic state, followed by ca. 500K of solid-state (glassy) cooling.

These results demonstrate that it is possible to use glassy materials derived from the drilling-induced quenching of magma to evaluate the physical state and thermal conditions attendant on deep scientific drilling of these systems.

Abstract ID: 35073

Final Number: U34A-0002

Title: Towards an ICDP drilling at Lake Nam Co (Tibet)

Presenter/First Author: Torsten Haberzettl, Friedrich Schiller University of Jena, Jena,

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Abstract Body: Nam Co is one of the largest and deepest lakes on the Tibetan Plateau (TP). Seismic data show an infill of >800 m of well layered undisturbed sediments in the central part of the lake. Sediment accumulation rates measured on a 10.4 m reference core, seismostratigraphic investigations, and molecular clock analyses suggest an age of the seismically imaged sequence between 460 and 1,900 ka. However, no basement reflector has been found indicating even older sequences. Multiproxy studies on the reference core provide an excellent high-resolution paleoclimate record covering the past 24 ka cal BP validated by extensive modern process studies and multi-dating approaches.

Situated on the central part of the TP, Nam Co is at an ideal location filling a gap in two ICDP/IODP transects. Due to this location at the intersection of Monsoon (increased precipitation) and Westerlies (increased evaporation) paleoclimate proxies clearly reflect the spatial and temporal interplay and thus the dominance of one of the two circulation systems. Considering that almost one third of the population of the world depends on the water supply from the TP the future hydrological development which is dependent on the interplay of the two systems will clearly have a major societal impact. To define parameters for future climate change scenarios and their consequences for ecosystems, it is of paramount importance to improve our knowledge of timing, duration, and intensity of past climatic variability and environmental impact, especially on long time scales.

Furthermore, the TP is characterized by a high degree of endemism of organisms that are dependent on continuously existing water bodies. Nam Co likely served as a dispersal centre for these organisms, as other shallower lakes desiccated during dry glacial periods of the Cenozoic. Nam Co appears to be a first class example for studying the link between geological and biological evolution in highly isolated TP ecosystems over long time scales.

Abstract ID: 36348

Final Number: U34A-0003

Title: Biostratigraphy, climate and ocean changes in the Gulf of Alaska during the Plio- Pleistocene

Presenter/First Author: Coralie Zorzi, GEOTOP-UQAM, Montréal,

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Co-authors: Anne de Vernal, University of Quebec at Montreal UQAM, Montréal, QC, Canada

Abstract Body: The Pliocene (5.33 and 2.59 Ma) was a relatively warm epoch characterized by high atmospheric CO_2 concentration (about 400 ppmv) and the absence of continental ice sheet in the Northern Hemisphere. It contrasted with the ensuing Pleistocene Epoch, characterized by lower atmospheric CO_2 concentrations and the onset of glaciations in North America and Eurasia. The present study focuses on the Gulf of Alaska with the aim to document climatic and circulation changes in the subarctic Pacific Ocean in relation with the development of glaciers in northwest North America. More specifically, the aims are to provide clues on the vegetation history of the adjacent land from pollen assemblages, and to reconstruct sea-surface conditions with special attention to productivity and salinity linked with the onset of upwelling from dinocyst assemblages. Marine sediments from sites ODP 887 (54°21.9'N ; 148°26.8'W ; 3645 m) and IODP U1417 (56°95.9'N ; 147°10.9W ; 4187 m) are currently being analyzed for their palynomorph content to reconstruct environmental . Preliminary data indicate very large amplitude change in concentrations of both pollen (from 20 to 1780 grains/cc) and dinocyst (from 0 to 280 cysts/cc) suggesting very large change in biogenic fluxes from terrestrial origin and marine production. In general, Pliocene samples contain more pollen than dinocysts, which suggest large fluxes from the terrestrial vegetation, but low marine productivity. Many Pleistocene samples reveal barren, but some samples record high diversity contrasting with Pliocene intervals marked by the dominance of *Brigantedinium* spp. and moderately abundant dinocysts, which suggest episodes characterized by high marine productivity. The Plio-Pleistocene being marked by important biostratigraphic changes, the interpretation of palynological data is challenging. Our study is part of a multi-proxy collaborative project involving sedimentology, diatom and biomarker analyses. Hence, in addition to document environmental impact of both local and regional drivers on local vegetation and climate, the multi-proxy study should contribute to develop a comprehensive picture of regional changes during the Plio-Pleistocene climate transition.

VOLCANOLOGY, GEOCHEMISTRY, AND PETROLOGY

Abstract ID: 33010

Final Number: VGP11A-01

Title: Rationale and Methods for Regional 3D Geological Mapping

Presenter/First Author: Harvey Thorleifson, Organization Not Listed, Minneapolis, MN

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Abstract Body: Geological mapping yields economic, social, and scientific benefits, so jurisdiction-wide, multi-resolution, seamless, and updated 2D mapping remains needed. In addition, 3D geological mapping will greatly increase scientific and societal benefits, by more explicitly accounting for properties of subsurface materials. For layers whose thickness can be inferred throughout their extent, the requirement is for depiction and prediction of the extent, thickness and properties of all mappable lithologic strata in a jurisdiction, to support applications such as groundwater management, engineering, and sedimentary basin assessments. Facies modeling and basin analysis guides this mapping of lithology which is needed for inference of properties such as hydraulic conductivity. Combined lithostratigraphic and allostratigraphic approaches may apply, the number of stratigraphic names should be minimized, and the work needs to extend to hydrostratigraphy. Compilation includes topography, bathymetry, soil mapping, plan view geological mapping, and drillhole

data. Data acquisition includes geophysics and new drilling. Model construction methods vary depending on resolution and data adequacy, with depth to bedrock or depth to basement maps being early efforts that motivate data compilation and clarify data collection priorities. With lithological data, the model is anchored at stratigraphic benchmarks, and strata are drawn by a geologist through lithological data, as a facies model guides interpolation; strata are drawn to the extent supported by data. With stratigraphic data, modeling may proceed directly from regularly spaced, correlated data. Appropriate geostatistical methods will be used at various phases of projects. Upon depiction of layers, heterogeneity, properties, and uncertainty are added. Concurrently, a basement map is needed, accompanied by increasing depiction of predicted 3D geometry of key structures, along with discretized basement physical properties. Programs should focus on societal needs, assess status of data and mapping, raise expectations among users, engage in long term planning, build institutional databases, reconcile stratigraphy, harmonize 2D mapping, launch geophysics and drilling, choose an appropriate approach, make a plan, and build support.

Abstract ID: 34841

Final Number: VGP11A-03

Title: Robust 3D Geological Models: Hard Data is Key

Presenter/First Author: Francine Fallara, Organization Not Listed, Val-d'Or,

Presenter/First Author Email: francine.fallara@innovexplo.com

Published Material: This presentation is based on my past 15 year experience in 3D geological modelling. Presently, I have no work under review.

Abstract Body: Understanding and incorporating 2D data, whether from surface field work or underground mine mapping, should always be the starting point of an integrated and coherent 3D geologic model, especially for areas with great geometric contrasts. Without this valuable data, 3D modelling is essentially performed with blinders on, and its absence results in a model that is too theory-driven, and lacks input from geologists and "real" field data.

Three-dimensional geologic models require complete, homogeneous and valid databases. The resulting 3D models are directly based on and rely on high-quality data. The data comprises both surface and underground observations. "Raw" or "hard" data should always be assigned more weight and act as rigid control points in 3D models. Hard data should always be distinguishable from interpreted data in 3D models. Investing the necessary time to learn how to homogenize and structure raw data in a rigorous way will be paid back during the 3D interpretation process.

Once 3D models are completed, they should be used as an exploration tool, populating their cells with user-chosen properties. Both quantitative and qualitative properties can be interpolated throughout the cells of the 3D model for further querying and questioning. Thus, the extra benefit of 3D map models is their use as dynamic interactive tools to help define new mineral exploration targets at depth.

A 3D map model is not a goal but a tool that should be dynamic, modified, questioned, shared and updated. Its future usefulness is determined by how well it can be utilized by a multi-disciplinary team of geologists, geophysicists, geochemists, engineers, metallurgists and environmental experts.

Abstract ID: 36285

Final Number: VGP11A-04

Title: 3D exploration targeting based on mineral deposit model: A case of study in Luanchuan district

Presenter/First Author: Gongwen Wang, China University of Geosciences Beijing, Beijing,

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Abstract Body: According to the geological setting (structure, magma, and stratum) and mineral deposit features (material origination, mineral spatial distribution, orebody geometry, and deposit type), geologists can construct metallogenic genesis/model which is base knowledge for exploring new mineral deposits or exploration targets at depth and surround in the deposit. Exploration targeting was not simply the application of concepts, including both genetic and deposit models, from economic geology research, but was rather the integration of such concepts with geophysics, spatial analysis, mineral economics, decision science and probability theory.

Luanchuan Mo district as a study, it is famous for three large magma-skarn type Mo deposits in China. However, the maximum exploration depth is not more than 1.2 km, the depth zones are need to integrated decision-making for new exploration targets. In this paper, the ground gravity and magnetic data inversion additional a borehole dataset analysis was implemented to identify potential targets, and the methodology is as follow: (1) 1:2000 geological and topographic maps and 282 borehole data was used to construct 3D geological model of Nannihu and Sandaozhuang deposit; (2) 3D models of magma and skarn orebodies, granite (porphyry) stock, and alternation objects were constructed using borehole data additional surface survey; (3) 3D kriging interpolation calculation for 3D Mo grade modeling using geochemical 65500 assay of borehole data; (4) fractal modeling (Hurst exponent and multi-fractal method) using borehole data to identify the orebody continuity and concentration features; (5) 3D buffer analysis integrating 3D granite (porphyry) bodies, the Formations with dolomitic marble, gravity and magnetic anomaly models for prediction potential targets at depth in this district (5.0×4.0×2.5 km). The research results show that both depth of the Northwestern of Nanihu and the Northeastern of Sandaozhuang deposits have skarn-type Mo potential targets, and the depth of former is deep to 2.1 km, and the depth of latter is deep to 2.5 km.

Abstract ID: 34966

Final Number: VGP11A-06

Title: Three-dimensional interpretation of geophysical data and geological implications

Presenter/First Author: li Zhen Cheng, University of Quebec Abitibi-Témiscamingue UQAT, Rouyn-Noranda, QC

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Co-authors: Bahman Abbassi, University of Quebec Abitibi-Témiscamingue UQAT, Rouyn-Noranda, QC, Canada; Pierre Boszczuk, , ,

Published Material: Two of three examples cited in this presentation are referred to two publications below. The third work is in preparation for publication this year. Cheng L. Z., Richard S., Allard M., Keating P., Chouteau M., Lemieux J., Vallée M.A., Bois D., and Fountain D., 2006. Geophysical case study of the Iso and New Insco deposits, Québec, Canada: Part II, modeling and interpretation. *Exploration and Mining Geology* (CIM), vo. 15 (1-2), p65-74. This paper is also Geological Survey of Canada contribution 2004295. Boszczuk Pierre, Li Zhen Cheng, Hanafi Hammouche, Patrice Roy, Sylvain Lacroix and Alain Cheilletz, 2011. A 3D gravity data interpretation of the Matagami mining camp, Abitibi

Subprovince, Superior Province, Québec, Canada. Application to VMS deposits exploration. *Journal of Applied Geophysics*, p77-86.

Abstract Body: Searching for a common geological model from multiple geoscience data interpretations not only reduces the ambiguity in single data interpretation, also complement information each other. The role of geophysical methods in such integrated multi-data sets interpretation is as useful tool for subtracting spatial information from the Earth interior. The important task of geophysicists is to be able to quantify the nature, volume and location of geophysical anomalous sources and make links between variations in geophysical field and the structural geology; or to define a specific geological significance from geophysical anomalies (e.g. information about the mineralization).

From geophysical observation we can recover a physical property distribution; further to find out its geological implication which is an inverse procedure. With the computation technology advancement, geophysical data inversions now can be realized from one dimension to three or four dimensions (later includes time scale). The key question for geophysicists is how much similarity or consistency between geophysical model and that of geology? To be better integrated geophysical interpretation and geological reality, the knowledge of petrophysics and the team work of geophysicists with geologists become obviously more than more important.

Through 3 examples we would show 1) sometimes geophysical methods detect directly ore bodies, therefore we could discriminate ore-rich zones from 3D geophysical data inversions. 2) We may contribute to structural geology by reconstructing the main geological units at the depth, estimating 3D morphology of intrusion and faults from geophysical data interpretation. 3) We could also do advanced 3D modeling of multiple geophysical data sets and, integrate geological and geochemical information together to build up a common geological model.

Abstract ID: 33990

Final Number: VGP11A-07

Title: Three-dimensional (3D) geologic map of the San Andreas Fault Zone, Central California, U.S.A. - revelations and lessons learned

Presenter/First Author: Russell Walter Graymer, Organization Not Listed, Menlo Park, CA

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Co-authors: Michelle Roberts, , Menlo Park, CA; Darcy McPhee, USGS California Water Science Center Menlo Park, Menlo Park, CA; Richard G Stanley, USGS, Baltimore, MD

Abstract Body: Using geologic map, petroleum well, and potential-field geophysical data we constructed a 3D geologic map of the San Andreas Fault and adjacent rock units from Pinnacles National Park (about 36°32´48˝N, 121°08´10˝W) to Gold Hill (about 35°49´27˝N, 120°21´10˝W) in a volume roughly centered on the fault, about 30-50 km wide, 15 km deep, and 107 km long. The 3D map reveals that, in addition to large strike-slip offset, the volume east of the fault has undergone significant fault-normal compression, resulting in a large basement antiform adjacent to the fault in the southern half of the model, as well as active thrust faulting associated with the 1983 M6.5 Coalinga earthquake. Fault-normal compression is also present west of the fault, but to a much lesser extent, with much of the volume undergoing only broad uplift and slight westward tilting since the start of the Pliocene. In contrast, the 3D map also reveals strata from at least two pull-apart basins. The northern end of the 3D map shows a large pull-apart basin west of the San Andreas Fault associated with early transtensional tectonism along the fault. Diatoms as old as ~14 Ma from basin fill constrain the timing of initiation of the fault zone, while rocks correlated with the upper part of the basin fill are found east of the fault roughly 200 km to the south. Adjacent to that pull-apart basin, east of the fault, is a thick but distinct sedimentary package (made up of different, in part younger, units) interpreted to be a strike-slip juxtaposed sliver of a younger pull-apart basin, the bulk of which now lies about 100 km to the north.

During the construction of the 3D map we were initially misled by the existing geologic maps, which use the same unit name for rocks of similar lithology but quite different age and stratigraphic level. In addition, the Waltham Canyon Fault, which appears to be a single structure in map view, was revealed to be composed of multiple, overlapping structures in 3D.

Abstract ID: 34300

Final Number: VGP12A-01

Title: Synchrotron X-Ray Microtomography Techniques Applied to the 3D Morphological and Textural Analysis of Geomaterials

Presenter/First Author: Lucia Mancini, Elettra-Sincrotrone Trieste, Basovizza,

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Published Material: SGI-SIMP Congress (Milano, Italy, 2014)EGU General Assembly (Wien, 2013)

Abstract Body: Imaging techniques play an important role in several research fields of the geosciences. The well known optical and scanning electron microscopy techniques are widely adopted tools for the investigation of the texture and morphology of rock samples. X-ray based techniques are also of particular interest and X-ray microradiography has proved to be useful for the analysis of soils.

In the last years a great interest has been posed on X-ray computed microtomography (micro-CT) techniques, based on both laboratory and synchrotron radiation sources, producing 3D images of the internal structure of objects with a spatial resolution at the micron- and submicron-scale. Investigations, performed directly in the 3D domain, overcome the limitations of stereological methods usually applied to microscopy-based measurements and enable to get images of the internal core of a sample by a non-destructive method, more suitable for further analyses and for precious or unique samples (archeological finds, fossils etc...). An intriguing challenge related to the use of micro-CT methods is to extract quantitative measures and indices directly from images data sets. Porosity and specific surface area as well as connectivity, tortuosity and anisotropy are interesting descriptors of a 3D model. To this purpose, we used the *Pore3D* software library developed at the Elettra-Sincrotrone Trieste laboratory (Italy) and specifically conceived for the handling of large 3D data sets. An open and customized software assures a complete control of the algorithm implementation and permits different strategies of analysis as a function of the specific scientific application.

Several applications of synchrotron X-ray micro-CT methodologies for the extraction of quantitative information from 3D images of geomaterials will be presented.

Abstract ID: 33436

Final Number: VGP12A-02

Title: Quantifying Internal Properties of Geologic Materials by Image Analysis

Presenter/First Author: Dork L Sahagian, Lehigh University, Bethlehem, PA

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Co-authors: Alexander A Proussevitch, University of New Hampshire Main Campus, Durham, NH

Published Material: Some were reported at previous AGU meetings. This is intended as an invited review of image analysis techniques in support of the session.

Abstract Body: As imaging techniques are refined, and new technologies emerge, our ability is enhanced to quantify size, shape, internal structure, and other morphological characteristics of geological materials. Internal structure has been particularly problematical at small scales (< cm).

3D information can be obtained using stereological methods on thin section or polished sections, but can only be used for simple convex shapes. For more complex shapes (with concavities, voids, etc.) it is necessary to use fully 3D techniques, such as those provided by Computed X-ray Tomography (CXT). Extracting quantitative information requires measuring the number of voxels within an object of interest. In order to determine the position of the boundary between internal objects (e.g. void vs. glass) "segmentation" of the images is a first step. Oftentimes, the resolution of the x-ray generated voxels is insufficient to resolve thin films between objects, and many small objects are imaged as a single very large, interconnected object. The volumes of the bubbles in pumices before coalescence can thus be reconstructed by sequentially "peeling" away the outer layer, then reconstructing vesicles with individual identities. Once this is accomplished, sizes, shapes, orientations, and proximity to neighbors can all be quantified.

Some geological materials are so small that imaging requires SEM techniques (e.g. ash, clay, etc.). Digital elevation models can be constructed for particles using Stereo SEM images. This is enabled by "dirty" surfaces that enable multi-directional reflection from the surfaces of the particles. For volcanic ash, the sizes of the bubbles that burst during fragmentation to form the ash can be determined by the radii of curvature of concavities on ash surfaces. SSEM can still only image the top of an ash particle, so if a reconstruction of the entire particle is desired, the lower half must be numerically reconstructed from the morphology of the upper half.

In sum, there are various techniques for obtaining quantitative information from a suite of imaging technologies, and specific approaches must typically be developed to answer specific research questions regarding geological materials.

Abstract ID: 34804

Final Number: VGP12A-03

Title: Eruptive shearing revealed by tomography

Presenter/First Author: Yan Lavallée, University of Liverpool, Liverpool,

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Co-authors: Kai-Uwe Hess, Ludwig Maximilian University of Munich, Munich, Germany; Jackie Evan Kendrick, University of Liverpool, Liverpool, United Kingdom; Kate J Dobson, University of Manchester, Glasgow, United Kingdom; Paul A Ashwell, University of Canterbury, Christchurch, New Zealand; Ben Kennedy, University of Canterbury, Christchurch, New Zealand; Fabian B Wadsworth, Ludwig Maximilian University of Munich, Munich, Germany; Jeremie Vasseur, LMU Munich, Munich, Germany; Donald B Dingwell, Ludwig Maximilian University of Munich, Munich, Germany

Published Material: this presentation will include a wide dataset, including some of the data presented in the following 2 studies under review- Dingwell D.B., Lavallée Y., Hess K.-U., Flaws A., Marti J., Nichols A.R.L., Gilg H.A., Schillinger B., in review. Eruptive shearing in tube pumice: pure and simple. *Nature Geosciences*. -Ashwell P.A., Kendrick J., Lavallée Y., Kennedy B.M., Hess K.-U., von Aulock F.W., Wadsworth F.B., Vasseur J., Dingwell D.B., in review. Permeability of compacting porous lavas: no impermeable plugs? *Journal of Geophysical Research – Solid Earth.*

Abstract Body: Magma ascent and eruption dynamics are regulated by changes in deformation mechanisms and the ability of magma to release gas. Recent advances in (neutron and x-ray) tomographic analyses provides us with a mean to image the internal structure of magma (especially its pore phase), allowing 3-D characterisation of sample. Here, we present the result of tomographic reconstruction of natural volcanic rocks (tube pumice, tuffisites and dome rocks) as well as crystal-poor and crystal-rich rocks experimentally deformed at magmatic condition to describe the evolution of the porous permeable network upon eruptive shearing relevant to different volcanic scenarios. The image reconstruction shows how bubble elongation and occasionally coalescence dominate crystal-poor magmas whilst micro-fracture coalescence dominates the permeable network of crystal-rich magmas. The permeable structure is further analysed to derive information regarding shearing conditions (pure vs simple) and fracture distribution depending on deformation modes (ductile vs brittle). We discuss our findings with respect to eruptive shearing during Plinian as well as lava dome eruptions.

Abstract ID: 33876

Final Number: VGP12A-05

Title: Bubble-Crystal Interactions in a Young Basalt Lava Flow – Preliminary Data from 3D X-Ray Microtomography

Presenter/First Author: Pia Pleše, Université du Québec à Chicoutimi, Chicoutimi, QC

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Co-authors: Michael Higgins, Univ Quebec a Chicoutimi, Chicoutimi, QC, Canada; Don R Baker, McGill University, Montreal, QC, Canada

Published Material: The first 3 sentences in the abstract refer to Higgins, M. (2009): The Cascadia megathrust earthquake of 1700 may have rejuvenated an isolated basaltvolcano in western Canada: Age and petrographic evidence. Journal of Volcanology and Geothermal Research. Volume 179, pp. 149–156.

Abstract Body: The Tseax monogenetic volcano lies at the southern margin of the Northern Cordillera volcanic province, BC, Canada. Its last eruption (1691±23 CE) produced a 32 km long basaltic lava flow which may have been triggered by the Cascadia megathrust earthquake in 1700 CE (Higgins, 2009).

The lava contains a framework of tabular plagioclase crystals with smaller interstitial equant olivine crystals, all set in a glassy matrix. Samples a few mm in diameter were imaged by X-ray µ-CT at APS Chicago, with the aim of studying the relations between the crystals and the gas bubbles (vesicles).

Olivine crystals are accompanied by small bubbles, located on their surface asperities, or within them, impeding crystal growth in that direction. Large bubbles, perhaps a first generation that had more time to grow and coalesce, are defined and restricted in size and shape by a framework of plagioclase crystals. They adhere perfectly to the longer plagioclase faces (010) but there is a melt film between them and the shorter faces as well as in the corners of two touching plagioclase crystals. This suggests that we should perhaps distinguish the process of nucleation of bubbles on crystal surfaces and their enlargement by surface wetting, for different crystals and different faces.

The texture of the large bubbles suggests that the pressure wave of the Cascadia megathrust earthquake may have enabled the growth of bubbles by wetting of plagioclase surfaces even if no new bubbles nucleated. The reduction in density of the magma could then have triggered the eruption.

Our next stage is to further quantify the morphological relations and to measure the contact angles between bubbles and different mineral phases. Combining these with mineral composition and structure differences will hopefully lead to a better understanding of bubbles and non-oxide crystal dynamics.

Abstract ID: 33856

Final Number: VGP12A-06

Title: Characterization of Bioaccessible Porosity in Soil Aggregates by Micro-CT Scanning

Presenter/First Author: Ali Akbari, McGill University, Montreal,

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Co-authors: Subhasis Ghoshal, McGill Univ, Montreal, QC, Canada

Abstract Body: In this study we characterized soil aggregate micro-structures in terms of pore network characteristics and evaluated the potential role of the micro-structure on biodegradation of petroleum hydrocarbons in a fine-grained soil obtained from an oil-contaminated site. Bioremediation experiments indicated significant biodegradation of about 50% of the total petroleum hydrocarbons and a relatively high remediation endpoint of about 620 mg/kg soil. It is likely that the residual hydrocarbons were entrapped in pores that were inaccessible to hydrocarbon-degrading bacteria. The intra-aggregate *bioaccessible porosity*, the fraction of aggregate volume constituted by pores that bacteria can access, was determined by X-ray CT scanning. A new image analyses procedure was developed to threshold the images, determine the boundary of aggregate and extract the pore network information. The CT scanning results showed that about 26% of soil aggregate volume was potentially accessible to the hydrocarbon degrading bacteria, whereas, about 1.5% of aggregate volume was attributed to inaccessible pores. The volume of pores smaller than 1 µm could not be determined by CT scanning and was determined by BET analyses. The significant volume of potentially non-bioaccessible pores can explain the observed relatively high remediation endpoint in the studied soil. The procedure for CT image analysis of intra-aggregate porosity developed in this study can be a new approach for a priori assessment of bioremediation performance in oil-contaminated soils.

Abstract ID: 33019

Final Number: VGP12B-01

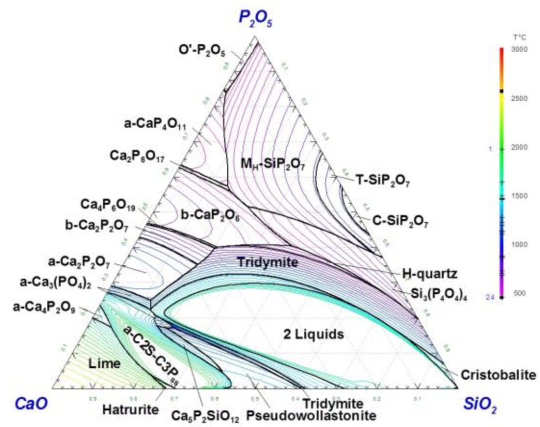
Title: Thermodynamic Optimization of the Li_2O-Na_2O-CaO-FeO-Fe_2O_3-Al_2O_3-SiO_2-P_2O_5 System

Presenter/First Author: Pierre Hudon, McGill University, Montreal, QC

Presenter/First Author Email: pierre.hudon@mcgill.ca

Co-authors: In-Ho Jung, McGill University, Montreal, QC, Canada

Abstract Body: P_2O_5 is an important oxide component in the late stage products of igneous rocks such as granites and anorthosites, for example. Most of the time, P_2O_5 combines with CaO and crystallizes in the form of apatite, while in volatile-free conditions, Ca-whitlockite is formed. In spite of their interest, the thermodynamic properties and phase diagrams of P_2O_5-bearing systems are still not well known yet. As a result, we critically reviewed and optimized the structural, thermodynamic and phase diagram data belonging to the system Li_2O-Na_2O-CaO-FeO-Fe_2O_3-Al_2O_3-SiO_2-P_2O_5. This system contains numerous compounds including the phosphate minerals lithiophosphate (γ-Li_3PO_4), Ca-whitlockite (β-$Ca_3(PO_4)_2$), silicocarnotite ($Ca_5SiP_2O_{12}$), nagelschmidtite ($Ca_7Si_2P_2O_{16}$), grattarolaite (α-$Fe_3(PO_4)O_3$), and rodolicolite (α-$FePO_4$). The liquid phase was parametrized using the Modified Quasichemical Model while solid solutions such as spinel and FeO were modelled using the Compound Energy Formalism and the Regular Solution Model, respectively. All available thermodynamic and phase equilibrium data were simultaneously reproduced and discrepancies in the available data resolved in order to obtain one set of model equations for the Gibbs energies of all phases as functions of temperature and composition at 1 atm. The CaO-SiO_2-P_2O_5 liquidus projection is shown below as an example. This is part of a larger research project to develop the thermodynamic database of the Li_2O-Na_2O-K_2O-CaO-MgO-MnO-ZnO-FeO-Fe_2O_3-Al_2O_3-SiO_2-P_2O_5 system at room pressure.



Liquidus projection (in mole fraction) of the CaO-SiO_2-P_2O_5 system at 1 atm.

Abstract ID: 33474

Final Number: VGP12B-02

Title: Computing dynamic titania activities through metamorphic evolution and implications on Ti-in-quartz thermobarometry

Presenter/First Author: Kyle T Ashley, Virginia Polytechnic Institute and State University, Blacksburg, VA

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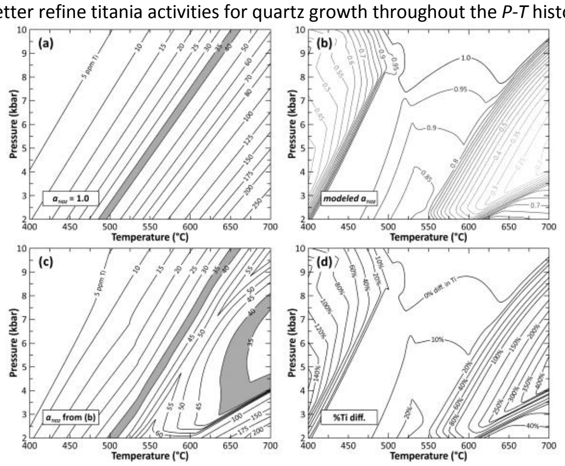
Co-authors: Richard Derek Law, Virginia Tech, Blacksburg, VA

Published Material: A manuscript on this work was submitted to Contributions to Mineralogy and Petrology, with a revised draft currently being processed by the editorial board.

Abstract Body: Meaningful metamorphic *P-T* estimation is made difficult due to susceptibility of minerals to chemical modification during retrogression and complex cation partitioning that occurs in some crystal systems. The simple exchange of Ti for Si in quartz and slow diffusion of Ti during retrogression makes Ti-in-quartz a potentially powerful thermobarometer. Calculation of temperature is dependent on estimating titania activity at the time of quartz growth. In metapelites this may be reasonably estimated if ilmenite or rutile is stable. However, due to participation of quartz in solution-transfer processes and metamorphic

reactions throughout the *P-T* history, calculating temperatures while only considering peak paragenesis may be erroneous. Here we calculate TiO_2 chemical potentials for known bulk rock compositions relative to that of a rutile-containing system (i.e., a standard state system) through the thermodynamic calculation package Perple_X and pseudosection generation. When projected in *P-T* space, a titania activity map is generated which allows for assessment of Ti solubility in quartz under various geologic conditions. Calculated activities are used to adjust the Ti-isopleth projection in *P-T* space. For an average sub-aluminous pelite composition, results are in good agreement with previous studies that found ilmenite-bearing assemblages buffer high TiO_2 activities (nearly 1.0), with lower activities for titanite-bearing assemblages (≥0.5). At high temperatures, significant deviation from an assumed pelite titania activity of 1.0 exists; here, assuming a dynamic activity results in Ti concentrations in quartz up to 400% different from assuming a standard state. This is due, in part, to sequestering Ti in biotite and destabilization of Ti-oxides at higher *T*. These large Ti discrepancies result in large temperature uncertainties. Therefore, our modeling approach may provide a method to better refine titania activities for quartz growth throughout the *P-T* history.



Abstract ID: 33498

Final Number: VGP12B-03

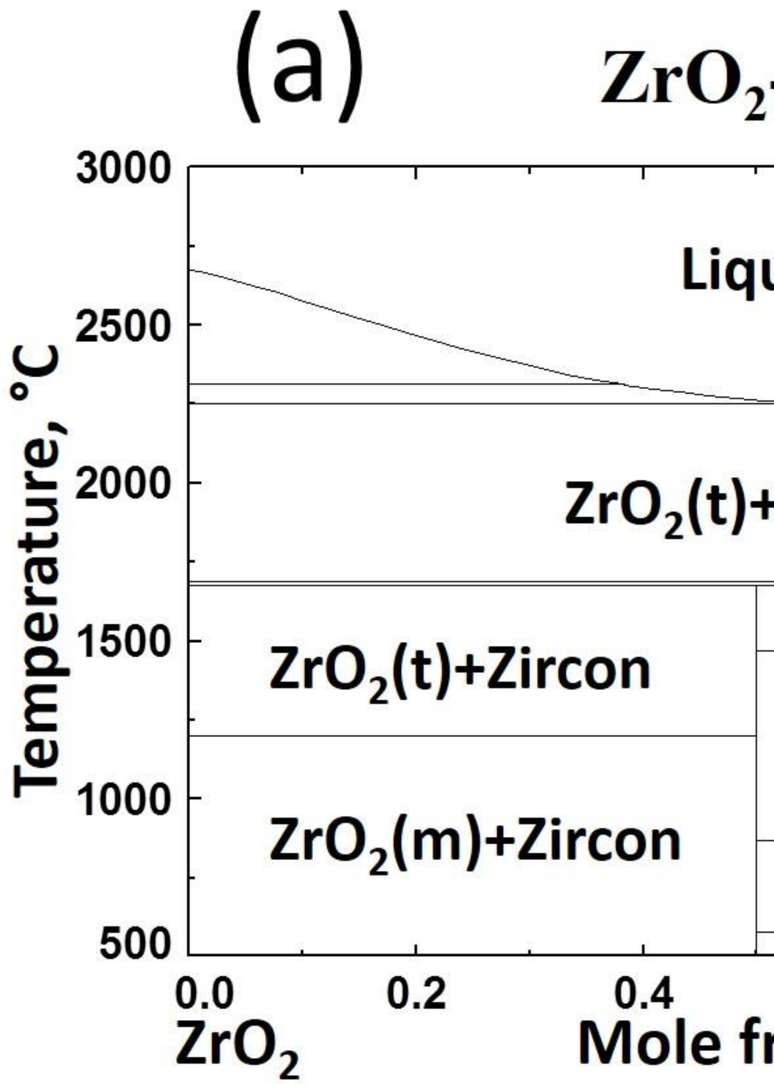
Title: Experimental investigation and optimization of the thermodynamic properties and phase diagrams of the $CaO-MgO-Al_2O_3-SiO_2-ZrO_2$ system

Presenter/First Author: Sunyong Kwon, McGill University, Montréal, QC

Presenter/First Author Email: sunyong.kwon@mail.mcgill.ca

Co-authors: Pierre Hudon, McGill University, Montreal, QC, Canada; In-Ho Jung, McGill University, Montreal, QC, Canada

Abstract Body: Zirconia-bearing systems are of great importance in geology. The minerals baddeleyite and zircon, for example, are quite useful in geochronology thanks to their refractory nature, capacity to contain trace amounts of uranium and thorium, and occurrence in numerous igneous and metamorphic rocks. Zirconia-bearing compounds are also quite used as refractory materials in the industry. Recently, numerous new thermodynamic property and phase diagram data were published for ZrO_2-containing systems which prompted a re-evaluation of the thermodynamic properties of the ZrO_2 unary system. In this study, new experimental phase diagram data were also collected and a critical evaluation and optimization of the thermodynamic properties and phase diagrams of the $CaO-MgO-Al_2O_3-SiO_2-ZrO_2$ system was performed. As an example, the optimized ZrO_2-SiO_2 binary system and $ZrO_2-CaO-MgO$ ternary system are shown in Figures 1a and 1b, respectively. The liquid phase was parametrized using the Modified Quasichemical Model while solid solutions were optimized using the Bragg-Williams Random Mixing Model with a polynomial expansion of the excess parameters. The optimized model parameters were incorporated to the oxide database of the FactSage software.



Abstract ID: 34008

Final Number: VGP12B-04

Title: Thermodynamic Optimization of the $MgO-MnO-Mn_2O_3-SiO_2$ System

Presenter/First Author: Sourav Kumar Panda, McGill University, Montreal, QC

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Co-authors: Zhanmin Cao, , , ; In-Ho Jung, McGill University, Montreal, QC, Canada

Abstract Body: The $MgO-MnO-Mn_2O_3-SiO_2$ system is of great importance in metallurgy and geochemistry. It contains many important minerals of geological interest such as the clino-, ortho-, and proto-pyroxenes ($MgSiO_3$), the pyroxenoids rhodonite ($MnSiO_3$) and pyroxmangite ($MgSiO_3$-

$MnSiO_3$), olivine (Mg_2SiO_4-Mn_2SiO_4) and braunite (Mn_7SiO_{12}), some of which being major constituents of the Earth's mantle. In order to develop a self-consistent thermodynamic database for the above system at 1 atm total pressure, all phase diagram (e.g. Fig 1a) and thermodynamic data (e.g. Fig 1b) available in the literature were critically evaluated. The Gibbs energies of liquid and solid solutions were described using thermodynamic models reflecting the structures of solutions. The liquid solutions were described using the Modified Quasichemical Model (MQM) while the solid solutions, such as the pyroxenes and olivine, were parametrized using the Compound Energy Formalism (CEF). For rhodonite, pyroxmangite and monoxide solid solutions, a simple Bragg Williams random mixing polynomial model was used to describe the solutions. The complex phase relationships in the system have been elucidated, and discrepancies among the data have been resolved. The database of the model parameters can be used along with Gibbs energy minimization software in order to calculate any phase diagram section or thermodynamic property.

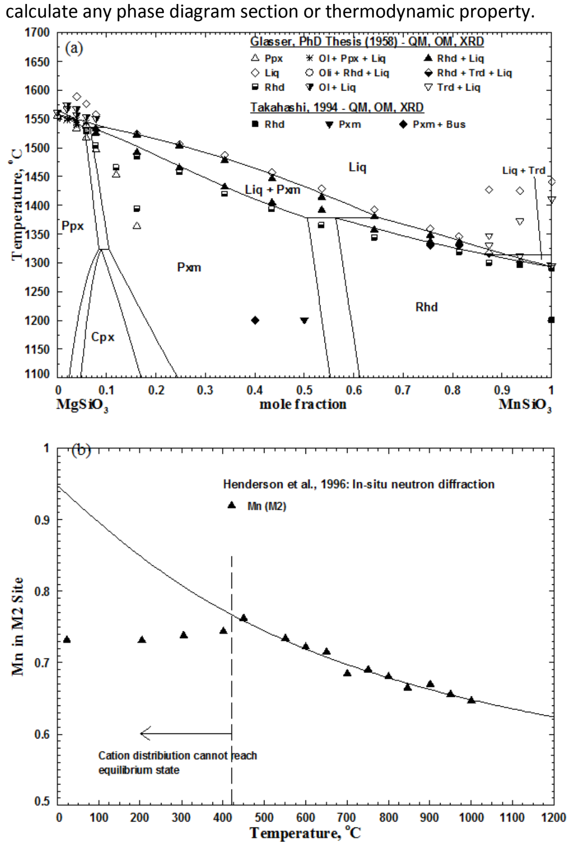

Figure 1. (a) Calculated phase diagram of the $MgSiO_3$-$MnSiO_3$ metasilicate section at reduced atmosphere ($P_{O2} = 10^{-15}$ atm) under 1 atm. total pressure, and (b) calculated cation distribution in $MnMgSiO_4$ olivine as a function of temperature.

Abstract ID: 34262

Final Number: VGP12B-05

Title: CONSONORM_HG: a new method of norm calculation for mid- to high-grade metamorphic rocks

Presenter/First Author: Lucie Mathieu, University of Quebec at Chicoutimi UQAC, Chicoutimi,

Presenter/First Author Email: mathiel@tcd.ie

Co-authors: Sylvain Trépanier, Mines Virginia, 300 Saint-Paul, suite 200, Québec, QC, Canada; Réal Daigneault, Centre d'études sur les Ressources minérales (CERM), Chicoutimi, QC, Canada

Abstract Body: The CONSONORM_HG norm provides a standardised solution to approximate metamorphic parageneses for mid- to high-grade metamorphic rocks. This norm integrates ternary phase diagrams computed using the Perple_X software developed by J. Connolly and collaborators (cf. http://www.perplex.ethz.ch/). What the CONSONORM_HG losses in precision, when compared to pseudo-sections and other types of diagrams abundantly used by metamorphic petrologists, it gains in simplicity and universality, as the CONSONORM_HG can be applied to any type of metamorphic rocks, whether their protoliths have the mafic or felsic composition of sedimentary, magmatic or hydrothermally altered rocks.

The CONSONORM_HG is designed for silicate, Fe-Ti oxydes and/or carbonate-dominated rocks, and it approximates the main parageneses of metamorphic rocks for pressures < 10 kbars and for the greenschist, blueschit, amphibolite and granulite facies. For each of the 17 P-T conditions modelled and depending on the Fe-Mg-Mn composition of the sample, the norm calculates silicate assemblages using one among three Al-Ca-NaK-FeMgMn tetrahedrons that are a convenient way to represent a large amount of silicate assemblages. In addition to silicates, the CONSONORM_HG calculates accessory minerals, Fe-Ti oxides, sulphides from analysed sulfur and/or from analysed metals and carbonates from analysed CO2 or from normative CO2 estimated from the LOI, following the NORMAT method. The CONSONORM_HG also integrates many reactions to address silicon deficits, as well as quartz-carbonates reactions, to better approximate natural parageneses.

The CONSONORM_HG was initially intended to facilitate the recognition of hydrothermally altered rocks in high-grade metamorphic area. This tool has also the potential to serve for the classification of metamorphic rocks, as the CIPW norm served the classification of magmatic rocks. This presentation will focus on the calculation sequence of the CONSONORM_HG.

Abstract ID: 34555

Final Number: VGP12B-06

Title: A Structural Molar Volume Model for Oxide Melts

Presenter: In-Ho Jung, McGill University, Montreal, QC

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First Author: Eric Thibodeau, McGill University, Montreal,

First Author Email: eric.thibodeau2@mail.mcgill.ca

First Author Student?: No

Abstract Body: The molar volume of an oxide melt is determined by its atomic packing which is a function of bond lengths, orientation, and atomic scale interactions. Molar volume is a calculated property obtained from density and composition measurements. The molar volumes of metallurgical slags and geological melts in particular, are difficult to determine due to the extreme experimental conditions required. Modeling the available experimental data with semi-empirical models reproduces the available experimental data while also providing meaningful predictions to composition ranges where no experimental measurements currently exist. Typically, in the geological literature, linear molar volume models are used. However, linear models have been shown to reproduce the experimental data only within certain composition range. That is, a linear model is incapable of describing the molar volume of oxide melt in all composition ranges. In this work, a non-linear structural molar volume model was developed to accurately reproduce the molar volume of molten oxides, of importance for geological and metallurgical applications. In the present structural model, the silicate tetrahedral Q-species calculated from

the Modified Quasichemical Model with the FactSage FToxid database were used as basic structural units and their unit volumes were used as binary model parameters along with the volume of pure oxides. All available experimental data for binary and ternary systems in the literature were critically evaluated based on their experimental techniques and experimental conditions to identify the most reliable data. From the optimized unary and binary model parameters, the present structural molar volume model can accurately calculate the molar volume and thermal expansion of the Li2O-Na2O-K2O-MgO-CaO-MnO-PbO-Al2O3-SiO2 melts at any composition and temperature under 1 atmosphere pressure.

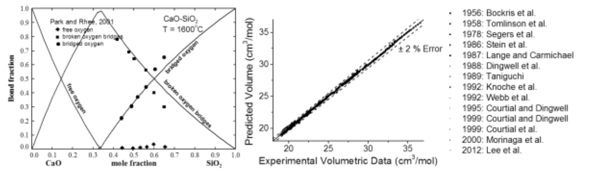


Figure 1. (a) Calculated bond fractions in binary CaO-SiO$_2$ melts from the Modified Quasichemical Model with optimized thermodynamic parameters, and (b) the accuracy of the present model for multicomponent system in comparison to the experimental data in literature.

Abstract ID: 34962

Final Number: VGP12B-07

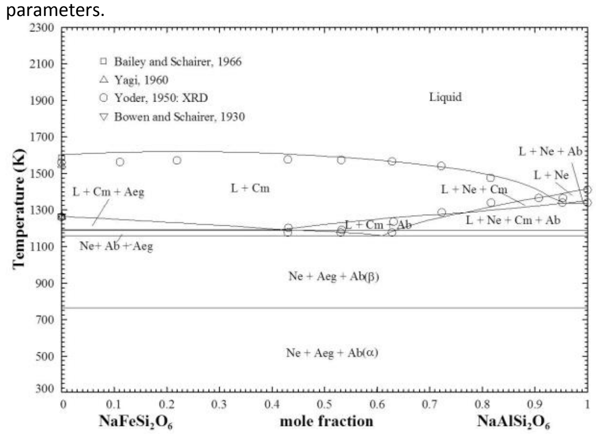
Title: Experimental Investigation and Thermodynamic Optimization of the Na_2O-FeO-Fe_2O_3-Al_2O_3-SiO_2 System

Presenter/First Author: Elmira Moosavi-Khoonsari, McGill University, Montreal, QC

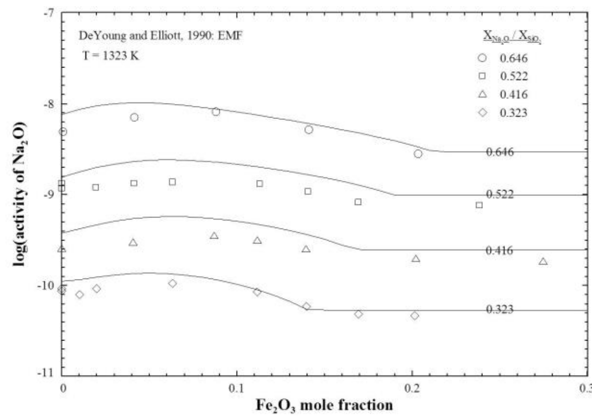
Presenter/First Author Email: elmira.moosavikhoonsari@mail.mcgill.ca

Co-authors: Pierre Hudon, McGill University, Montreal, QC, Canada; In-Ho Jung, McGill University, Montreal, QC, Canada

Abstract Body: The Na_2O-FeO-Fe_2O_3-Al_2O_3-SiO_2 system possesses many minerals of importance for geology and metallurgy such as wüstite, spinel, corundum, aegirine, nepheline (carnegieite), albite, jadeite, fayalite, and silica (quartz, tridymite, cristobalite). Phase equilibria among these minerals and other compounds of this system are indeed very complex due to the change in Fe oxidation state with oxygen partial pressure and the substitution of Fe by Al. In the present study, a coupled experimental study and thermodynamic modeling approach was used to optimize the phase diagrams and thermodynamic properties of the whole system at 1 atm. New experiments were carried out in the Na_2O-FeO-Fe_2O_3-Al_2O_3 system in air and at Fe saturation, a critical evaluation of all experimental phase diagrams and thermodynamic property data available in the literature was performed, and new thermodynamic models were developed to create a new thermodynamic database that describes the Na_2O-FeO-Fe_2O_3-Al_2O_3-SiO_2 system. All the data were reproduced within experimental error limits from 298 K to above liquidus temperatures for all compositions and oxygen partial pressures from metallic Fe saturation to air. The phase equilibria and thermodynamic properties of this multi-component system at 1 atm were reasonably predicted using only binary and ternary model parameters.



Calculated optimized aegirine – jadeite section in air.



Calculated activity of Na_2O with reference to liquid standard state in the Na_2O-Fe_2O_3-SiO_2 system in air.

Abstract ID: 36542

Final Number: VGP12B-08

Title: Thermodynamic modeling of metal transport in H_2O-CO_2 vapours: CO_2-Fluxing Crashes Metal Mobility

Presenter/First Author: Vincent van Hinsberg, McGill University, Montreal, QC

Presenter/First Author Email: V.J.vanhinsberg@gmx.net

Co-authors: Kim Berlo, University of Oxford, Oxford, United Kingdom; Artaches A Migdissov, Los Alamos National Laboratory, Los Alamos, NM; Anthony E. Williams-Jones, McGill University, Montreal, QC, Canada

Abstract Body: Magmatic systems host many types of ore deposits, including world-class deposits of copper and gold. It is now generally accepted that magmas are the source of metals and ore-forming fluids, although in some cases their input may be restricted to introducing thermal disturbances and associated hydrothermal circulation. In these magmatic-hydrothermal systems, low-density solutions, or vapours, are an important carrier of metals. Such vapours are water-dominated at low pressure, but CO_2 becomes a progressevely important conponent in vapours exsolved from magma at depth, especially for mafic magmas. Fluxing of these CO_2-rich vapours through the more shallow parts of the magmatic-hydrothermal plumbing system is now recognized as ubiquitous during open-system magma degassing.

In this contribution, we show that such CO_2-fluxing leads to a dramatic drop in element solubility in the previously water-dominated vapour, up to a factor of 10,000 for Cu, as calculated from new thermodynamic stability constants for metal species in vapour, and a new model for understanding metal solvation. The predicted drop in metal solubility far exceeds that which would be calculated for the temperature and pressure gradients expected in magmatic-hydrothermal systems. CO_2-fluxing thus potentially represents a highly efficient, but as of yet unrecognised mechanism for metal deposition in magmas and host rocks.

Abstract ID: 34606

Final Number: VGP13A-01

Title: Recrystallization and New Growth of Radiation-Damaged Zircon

Presenter/First Author: John M. Hanchar, Memorial University of Newfoundland, St John's, NL

Presenter/First Author Email: jhanchar@mun.ca

Co-authors: Wanda Aylward, , , ; Mark David Schmitz, Boise State University, Boise, ID; Richard Wirth, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany

Published Material: About 20% was presented at the Fall 2012 AGU meeting in san Francisco

Abstract Body: Nearly metamict zircon crystals from the Saranac Prospect near Bancroft, Ontario were ground to a fine powder for powder XRD measurements, HR-TEM imaging and analyses, and CA-TIMS analyses. Aliquots of the ground zircon powder were annealed in situ using a Pt furnace during which time simultaneous powder diffraction data were acquired starting at 25 C, at elevated temperature (from 500 C to 1400 C) at selected time intervals. The powder XRD results indicate that below ~900 C the recrystallization of zircon is incomplete, even after 36 hours. At 1150 C the zircon powder shows significant recrystallization in less than one hour. Before annealing the zircon powder consisted of clear, transparent to brown, translucent, complexly zoned fragments. After heating at 900 C the majority of material had transformed to white opaque microcrystalline fragments. The clear fragments are thought to be preexisting original minimally radiation damaged crystalline zircon, the brown complexly zoned fragments are likely preexisting extremely metamict zircon, and the white opaque fragment newly recrystallized zircon and ZrO2. At 1150 C all that remained after heating were dominantly white opaque fragments and extremely rare clear fragments. A variety of fragment types from the unannealed, 900 C, and 1150 C anneals were chemically abraded at 190 C for 12 hours. After chemical abrasion, all unannealed material, nearly all material from the 900 C anneal, and all white opaque microcrystalline material from the 1150 C anneal, dissolved. Only the rare residual clear, transparent fragments from the 1150 C anneal remained and yielded concordant U-Pb ID-TIMS dates of 1064 Ma confirming the hypothesis that low-U closed system domains are preserved through annealing up to 1150 C and can be extracted via chemical abrasion from even dominantly metamict zircon crystals. By contrast, newly formed post-annealing recrystallized zircon appear to be quite soluble during chemical abrasion process.

Abstract ID: 34206

Final Number: VGP13A-02

Title: Deformation of Zircon Under High Pressure

Presenter/First Author: Ievgeniia Morozova, University of Western Ontario, London,

Presenter/First Author Email: imorozov@uwo.ca

Co-authors: Sean R Shieh, University of Western Ontario, London, ON, Canada; Desmond Moser, Western University, London, ON, Canada; John M. Hanchar, Memorial University of Newfoundland, St John's, NL, Canada

Abstract Body: Zircon ($ZrSiO_4$) is a strong and refractory mineral and can retain trace elements such as U, Th and Pb for age determination and evolution of early Earth. Isotopic data obtained from zircon can provide insightful information about evolution of crust and mantle differentiation. Moreover, zircon can be used as an indicator for impact deformations. It is believed that zircon age determination may correlate with its microstructures. Deformation of zircon can affect diffusion and thus result in uncertainties in age determination. Therefore, deformation study of zircon may have significant implications for the dynamics and evolution of planets. Study of zircon under high pressure can help us to understand mechanical and elastic properties of zircon and determine the nature of deformations at mantle conditions.

Angle-dispersive X-ray diffraction in a radial geometry using a diamond anvil cell was performed at beamline X17C, National Synchrotron Light Source, Brookhaven National Laboratory. Our results showed that zircon is sensitive to stress and weak deformation was observed even at 1 GPa. Ratios of differential stress to shear modulus (t/G) are in the range of 0.002- 0.008 at pressure to 30 GPa. Differential stress supported by zircon showed that (200) is the weakest plane and could be responsible for the onset of deformation. Zircon to reidite transformation was found at above 18 GPa, which is slightly lower than previous studies. Our results suggested shear strength may play a key role for the transition. Our volume data fitted to Birch-Murnaghan equation of state yielded a bulk modulus of 270.03±4.6 GPa (K_0=4), in broad agreement with previous reports. Weak texture in (100) was observed at low pressure and became more profound with pressure. At pressure above 11-13 GPa, (100) texture rotated towards to (111) due to the applied stress.

Abstract ID: 35224

Final Number: VGP13A-03

Title: *In situ* Microstructural and Mechanical Analysis of Zircon and Monazite Using Type Sections for U-Pb Strain Chronometry

Presenter/First Author: Giancarlo A Jones, University of Western Ontario, London,

Presenter/First Author Email: gjones47@uwo.ca

Co-authors: Desmond Moser, Western University, London, ON, Canada; Ivan Barker, University of Western Ontario, London, ON, Canada

Abstract Body: Direct radiometric dating of deformation in the lithosphere has been a longstanding goal in geochronology. Moser et al. (2009) have demonstrated that zones within textured zircon grains from the lower crust beneath the Vredefort impact structure in South Africa date a lower-crustal flow event. The material setting(s) that gave rise to zircon deformation and Pb loss are yet not well understood. We explore the relationship between *in-situ* material properties, textural features in zircon and monazite grains and their petrologic setting in these type sections of the mylonitic mafic lower-crust. Methods used include EBSD mapping, and texture analysis with commercial and MTEX software. In one thin section we have identified 64 zircons ranging in size between 4 and 190 microns. The largest grains are enclosed in garnet macrocrysts and more abundant smaller grains are in the matrix and garnet coronae. A total of 145 monazites were identified between 4 and 49 microns in size. Monazites were mostly restricted to the matrix. Textures in BSE imaging have proved useful as a predictor of deformation microstructures. Using this proxy, deformed grains were found exclusively in the matrix and are typically

larger, anhedral and non-equiaxed. Low-angle grain boundaries were measured in these grains using EBSD. Monazites are less textured than zircons. It remains to be determined whether these are primary or secondary phases. Comparisons will be made with samples from other high-grade terranes including the Central Gneiss Complex of Norway and the Kapuskasing Uplift in Ontario. LA-ICP/MS will be used to investigate spatial relationships of age-resetting and texture. We hope that this work will increase our predictive capacity for locating ideal rock types and environments for U-Pb strain chronometry.

Abstract ID: 35163

Final Number: VGP13A-04

Title: Untangling impact ages and crustal processes in highly shocked planetary materials using accessory minerals

Presenter/First Author: James Darling, University of Portsmouth, Portsmouth,

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Co-authors: Desmond Moser, Western University, London, ON, Canada; Kim Tait, Royal Ontario Museum, , Canada; Ivan Barker, University of Western Ontario, London, ON, Canada; Kevin Chamberlain, University of Wyoming, Laramie, WY; Axel K Schmitt, University of California Los Angeles, Los Angeles, CA

Published Material: Some of the results were presented at IMA2014, but this presentation will add significant new data and insight.

Abstract Body: Separating the effects of shock metamorphism from endogenic crustal processes continues to be a major challenge for the study of meteorites and terrestrial impact structures.

Here we show that in highly shocked Martian and Lunar meteorites this evolution can be resolved by combining electron nanobeam techniques (CL, EBSD, TEM) with in-situ U-Pb isotope analyses by SIMS or LA-ICP-MS. We focus upon the effects of shock metamorphism on the U-Pb systematics of baddeleyite (ZrO_2) and zircon ($ZrSiO_4$) – micron-scale phases common to achondrites and terrestrial impact structures. Unlike zircon, the relationship of shock heating and deformation with retention of radiogenic Pb in baddeleyite is poorly known.

In both NWA 5298 (shergottite) and NWA 2200 (Lunar anorthositic breccia), baddeleyite grains from individual polished thin-sections show a wide array of deformation microstructures. These include fracturing, varying degrees of amorphization and granulation, plastic deformation, and recrystallization: reflecting local variations in shock pressures and waste heat. SIMS U-Pb isotope analyses reveals variable degrees of age resetting in both samples. For NWA 5298, variable Pb loss (as high as 80 %) can be directly correlated with observed microstructures and with the extent of post-shock zircon rims that are linked to release of Si-rich fluids during quenching of shock melt pockets during transit to space. In NWA2200, the range of baddeleyite $^{207}Pb/^{206}Pb$ ages (ca. 4050 to 3850 Ma), is significantly younger than zircons with shock microstructures from the same sample (ca. 4400 to 3950 Ma), reflecting either a distinct provenance or differing shock-response of the two phases.

These findings, contrary to the results of shock loading experiments, indicate that baddeleyite U-Pb ages can be reset under certain shock metamorphic pathways. The combined microstructural and U-Pb data therefore provide a powerful tool for determining both the primary age of the meteorite assemblages and bracketing the time of impact events.

Abstract ID: 35378

Final Number: VGP13A-05

Title: Testing for age correlation among the young shergottites

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Abstract Body: Recent investigations have demonstrated that the application of ion and nanoscopic electron beam analysis to highly refractory U-bearing minerals in martian meteorites can reveal the complex petrogenetic history of these rocks, including igneous crystallization and shock ejection. We are evaluating the extent to which the geochemical grouping of the shergottites according to depleted-intermediate-enriched REE compositions and mafic-permafic-ultramafic major element composition axes are reflected in the crystallization ages of shergottites measured by in situ U-Pb dating of igneous Zr-rich minerals and phosphates. We are also evaluating the extent to which martian phosphate minerals record post-crystallization alteration (e.g., by fluids and by impact heating), and searching for launch-generated assemblages (e.g., zircon) that can constrain the timing of the impact events which delivered the shergottites to Earth. Our study encompasses a wide range of shergottites, many of which yield mineral crystallization ages from the last several hundred million years. Phase mapping using SEM-EDS has demonstrated a common association of igneous baddeleyite with ilmenite-dominant oxide assemblages. Primary igneous phosphates, predominantly Mg-merrillite can show partial replacement by chlorapatite in association with pockets of glassy SiO_2-K_2O-rich shock melt. Despite shock effects, all the shergottites in this study exhibit dominantly igneous textures, including core-to-rim zoning of pyroxene and olivine from Mg-rich to Fe-rich and igneous zoning in plagioclase. Isotopic and trace element analyses, spatially correlated with primary and secondary microstructures will test for age correlation and potential comagmatic samples of young martian magmatism.

Abstract ID: 35331

Final Number: VGP13A-06

Title: Atom Probe Tomography of Zircon and Baddeleyite Geochronology Standards

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Abstract Body: Atom Probe Tomography (APT) is an analytical technique whereby the positions of elements, and their isotopes, can be reconstructed in 3D, shedding light on nano-scale trace element mobility in geochronology minerals. The sample is extracted from the bulk material and milled using a dual-beam FIB SEM into a needle shape with an apex radius of 50-100nm. Single atoms (or small groups of atoms) are ionized by

UV laser pulse from the surface while under the presence of a large electric field and removed from the surface one-at-a-time. Each removal (field evaporation event) is synchronized to a timing pulse and projected to a 2D position-sensitive detector providing ion identification through time-of-flight mass spectroscopy and, ultimately, a composition map of the surface. Done iteratively over many millions of ions, the evolving surface information is reconstructed as a 3D map of individual ions from which information can be extracted for a for a variety of real-space analyses. In general, optimal APT acquisition conditions are material dependent. As APT is a destructive technique, it may be advantageous to perform optimization on non-precious, geochronology standard materials to optimize both data quality and analysis yield prior to sacrificing the true material of interest. In the present work, we explore the effect of various laser-pulse energies on zircon (BR266) and baddeleyite (Phalaborwa) standards. Because limited analysis yield is an issue for APT, possibly exacerbated by deformation microstructure, we also explored some post-specimen-preparation treatments (such as annealing) on both the baddeleyite standard and shocked terrestrial baddeleyites in an effort to increase sample yield and test for induced chemical segregations. Transmission EBSD (TKD) mapping of microtips was also explored to integrate lattice orientation(s) with the 3D APT map. We will show APT analyses from these materials and report on our efforts to improve analysis yield to date.

Abstract ID: 34803

Final Number: VGP13A-07

Title: Combining Nano Scale Microstructural Analysis and U-Pb Geochronology of Terrestrial Baddeleyite to Unravel Crustal and Bombardment Chronology

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Abstract Body: Baddeleyite (monoclinic-ZrO_2) commonly crystallizes in mafic and ultra-mafic rock types where zircon ($ZrSiO_4$) does not, rendering it a key geochronometer within these silica under-saturated lithologies more prevalent on the Moon and Mars. It is an especially important geochronology mineral when examining *ex-situ* meteoritic samples derived from other planetary bodies, as many grains within an igneous population survive ejection and give the timing of primary crystallization whereas others experience shock heating and fluid alteration to cause partial to complete age re-setting to the time of an impact event. Discrimination of these scenarios in other samples so as to best interpret U-Pb age will benefit from a fuller knowledge of the shock metamorphic response of baddeleyite to known natural and experimental conditions. Here we present our first ground-truthing efforts toward this goal with an analysis of the evolution of orientation and isotopic microstructure of baddeleyite from the Sudbury impact structure - a globally unique, terrestrial example of these impact processes. Micro-baddeleyite grains (<15µm) within the 2.45 Ga Matachawan diabase dyke swarm, subjected to shock metamorphism as a result of the 1.85 Ga ~200km diameter Sudbury impact structure are being comprehensively analysed along a (near linear) transect across the Superior province radiating out from the boundary with the melt sheet. Electron Backscatter Diffraction (EBSD) mapping reveals typical igneous cooling twins parallel to [100] but also lattice misorientations up to <15°. Atom probe tomography of coherent material (i.e. no apparent fractures or phase discontinuities) reveals nanoclusters of Fe, Al and Ca presently interpreted to have been introduced following shock metamorphism. Distribution analysis of trace elements including U and Pb is underway and will be compared to isotopic analysis of residual grain material using complimentary mass spectrometry methods. Baddeleyite is a common, though tiny, crustal phase that has great potential to improve inner solar system crustal and impact chronologies.

Abstract ID: 36793

Final Number: VGP13A-08

Title: EBSD and Atom Probe Geochronology of Zircon and Baddeleyite from Early Mars

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Published Material: A minor component (10%) of these findings was presented at Goldschmidt 2013 in Florence, IT.

Abstract Body: A rare record of the earliest history of Mars is accessible in the crystal and lithic clasts of meteorite NWA 7475, one of a group of recently discovered relatively water-rich stones from Rabt Sbayta, Morocco, interpreted to be a suevite-like regolith breccia [1]. SIMS U-Pb dating of the related meteorites by other workers [2,3] has identified zircons as old as 4.44 Ga making them invaluable physical evidence of martian crustal processes. The zircon population experienced a Pb-loss event approximately 3 billion years later, the cause of which is still being investigated. Here we present in-depth examination of the chemical and orientation microstructure of zircon and baddeleyite by EBSD and atom probe tomography (APT) in an effort to gain additional information on Early Mars bombardment history and subsequent metamorphism. FEG-SEM mapping of accessory phases in a thick section identified several hundred small zircon grains in the size range of 4 µm to 25µm in longest dimension (mean= 7µm) and over 100 baddeleyite grains of similar size distribution. A 3D APT map of an approximately 80nm x 80nm x 350nm volume of zircon was homogeneous with respect to trace elements including Li; however, U and Pb were below detection. EBSD mapping of an igneous zircon crystal clast revealed amorphous, U-rich domains that are now metamict, signifying a lengthy upper crustal residence. An APT map from an unfractured, crystalline domain reveals chains of nanoclusters of Fe, Al, Ca. These are interpreted, by analogy with terrestrial observations, to be due to fluid-assisted contamination along fractures during regolith metamorphism. APT geochronology of an anhedral baddeleyite crystal clast yields a Pb isotope ratio consistent with ≥4 Ga formation. A metamorphic nano-scale rim of zircon on this grain appears in a second APT map, and points to martian Si metasomatism of the regolith at some point prior to the meteoroid launch event. These and other nanoscale crystal histories of U-Pb dating phases will be presented to add to our growing picture of martian crustal processes preserved in these rare specimens. [1] Wittman, A., et al., 2015 (in press); *MAPS* [2] Humayun, M. et al., 2013; *Nature* [3] Nemchin, A. et al., 2014; *Nature Geoscience*

Abstract ID: 35286

Final Number: VGP14A-0388

Title: Processing of X-ray microtomography images to investigate crystallized volcanic rock textures

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Abstract Body: X-ray computed microtomography has become a fundamental tool in geosciences to study rock textures directly in 3D. This technique is useful to study the vesiculation of pumices [1], but only recently there has been more interest to study the crystallization process using volumetric datasets. Crystal and silicate glasses often have similar density and absorption contrast, therefore, image processing requires more sophisticated procedures to separate them.

Feldspars are one of the most abundant crystalline phases of igneous rocks, hence their crystallization conditions and abundance are intensely investigated by geologists. Moreover, feldspar is one of the most difficult phases to segment during image analysis, making the separation of feldspars from the silicate glass a challenge.

Here we show that the crystallinity of natural pumice of Stromboli and synthetic trachyte from Campi Flegrei magma can be studied using microtomographic datasets. Data were collected using the propagation-based synchrotron X-ray phase contrast microtomography technique at the SYRMEP beamline of the Elettra-Sincrotrone Trieste Laboratory (Basovizza (Trieste), Italy). Although X-ray phase contrast imaging can improve the visualization of weakly absorbing features, making visible the edge of feldspars, the segmentation of these crystals cannot be directly obtained from the raw phase contrast X-ray images. Phase-retrieval methods are needed for extracting phases of interest. A single distance phase-retrieval algorithm [2] was applied to the dataset to improve the contrast between feldspar and glass. Through this technique we are able to isolate feldspars both in natural samples and in synthetic ones, and to perform quantitative analysis of these phases using volumetric datasets. Our preliminary results have demonstrated that phase retrieval processing will be an invaluable tool for geologists to study rock textures.

[1] Polacci M. et al. (2009) J. Geophys. Res. 114, B01206. [2] Paganin D. et al. (2002) J. of Microscopy 206, 33-40.

Abstract ID: 34805

Final Number: VGP14A-0389

Title: 3D IMAGE ANALYSIS OF DEFORMATION BANDS IN POROUS CARBONATE GRAINSTONES

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Abstract Body: Recent studies based on field and laboratory data have documented the effects of Deformation Bands (DBs) in fluid flow in porous rocks. The hydraulic properties of porous carbonates rocks could change abruptly due to the presence of DBs. The inner structure of DBs could show high variability in terms of textural and petrophysical properties, which have been traditionally assessed with 2D microscopy techniques.

The aim of this work is to perform a quantitative 3D image analysis of the microstructure of DBs hosted in porous carbonate grainstones by using a non-destructive 3D-imaging technique. The experiments consisted of the synchrotron X-ray computed microtomography (micro-CT) characterization of rock samples prepared in small parallelepipeds (4x4x40 mm size) and corresponding to grainstones highly affected by DBs exposed in San Vito Lo Capo peninsula (Sicily, Italy), Favignana Island (Sicily, Italy) and Majella Mountain (Abruzzo, Italy). For the analysis, the data is segmented in two main components porous and solid phases. The properties of interest are porosity, connectivity, a grain and/or porous textural properties, in order to differentiate host rock, DBs and their inner structure.

The preliminary results of the quantitative X-ray micro-CT image analysis indicate trends of porosity and connectivity for host rock, DB and zones therein. San Vito Lo Capo's sample presents the most complex structure of DB, which is composed by three inner zones. Wherein, the porosity and connectivity are reduced from the outer to the inner zone of the DB due to grain compaction, cementation and grain size reduction. For the samples of Favignana Island and Majella Mountain, no differentiated zones within the DBs were found. However, for the Majella Mountain's sample we observed a low porosity zone surrounding the DB that could be the result of water interaction. In general, we noted that the porous space within DB is poorly connected and it is about five times less than in the surrounding host rock. The preliminary results presented in this study and future analysis may be helpful for better understanding the inner structure of deformation bands and their implications to fluid flow in porous carbonates.

Keywords: *Deformation bands, Grainstones, X-ray computed tomography.*

Abstract ID: 34156

Final Number: VGP14B-0390

Title: INSIGHTS INTO THE ANALYSIS OF MICROMETRE-THIN RIMS USING LA-ICP-MS: DEPTH-PROFILE AND GRAIN MAPPING OF UNPOLISHED CRYSTALS

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Published Material: Kelly, C.J., McFarlane, C., Schneider, D.A., and Jackson, S.E. (2014) Dating micrometre-thin rims using a LA-ICP-MS depth-profiling technique on zircon from an Archean metasediment:comparison with the SIMS depth-profiling method. Geostandards and Geoanalytical Research, DOI: 10.1111/j.1751-908X.2014.00314.x

Abstract Body: Zircon, in the presence of alkaline fluids, can undergo coupled dissolution-reprecipitation. This fluid mediated alteration manifests itself as µm-scale rims on the outer surfaces and within existing imperfections of zircon crystals. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was examined as a tool to interrogate the lateral and depth variation of isotopic (U-Pb) and elemental (REE) distributions within the rims of unpolished zircons from an Archean metasediment. Our LA-ICP-MS U-Pb depth profile technique was able to identify micron-thin (<3 µm), concordant, isotopically distinct mineral domains (rims) characterized by a ca. 100 m.y. younger $^{207}Pb/^{206}Pb$ age associated with 2σ age-uncertainties as low ~0.2%, as well as elevated U content relative to the zircon interior (up to an order of magnitude). Our calculated penetration rate suggests that each laser pulse excavates depths of ~0.06 µm. Ages resolved through the LA-ICP-MS U-Pb depth profile method overlap, within 2σ uncertainties, the $^{207}Pb/^{206}Pb$ ages measured using SIMS U-Pb depth-profiling on the same population of zircon. The rims are further evinced by the presence of a relative enrichment (>3 orders of magnitude) in REE measured using an independent LA-ICP-MS depth-profiling technique on the same zircon. The enrichment of REE was used as an indicator of rim material. LA-ICP-MS techniques were developed to generate trace element concentration maps, with a lateral spatial resolution of 7 µm, of the outermost 3 µm of unpolished zircon grains. These maps demonstrate the heterogeneous nature of the crystallization of rim material, commonly demonstrating preferred growth along fractures or within isolated domains on the grain surface. The LA-ICP-MS techniques are capable of quickly identifying, and chemically and isotopically characterising zircon rims, which are an indication of low temperature, yet geologically significant, fluid events that may otherwise remain unidentified.

Abstract ID: 35045

Final Number: VGP14B-0391

Title: Microstructural response of U-Pb dateable phases across the Vredefort impact structure, South Africa.

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Abstract Body: The precise chronology of impact events on planetary surfaces has implications for Earth's crustal and bio-evolution. U-Pb isotopic dating of accessory phases such as zircon has proved valuable in the pursuit of an enhanced impact chronology, as sufficient shock damage and heating can cause up to 100% Pb-loss while preserving microstructures diagnostic of specific shock environments. Other geochronology phases (e.g. baddeleyite, monazite) also have the potential to contribute to the understanding of shock processes. However, there have been few systematic studies of how zircon and these minerals respond microstructurally and isotopically in a crater environment relative to benchmark shock indicator minerals such as quartz and plagioclase. Here we present initial findings of such a comparison across a known shock metamorphic gradient of ~60 GPa and 900 °C at the 2.020 Ga Vredefort dome, South Africa. Electron nanobeam techniques using a FEG-SEM were applied to map, contextualize and analyze various coexisting accessory phases and measure chemical and orientation microstructures (e.g. CL, EBSD) along with impact-induced melt inclusions. We report preliminary results from low, medium and high shock metamorphic grades of the deeply eroded crater floor. Coexisting phases at the low-grade site include zircon, baddeleyite and titanite, while the high-grade site hosts zircon, monazite and apatite. In all samples, accessory phases entirely enclosed by rock forming minerals (e.g. albite) show less shock damage than those along grain boundaries, revealing the heterogeneity of shock effects within a given sample. Shock microtwins are pervasive, whereas other diagnostic shock effects such as glass inclusions have only been identified in high and medium-grade samples. A more complete understanding of the microstructural and U-Pb response at Vredefort will become a reference for interpreting age and provenance of shocked detrital or *ex-situ* minerals from Earth, meteorites, Apollo breccias and future sample return missions.

Abstract ID: 33573

Final Number: VGP14C-0392

Title: Thermodynamic modeling of the Li_2O-Na_2O-Al_2O_3-SiO_2 system under atmospheric pressure

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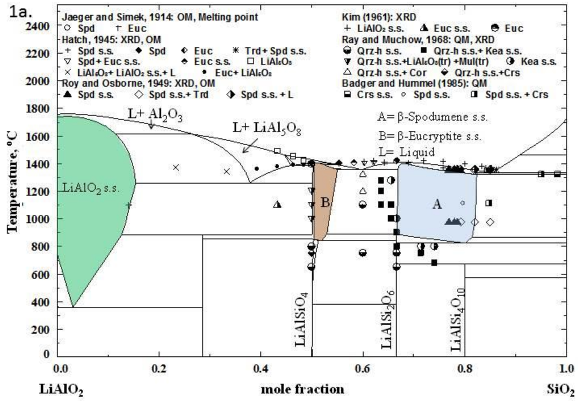
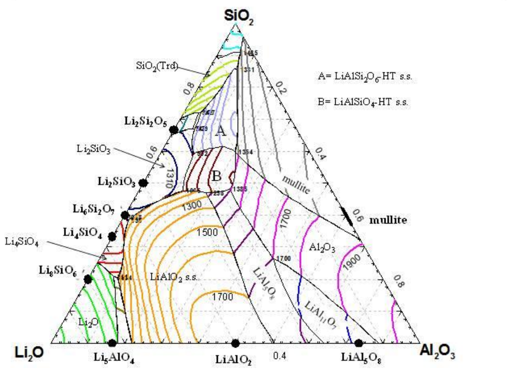
Abstract Body: The system Li_2O-Na_2O-Al_2O_3-SiO_2 contains numerous minerals of geological interest such as eucryptite ($LiAlSiO_4$), spodumene ($LiAlSi_2O_6$), petalite ($LiAlSi_4O_{10}$), nepheline ($NaAlSiO_4$), jadeite ($NaAlSi_2O_6$) and albite ($NaAlSi_3O_8$) which are present in alkali-rich granites and pegmatites, for example. A critical assessment of the Li_2O-Na_2O-Al_2O_3-SiO_2 system was conducted using all available literature data. All the thermodynamic properties (like enthalpy, entropy, heat capacity, heat content, etc.) and phase diagram data (e.g. $LiAlO_2$-SiO_2 in Fig. 1a) were thermodynamically optimized and compared with experimental data. The solubility of SiO_2 in $NaAlO_2$, $LiAlO_2$, eucryptite, spodumene, nepheline, jadeite and albite was successfully modelled (e.g. in Fig. 1a) by taking into account the complex crystallographic structure of all the polymorphs involved. A set of optimized model parameters was obtained for all the phases of the system which could reproduce all reliable thermodynamic and phase equilibria data within experimental error limits over the entire temperature and composition range. Our database can be used along with Gibbs energy minimization software to calculate unknown thermodynamic properties and any phase diagram (such as the Li_2O-Al_2O_3-SiO_2 ternary

liquidus projection shown in Fig. 1b).

1a.





Abstract ID: 34744

Final Number: VGP14C-0393

Title: TCInvestigator: Automated Calculation of Contours for THERMOCALC Pseudosections

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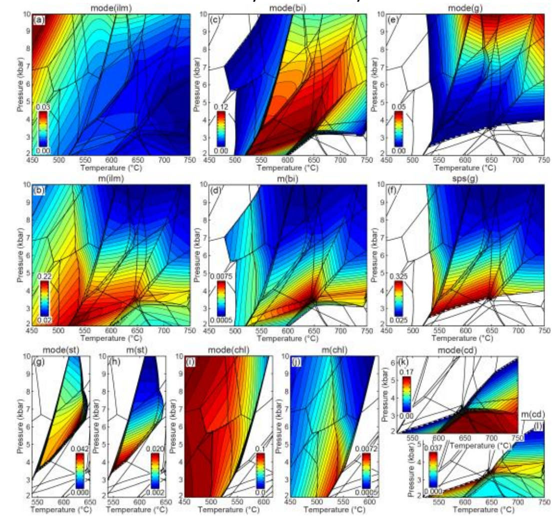
Published Material: A preliminary version of this software was presented on a poster at EGU 2014

Abstract Body: Forward modelling of bulk-rock compositions to constrain pressures and temperatures (P-T) of metamorphism based on mineral assemblage is a commonly used technique. The pseudosections produced contain a wealth of information about predicted mineral compositions and abundances that goes far beyond variations in mineral assemblage. In practice, utility of these parameters is limited because calculation of compositional isopleths and contours of modal mineral abundance are time consuming to calculate for THERMOCALC pseudosections. Our new software called TCInvestigator provides a quick and user friendly way to contour all compositional parameters and mineral modes across a THERMOCALC pseudosection.

TCInvestigator takes the postscript pseudosection diagram and creates a grid of points at a user-specified resolution. THERMOCALC is then used to calculate the equilibrium mineral assemblage at each point using an initial starting guess provided by the user (this can be calculated during initial pseudosection calculation). Once all points have been tried, any that failed to calculate are re-tried using interpolated starting guess values from the surrounding points. This procedure is iterated until no more solutions are found. Any remaining unsolved points are then interpolated numerically from surrounding solutions to produce a fully quantified set of mineral modes and compositions. Following calculation, the dataset can be contoured and output as figures, output as a Matlab readable binary structure or selected compositions written to an ASCII text file. Automated contouring using TCInvestigator allows the user to consider easily all compositional variables at one time. As new P-T conditions and bulk compositions are explored using improved thermodynamic datasets this software will provide a quick and simple way to identify key compositional and modal variations in the newly-modelled systems.



Abstract ID: 34810

Final Number: VGP14C-0394

Title: Thermodynamic Properties of Dilute Aqueous Electrolytes and Non-Electrolytes at Elevated Temperatures, from Molecular Dynamics Simulations

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Abstract Body: Thermodynamic properties of aqueous solutes are key parameters in geochemical modeling of fluid-driven and fluid-mediated processes. Properties at infinite dilution comprise the most commonly used solute standard state convention, and are thus required for essentially all fluid-rock reaction modeling. In this study we use classical molecular dynamics simulations to estimate thermodynamic quantities for ions, ion pairs and non-electrolytes at elevated temperatures and low to high pressures (i.e., from vapor-like to liquid-like fluid densities). Simulations are done using the SPC/E water model, and solutes including Na^+, Cl^-, $NaCl^0$and Ar are included with concentrations set to 0.01 molal. Hydration free energies for atoms, ions or ion pairs are calculated by lambda dynamics.

Hydration free energies of aqueous solutes at near-critical and super-critical temperatures show a systematic dependence on fluid density under isothermal conditions, with more pronounced density dependence at low pressures and only weak density dependence at high pressures. Hydration

free energies also show relatively weak isochoric temperature dependence at super-critical temperatures. The density dependence seems to reflect short-range and long-range density fluctuations resulting from solvation. Free energies of hydration for non-electrolytes show trends opposite to those for electrolytes. Differences in hydration free energies for neutral ion pairs compared to free ions are used to estimate dissociation constants at these conditions.

One advantage of the methods used here is that experimentally determined solvation free energies of electrolytes are difficult to deconvolute into cation and anion contributions due to the charge balance restriction, whereas the present data are implicitly resolved into contributions from individual ions. Moreover, thermodynamic data (hydration free energies) can be linked to other calculated properties, such as the solvation structure around ions and non-electrolytes. Correlations between free energies and structural data thus can be used to interpret the factors controlling thermodynamic properties.

Abstract ID: 35680

Final Number: VGP14C-0396

Title: How to choose solution models for phase equilibria modeling of migmatitic metapelites?

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Abstract Body: Phase equilibria modelling is a widely used tool to investigate the evolution of metamorphic rocks. One approach consists in fixing the bulk chemical composition and calculating the mineral phase assemblages by minimizing the Gibb's free energy. Because mineral phases share chemical elements and compete with each other's, the choice of mineral solution models is of uttermost importance. Despite their wide use, few studies have tested the reliability of this technique by reproducing well-controlled cases, such as experimental studies and none have investigated whether a set of solution models performs better than others. In this study, we investigate these issues by calculating phase equilibria in the Na-Ca-K-Mn-Fe-Mg-Al-Si-H-Ti-O chemical system for three partial-melting experiments using different set of solutions models. These experiments span a range of pelitic bulk compositions and were conducted between 500 and 1000 MPa, as well as between 750 to 1050°C. The software Perple_X is used because it is the only one offering total flexibility for the choice of models. The stability field, compositions, and proportions of the various mineral phases for each calculation are compared with experimental results. We focus on biotite, garnet and plagioclase, for which the compositional isopleths are most commonly used for thermobarometry conducted with phase equilibria modeling. We show that it is possible to reproduce experimental results with relatively good accuracy (discrepancies generally varying by 20 to 50°C for a given pressure), notably for the biotite-in, the melt-in and Ti-oxides equilibria However, a specific set of solution models is required, and it is not necessarily composed of the models generally used.

Abstract ID: 36769

Final Number: VGP14C-0397

Title: Multicomponent Diffusion Modelling Applied to the Sudbury Igneous Complex

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Abstract Body: Chemical diffusion is an essential transport mechanism for many magmatic processes. Diffusion across interfaces separating liquid layers with initially stable density distributions may engender unstable density distributions leading to rapid homogenization of the layers. We developed a finite difference model to simulate diffusion in a multicomponent silicate melt in order to better understand the evolution and differentiation of igneous systems, in particular, the Sudbury Igneous Complex in Ontario, one of the largest meteorite impact craters on Earth. The Sudbury impact melt was differentiated into norite cumulates, quartz gabbro, and granophyre. Within the granophyre unit, there exists a second layer of quartz gabbro which suggests a reversal in the crystallization sequence. This reversal might be explained as a boundary between two melt bodies, separated by either temperature or composition or both, that must have allowed diffusion-driven chemical exchange.
The diffusion partial differential equation is modelled using the semi-implicit Crank-Nicolson finite difference scheme, which involves spatial discretization and solving a system of equations to advance in time. The diffusion coefficient is a proportionality constant between the molar flux and the concentration gradient. The matrix of diffusion coefficients is called the diffusion matrix and is obtained from empirical experiments on the five-component K20-Na20-Al2O3-SiO2-H2O system. Taking an average composition of the granophyre above the boundary and an average composition of the Copper Cliff offset dikes and projecting them onto the five component system, we ran the model at 1200 degrees at 5000 bar. Preliminary results show an overstable density distribution when the magmas are dry and fingering instabilities when >3 weight percent water is added to the upper layer; however, at approximately 2 weight percent water, the upper layer is able to diffuse stably with the lower layer, allowing the two magma bodies to evolve without being rapidly homogenized by diffusion-driven convection.

Abstract ID: 33284

Final Number: VGP21A-01

Title: Petrological Insights on the Northern Canadian Cordillera Lithosphere: in the Footsteps of Don Francis

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Co-authors: Kelly Russell, University of British Columbia, Vancouver, BC, Canada

Published Material: Presentation is synopsis of published (GSA Bull, Lithos, Bull Volc) and unpublished data

Abstract Body: Geochemical, petrological and volcanological studies of the Neogene to Recent volcanic rocks distributed across the northern Canadian Cordillera by Don Francis and coworkers have contributed greatly to our current understanding of the origins, architecture and dynamics of the Cordillera lithosphere. Their work has generated many critical new hypotheses concerning: (I) the sources for the highly undersaturated magmas (e.g., nephelinites), especially highlighting the potential role of amphibole for influencing their trace element characteristics, (II) using melt chemistry to map lithospheric structure, and (III) geochemical and geophysical properties of peridotite xenoliths to aide interpretations of lithospheric structure from broad-scale geophysical studies (i.e., LITHOPROBE). Here we summarize our recent research progress in the northern Cordillera that over the past 20 years has been informed and inspired by Don's work and that also addresses these three broad topics.

(I) MAGMA ORIGIN, TRANSPORT & ERUPTION: uses of thermodynamic modeling to constrain the intensive properties (e.g., activity of silica and oxygen fugacity) of the source regions, the petrogenetic relationships between nephelinites, basanites and alkali olivine basalts, and the depths of initiation of phenocryst crystallization and magma storage.

(II) XENOLITH STUDIES OF THE MANTLE LITHOSPHERE: combining peridotite geothermometry with models for lithospheric geotherms to constrain depths of xenolith entrainment, identification of 'cryptic' metamorphic events in high grade quartzofeldspathic metamorphic xenoliths, and comparison of peridotite-hosted amphibole veins to inferred lithospheric melt compositions.

(III) GLACIOVOLCANIC INSIGHTS ON PALEOCLIMATE: constraining the timing of formation and decay of the Cordilleran ice sheets, as well as the potential fundamental isostatic controls of ice-loading on hot, possibly melt-laden crustal and mantle lithosphere.

Abstract ID: 34189

Final Number: VGP21A-02

Title: Delving into density and its role in magmatic processes

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Co-authors: Silvano Sinigoi, , ,

Abstract Body: Density difference between liquid and solid causes convection in magma chambers, controls mixing between primitive and evolved magmas and influences where minerals crystallize. Magmas leave their mantle source and move upwards because most silicate liquids are less dense than surrounding rocks. But this is not always the case. Fe-rich liquids produced by plagioclase crystallization are denser than normal crustal rocks, and following accumulation of plagioclase in anorthosite massifs, they migrate downward to accumulate deeper in the crust.

In the mafic-ultramafic conduits that host Ni-sulfide deposits, magma flows in two directions. The segregation of mafic minerals (olivine, pyroxene) and immiscible Ni-Fe sulfide liquid produces low-density evolved liquid, which continues towards the surface, and a dense slurry of crystals plus sulfide and silicate liquids. These slurries normally accumulate on the floor of the conduit, but if the floor is steeply sloping, the slurries slump downwards, depositing their load of crystals and sulfide liquid deeper in the conduit system. The latter process may play an important role in generating Ni sulfide ore deposits.

Many mafic-ultramafic intrusions; e.g. the Uitkomst intrusion in South Africa and the mafic complex in the Ivrea zone of Italy, contain remarkable rafts of sedimentary rock midway through the intrusion. The rafts have a near-horizontal orientation and separate lower ultramafic cumulates from overlying gabbroic rocks. In the Uitkomst intrusion, the rafts are aligned with strata with the same lithology in the surrounding rocks. These features suggest that magma was emplaced slowly and passively between layers of more resistant sedimentary rocks. Differentiation arises from the input of dense mafic magma into the lower portions of the intrusion while less-dense evolved liquids penetrate higher in the intrusion.

Abstract ID: 34264

Final Number: VGP21A-03

Title: Primitive replenishment of Neoproterozoic Franklin Sills on Victoria Island

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Co-authors: Ben Hayes, , , ; Charlie Beard, , , ; Johan C J Lissenberg, Cardiff University, Cardiff, United Kingdom; Dominique Weis, University of British Columbia, Vancouver, BC, Canada; James S Scoates, University of British Columbia, Vancouver, BC, Canada; Boswell A Wing, McGill University, Montreal, QC, Canada; H Richard Naslund, Binghamton University, Binghamton, NY

Published Material: The basic story is in 3 papers, 1 accepted in press, 2 submitted.

Abstract Body: The Neoproterozoic (~723-716 Ma) Franklin Large Igneous Province on Victoria Island, Arctic Canada, has a sill-dominated magma plumbing system. Franklin magmas ascended along fault-guided feeders, some reaching the surface to erupt as the Natkusiak flood basalts. We investigated three sections through a 20-40m thick sill, separated by a total distance of >50 km, and emplaced at the same stratigraphic horizon. This sill is geochemically equivalent to the basal Natkusiak lavas, and has a basal olivine-enriched layer containing ≤ 55% olivine, overlain by an internally-differentiated gabbroic unit. Pb, Sr and S isotopic data show that the olivine basal layer is not consanguineous with the gabbro, which implies that this sill is a composite intrusion. We suggest that the olivine-enriched basal layer originates from a slurry replenishment event injected into a partially crystallized gabbroic sill. A gradual westward shift towards more Fe-rich olivine zone bulk compositions suggests that this olivine slurry gradually mixed with the resident gabbroic mush as it propagated westward. Along strike comparisons of Pb isotopic compositions suggest that at least three chemically distinct magmas were injected into this sill, each of which assimilated different crustal contaminants prior to emplacement. Near the inferred conduit feeder, Pb isotopic compositions and an abundance of calc-silicate reaction products suggest that magmas assimilated small amounts (<10%) of dolostone. We infer that much of the assimilation occurred within the feeder conduit because these commonly contain cataclastic breccias, so increasing surface area and reactivity. We suggest that the high-Fo content of some olivine crystals records buffering of melt MgO/FeO during dolostone assimilation.

Abstract ID: 33224

Final Number: VGP21A-04

Title: THE ASCENT OF KIMBERLITE: INSIGHTS FROM OLIVINE

Presenter/First Author: Kelly Russell, University of British Columbia, Vancouver, BC

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Co-authors: Curtis Brett, , , ; Graham D Andrews, California State University Bakersfield, Bakersfield, CA; Thomas Jones, , ,

Published Material: We have a paper in review with EPSL and presented a earlier form of this material at the 2014 Goldscmidt meeting (I was an invited speaker)

Abstract Body: Kimberlite magmas derive from ultra-deep (≥200 km) mantle sources and transport high loads (>25 vol. %) of mantle-derived xenoliths and xenocrysts to the Earth's surface. A distinctive trait is their high abundance of ellipsoidal-shaped olivine grains derived from disaggregation of mantle peridotite. Russell et al. (2012) provided a simple model for the rapid ascent of these enigmatic magmas involving deep-

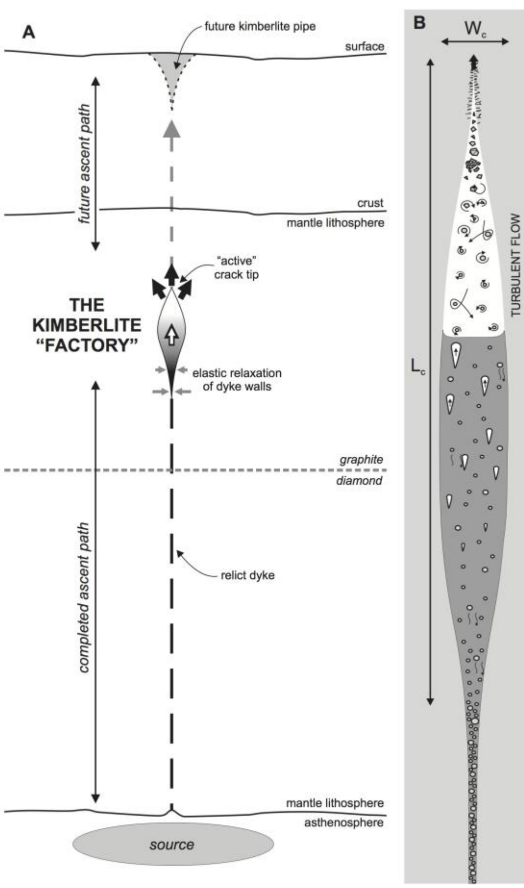
seated fluid production driven by preferential assimilation of orthopyroxene (Opx) by parental carbonatitic melts [1]. Here we expand on this model using evidence embedded in morphological (rounding) [2,3], textural (sealed/healed cracks) [2], and surface (smooth and flakey) [3] properties of xenocrystic olivine. These features develop during transit through the cratonic mantle lithosphere. The ascent process operates as a "*kimberlite factory*" (Fig. 1) wherein progressive upward dyke propagation of the carbonatitic melt fractures, entrains and disaggregates peridotitic mantle. Opx xenocrysts are preferentially assimilated causing deep-seated exsolution of a CO_2-rich fluid providing buoyancy for the accelerating and turbulent ascent of the magma. Individual olivine xenocrysts undergo abrasive milling in the fluid-rich head of the dyke and decompression cracking over ascent distances of 15-25 km. Continued chemical modification of the carbonatitic melt by Opx assimilation results in a silica-enriched, olivine-saturated *kimberlitic* melt that crystallizes olivine to form overgrowths on milled and rounded olivine xenocrysts. The lack of decompression cracks within olivine overgrowths indicates that the melt becomes saturated with respect to olivine at depths < 25 km from the Earth's surface.

[1] Russell et al. (2012) *Nature* **481**, 352–356.

[2] Brett (2009) Unpublished M.Sc. Thesis.

[3] Jones et al. (2014) *Solid Earth*.

Fig. 1. Architecture of kimberlite factory. (A) The factory is an elastically-inflated portion of the kimberlite dyke. (B) Upper portion (white) comprises a turbulent, CO_2-rich fluid suspension of olivine xenocrysts sampled from the damage zone formed at the crack tip during dyke propagation. Grey region is a transitional to laminar flow regime comprising, frothy to bubbly kimberlite melt and xenocrysts sedimented from the overlying turbulent column of fluid.



Abstract ID: 34361

Final Number: VGP21A-05

Title: CO_2-rich arc volcanism on the early Earth

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Published Material: 30% in various journals

Abstract Body: The moon-forming impact left the Earth with a dense (ca. 100 bar) and hot (ca. 200 C) CO_2-rich atmosphere. The Earth did not become habitable until the bulk of this CO_2 subducted into the mantle. Specially, thermophile conditions (ca. 100 C) existed when 25 bar of CO_2 remained and clement conditions with a few bars remaining. Oceanic crust was likely thick ca. 20 km. Rapid episodes of subduction and spreading likely produced most of the oceanic crust. Axial magma chambers existed beneath basaltic lids. Circulating seawater fully carbonatized the uppermost basalt. There was net subduction of CO_2 into the mantle, but CO_2-rich arc volcanics were likely common. Peralkaline volcanism has been rare since the Hadean as these conditions have never returned. Modern peralkaline rocks and published laboratory experiments provide a guide to the composition of these rocks. Seawater and meteoritic water reacted with the arc rocks to produce alkaline, reducing brines. Elements that both preferentially entered the arc lavas and dissolved into surface water built up in the ocean and the crust. By 3.8 billion years ago, CO2 subduction was nearly complete. Life had originated and atmospheric CO_2 had waned to near modern levels.

Abstract ID: 34662

Final Number: VGP21A-06

Title: Early differentiation processes recorded by ^{142}Nd and ^{182}W in Eoarchean rocks from Isua

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Published Material: Part of the results were presented in the AGU Fall Meeting 2014.

Abstract Body: The earliest phases of Earth's evolution can be investigated using the short-lived ^{182}Hf-^{182}W and ^{146}Sm-^{142}Nd isotopic systems. Tungsten is siderophile while Hf is lithophile, so metal-silicate segregation fractionates the Hf/W ratio of both planetary mantles and cores. Both daughter nuclides, W and Nd, are more incompatible than the parent nuclides Hf and Sm, so modification to Hf/W and Sm/Nd ratios in the silicate Earth can also be caused by crystal-liquid fractionation. Because of the short half-lives of ^{182}Hf and ^{146}Sm (8.9 Ma and 103 Ma, respectively), variations in ^{182}W and ^{142}Nd can only be produced, respectively, during the first ~ 50 Ma and ~ 500 Ma of Earth's history. Here we present data from 3.8-3.3 Ga mafic samples from the Isua supracrustal belt (ISB, SW Greenland). The mantle source of these rocks was characterized by ^{182}W and ^{142}Nd excesses, relative to terrestrial standards and modern rocks, of up to 15 ppm and 13 ppm, respectively. Possible models to explain the ^{182}W excesses include: 1) the ISB rocks derived from portions of the post-core formation mantle that were isolated from late accretionary additions. However, this model is not supported by the HSE abundances in these rocks. 2) ISB rocks derive from portions of the mantle that differentiated in an early magma ocean. This last model implies that high Hf/W domains can survive for over 1 Ga in the convecting mantle. The ^{182}W/^{184}W and ^{142}Nd/^{144}Nd ratios in the Isua rocks are not correlated. This suggest that either the differentiation of the magma ocean took place within the first ~ 60 Ma of the Earth history or, because of the different time scales for ^{142}Nd and ^{182}W growth, two or more differentiation events are responsible for the isotopic enrichments. Samples from the ISB, with ages between 3.8 Ga and 3.3 Ga, show gradual diminution of ^{142}Nd anomalies until they are no longer resolved by ~ 3.3 Ga. By contrast, there is no diminishment of the ^{182}W variability with time in the ISB suite. Tungsten concentrations of the samples studied range between 0.1 ppm and 3 ppm. The high W concentrations in some of these samples likely reflect the mobility of W in hydrous fluids. The W isotopic composition of the Archean mantle through time is estimated from the samples with W concentrations expected for typical mantle melts of a source with bulk silicate Earth-like (13 ppb) W concentrations.

Abstract ID: 35941

Final Number: VGP21A-07

Title: Trying to see through the metamorphism: trace element zoning in the assemblages of the Nuvvuagittuuq Greenstone Belt, Canada

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Co-authors: Mohadeseh Majnoon, McGill University, Montreal, QC, Canada; Jonathan O'Neil, University of Ottawa, Ottawa, ON, Canada

Published Material: 20% presented at the 2011 GAC-MAC.

Abstract Body: The Nuvvuagittuuq Greenstone Belt (NGB), northern Quebec, is some of the oldest preserved crust yet found: it has a minimum age of 3.75 Ga and is possibly as old as 4.3 Ga. The supracrustal units (which include remnant pillow structures) offer a window into Eoarchean crustal formation and seafloor processes if the effects of the intervening history can be characterized. Unfortunately these rocks have been pervasively metamorphosed, probably four times, most recently during a craton-wide thermal event at 2.7 Ga. Several mafic sequences (Ujaraaluk unit) record upper amphibolite conditions with high-variance assemblages of garnet + biotite + plagioclase + quartz (no amphibole) or biotite + amphibole + plagioclase + quartz ± garnet (cummingtonite or anthophyllite or Mg- or Fe-hornblende occurring alone or in combination).

These phases are unzoned with respect to major cations, suggesting a prolonged residence at elevated temperatures. Conventional geothermobarometry applied to both assemblages gives temperatures and pressures clustering around 610°C and 4.2 kbar, respectively. Pseudosection calculations confirmed the results from conventional thermobarometry. No parts of the NGB retain greenschist facies peak conditions.

The pervasive metamorphism has thus largely erased the record of previous metamorphism or the original protolith mineralogy. Garnets from some samples do record multiple concentric yttrium concentration zones, and accessory minerals are complexly zoned. Monazite in particular frequently displays a core with oscillatory zoned thorium and uranium concentrations, surrounded by overgrowths with distinct U, Th, REE concentrations. These slow diffusing trace elements may help constrain earlier parts of the metamorphic history of these rocks, including element mobility.

Abstract ID: 35253

Final Number: VGP22A-01

Title: Mercury abundance in the mantle and relevance to the moderately volatile element budget of the Earth

Presenter/First Author: Dante Canil, University of Victoria, Victoria, BC

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Co-authors: Peter William Crockford, McGill University, Montreal, QC, Canada; Kevin H Telmer, , Victoria, BC, Canada; Ricardo Rossin, University of Victoria, Victoria, BC, Canada

Abstract Body: Despite a long history of use for Hg as a pathfinder to locate ore deposits, the abundance of Hg remains the most poorly constrained element in the Earth's crust and mantle. We measured Hg concentrations in 37 igneous rocks from an arc crustal section and in 30 mantle peridotites from ophiolite, orogenic massif and xenolith settings. The distribution of Hg in the rock samples shows a 'nugget effect', suggesting it is concentrated in a trace phase, likely sulfide. The abundance of Hg in the crustal samples varies from 0.9 - 8 ppb and correlates with S and Cu but no other index of differentiation. The mean of our data produces 2.9±2.6 Hg for the bulk crust, a factor of 10 lower than previous estimates. The mantle peridotites contained 0.2 - 5 ppb Hg and a correlation of Hg with Al, Cu, S or loss on ignition (LOI) depending on sample type. Secondary uptake of Hg due to low-temperature alteration or mantle metasomatism is evident in the ophiolite and orogenic massif samples, respectively. The primitive upper mantle (PUM) is estimated to contain 0.4 - 0.6 ppb Hg based on a depletion/enrichment trend in fresh peridotite xenolith samples that demonstrably retained their primary Cu/S during emplacement. During mantle melting to produce the crust, Hg behaves as a mildly incompatible element similar to Cu with D_{Hg} residue/melt ~ 0.1. For a chondritic abundance of 310 ppb Hg, our estimate for Hg in the mantle shows this element has a similar depletion to Se, Te or S in the bulk silicate Earth. As in the case of Se or Te, the bulk silicate earth depletion in Hg may be due to siderophile behaviour during accretion but this remains to be tested by experiment.

Abstract ID: 34273

Final Number: VGP22A-02

Title: Se-Te fractionation by sulfide–silicate melt partitioning: Implications for the late accretion history of Earth

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Co-authors: Neva Fowler-Gerace, University of Toronto, Toronto, ON, Canada

Published Material: preliminary results have been presented in past meetings, and a paper in EPSL is in the final revision stage

Abstract Body: Selenium and tellurium are geochemically unique, being both volatile and strongly siderophile, so their mantle abundances may preserve information on the late accretion history of Earth. However, the effects of melting and crystallization on the mantle Se and Te composition are not well constrained, especially in terms of the role of residual sulfide. To better understand this behaviour, partitioning of Se and Te has been measured between coexisting sulfide liquid, monosulfide solid solution (MSS) and silicate melt at 0.9-1.5 GPa, 1200-1300ºC, FMQ -1.2 to -1.6 and 3-22 wt% FeO in the silicate melt. Se and Te are highly compatible in the sulfide phase relative to silicate liquid (D > 600), with the identity of the sulfide dictating the sense of Se-Te fractionation. Measured D_{Te}/D_{Se} is ~5-9 for sulfide liquid/silicate liquid partitioning, but MSS/silicate melt partitioning yields D_{Te}/D_{Se} of ~0.5-0.8. At fixed fO_2, $D^{SulLiq/SilLiq}$for both Se and Te decrease ~8-fold as silicate melt FeO increases from 3-22 wt%. Assuming a chondritic mantle Se/Te, predicted MSS and sulfide liquid compositions are generally in accord with natural mantle sulfides. Agreement is less so for orogenic and ophiolitic suites, likely owing to Te redistribution in accessory PGM. Notably, Se/Te in subduction-related Yakutian diamond inclusions are significantly lower than values expected from a chondritic mantle, suggesting that the subducted crust, or fluids derived therein, develops Se/Te much lower than chondritic values; subduction may therefore provide a means to lower the Se/Te of the mantle through time. The Se/Te ratio of silicate melt derived from a sulfide liquid-saturated mantle is significantly higher, and more variable, than for silicate melt in equilibrium with residual MSS. The relatively high Se/Te in MORB is therefore consistent with derivation from a chondritic mantle containing residual sulfide liquid. Model results for sulfide-saturated melting residues predict little deviation in Se/Te or Se and Te abundances relative to initial values. In contrast, sulfur-free, refractory orogenic harzburgites show a range of Se/Te (both sub and suprachondritic), the origin of which is unclear. Experiments are in progress to assess the trajectory of residual solids after sulfide exhaustion.

Abstract ID: 36530

Final Number: VGP22A-03

Title: The Origin of Fe-rich Domains in the Earth's Mantle

Presenter/First Author: Dejan Milidragovic, Laval University, Quebec City, QC

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Co-authors: Don Francis, McGill University, Montreal, QC, Canada

Abstract Body: Primitive lavas, mantle xenoliths, and melting experiments indicate that the bulk of the Earth's mantle has a limited range of Mg-numbers, centered at ~0.90. The relatively low FeO content of the Earth's mantle (~8 wt. %) contrasts with the relatively high inferred FeO contents of the Martian mantle and of the basaltic meteorites derived from the asteroid belt. Rare, predominantly Neoarchean (ca. 2.7 Ga), ultramafic lavas and plutonic rocks (ferropicrites) on Earth resemble the FeO-rich SNC and HED meteorites and require mantle sources with significantly lower Mg-numbers (<0.81) than those of the bulk of the Earth's mantle. The occurrence of ferropicrites on Earth suggests the existence of volumetrically minor, but widespread, FeO-rich heterogeneities in the mantle during the Archean.

The origin of inferred FeO-rich heterogeneities in the Earth's mantle remains poorly understood, but their existence may be of fundamental importance to the understanding of the Earth's accretion history and chemical evolution. A number of hypotheses have been proposed to explain the petrogenesis of ferropicrites and the anomalous FeO-enrichment in the Earth's mantle. Models invoking mantle metasomatism by Fe-rich melts/fluids do not account for the relatively flat trace element profiles of "subalkaline" ferropicrites, nor the absence of correlation between trace-element and FeO enrichments in the "alkaline" ferropicrites. Similarly, producing FeO-rich residual peridotite by ancient garnet fractionation in a Hadean magma ocean is inconsistent with the Archean Nd model ages of ferropicrites. These limitations suggest that the Fe-enrichment of ferropicrite mantle sources may be primary. The major element similarities between the ferropicrites and basaltic meteorites favour a model involving the late addition of Fe-rich peridotite via meteorite bombardment.

Abstract ID: 33279

Final Number: VGP22A-04

Title: An Archean Ferropicrite Conundrum

Presenter/First Author: Claude T Herzberg, Rutgers Univ, Piscataway, NJ

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Abstract Body: The iron content of the mantle plays an important role in mantle geodynamics owing to its impact on buoyancy. Xenolith and outcrop occurrences indicate Earth's bulk mantle is similar to peridotite having about 8% FeO, although it can be subsequently modified by a variety of processes. Experimental petrology and calculations show that many primitive olivine-phyric lavas are consistent with partial melting of normal mantle having 8% FeO; Phanerozoic examples are modern MORB and many, but not all, magmas in ocean islands and large igneous provinces; Archean examples are common basalts in greenstone belts and komatiites. Rare Archean ferropicrites in lavas and sills have the highest FeO contents on Earth, they are distributed in all cratons [1], and their importance has been underappreciated. They have been interpreted as melting of an iron-rich mantle source which itself was produced by late meteorite infall of Mars-like compositions [1, 2], by solidification of Earth's magma ocean [3] or other processes [2]. However, calculations show that the FeO content of a primitive lava is actually compatible with a range of mantle FeO contents [4]. For example, it is possible that some ferropicrites were produced by partial melting of normal mantle peridotite having 8% FeO, but this would have required unusually high pressures. One approach to the problem involves testing the plausibility of a high pressure origin; if it can be excluded from other lines of evidence, then an iron-rich mantle origin will be much more secure. [1] Milidragovic & Francis (2015) Geochim. Cosmochim. Acta, in press. [2] Milidragovic et al. (2014), J. Petrol. 55, 2481-2512. [3] Goldstein and Francis (2008). J. Petrol. 49, 1729-1753. [4] Herzberg and O'Hara (2002), J Petrol. 43, 1857-1883.

Abstract ID: 34381

Final Number: VGP22A-05

Title: Experimental investigation of the mantle sources and melting conditions for Mercury's basalts

Presenter/First Author: Olivier Namur, University of Hannover, Hannover,

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Co-authors: Max Collinet, , , ; Bernard Charlier, University of Liège, Sart Tilman, Belgium

Abstract Body: Chemical measurements of Mercury's surface by MESSENGER have been used to distinguish two geochemical provinces: (1) the Northern Volcanic Plains (NVP) made up of low-Mg basaltic komatiites and the Intercrater Plains and Heavily Cratered Terrains (IcP-HCT) made up of high-Mg komatiites. Here we present intermediate- to high-pressure and high-temperature phase relationships of two compositions relevant to Mercury's surface (NVP and IcP-HCT). Assuming that the mantle source is polymineralic, we use experimental data to infer the multiple saturation point (MSP) of surface lavas, i.e. pressure and temperature of melt generation in the mantle based on the co-saturation of forsterite (*Fo*) and enstatite (*Ens*) as liquidus phases. Starting compositions were based on X – Ray Spectrometer (XRS) data from solar flares. Given the relatively high sulfur concentration of Mercury's lavas, we performed experiments on sulfur-free and sulfur-saturated starting compositions. We ran experiments for 4-8 hours at 1310-1650°C. All experiments show a large proportion of quenched melt with a variable, but generally low, proportion of crystal phases. For the sulfur-free NVP composition, experiments are saturated with *Fo* from 0.1 to 1.0 GPa (1310-1410°C), *Fo* and *Ens* at 1.2 GPa (1440°C) and *Ens* at 1.5-2.0 GPa (1450-1470°C). These data suggest that the position of the MSP is situated at ca. 1.2 GPa and 1450°C. For the IcP-HCT composition, the MSP is located at 1.8 GPa (1650°C). The presence of sulfur in starting composition changes significantly the conditions of the MSP (NVP: 0.75 GPa, 1370°C; IcP-HCT: 0.75 GPa, 1450°C) due to the depression of the liquidus in the presence of volatiles. The MSPs that we obtain, together with the major element compositions of surface lavas, indicate that at least two contrasted mantle sources contributed to volcanic activity at Mercury's surface. Mercury's mantle may therefore be vertically or possibly laterally stratified with a lherzolitic mantle at great depth (>1.5 GPa) and a harzburgitic shallower mantle.

Abstract ID: 33080

Final Number: VGP22A-06

Title: Hydrous Phase Equilibria of the Upper Martian Mantle: Constraining Water Saturated Solidus to 4 GPa

Presenter/First Author: Aleksandar Miskovic, University of British Columbia, Yellowknife, NT

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Published Material: Presented at the Goldschmidt 2009 conference in Davos in an alternate form

Abstract Body: The melting behaviour of an undegassed Martian mantle was investigated to explore the potential influence of water on the mode of early planetary differentiation. Mars is a particularly interesting planet given that it accreted from a chondritic mix richer in volatile elements than other terrestrial bodies and because its size is equivalent to a proto-planet just before the giant impact stage suggesting that Mars might have escaped the formation of a magma ocean which would have largely obliterated the evidence of early accretion and differentiation. Experimental phase relations from terrestrial studies predict storage of significant amounts of water deep inside the planetary interior in the form of hydrous Mg-silicates (talc, chlorite, antigorite) and nominally anhydrous minerals such as stishovite, majorite or the high-pressure olivine polymorphs wadsleyite and ringwoodite. A majority of the experimental work however, is based on the simplified terrestrial mantle analog compositions and little is known about the effects of Fe, Al, Cr, P that are both important constituents of the Martian mantle and may significantly influence phase equilibria. For example, apatite and spinel will be stabilized to higher pressures in Mars than in Earth as a consequence of the higher mantle phosphorus and chromium contents. The reduced, Fe^{2+}-enriched and Al-deficient mantle of Mars will also restrict the stability of olivine to lower pressures while hydrous Mg-silicates such as amphibole and chlorite will break down at considerably lower temperatures in the less magnesian Martian mantle. Furthermore, the position of H_2O-saturated solidus relative to the stability fields of hydrous minerals has only been closely scrutinized at relatively low pressures below 3.0 GPa (Médard and Grove, 2007). The melting relations of dense hydrous silicates, and in turn the dominant phase regimes in deep mantle of early Mars depend on where and to what extent the slope of the wet high-pressure solidus reverses to positive dP/dT in deep Martian mantle. Recent results of experimentally determined hydrous phase equilibria and melting relations from wet Martian mantle above 3 GPa are shown and compared to the existing thermal models of planetary evolution.

Abstract ID: 34617

Final Number: VGP22A-07

Title: A Planetary Perspective on the Origin of Fe-rich Basalts

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Co-authors: Dejan Milidragovic, Laval University, Quebec City, QC, Canada

Published Material: Part of this has been presented orally at the GSA Fall Meeting in Vancouver

Abstract Body: The basalts of the terrestrial planets document a radial increase in the Fe content of their mantle sources that likely reflects the fractionation of Fe during the condensation of the Solar nebula. Orbital dynamic arguments for wide feeding zones during the accretion of the terrestrial planets have overshadowed the classic demonstration by Lewis (1972) that the metal/silicate ratios of the planets are broadly consistent with those predicted by the solar condensation sequence for a radial decrease in temperature in the Solar nebula. As predicted by Lewis, recent planetary basalt data indicates that the Fe content of the Mercurian mantle appears to be the lowest in the Solar system, whereas the mantles of Mars and 4 Vesta (Eucrite meteorites) have the highest Fe contents. In keeping with numerical simulations of planetary accretion, however, this radial increase in mantle Fe is not continuous. The Venusian and modern Terrestrial basalts have similar intermediate Fe values, whereas there is a discontinuous increase to the Fe contents of the basalts of Mars and 4 Vesta. A similar discontinuity in Fe exists between Archean komatiites and ferropicrites on the Earth, and between Highland and Mare basalts on the Moon, with the latter two in both cases having Fe contents similar to those of Mars and 4 Vesta. Broadly, there are 2 distinct basalt populations. One poor in Fe, but high in Al, characteristic of the inner terrestrial planets, and the other rich in Fe, but poor in Al, characteristic of Lunar Mare basalts, Archean ferropicrites on the Earth, and the basalts of Mars and the inner asteroids. This dichotomy may reflect the existence of a "sulfide line" in the early Solar nebula at approximately 700K between the orbits of the Earth and Mars. Sunward of the sulfide line, the Fe content of silicate condensates reflects equilibria with metallic Fe and increases radially with decreasing temperature. Outward of the sulfide line, however, the Fe content of silicate condensates will be buffered at a relatively high value determined by the relative Solar abundance of Fe and S. The mantle sources of Archean ferropicrites on the Earth and Lunar Mare basalts may reflect the addition of Fe-rich material during the late heavy bombardment via the destabilization of the inner asteroid belt during the outward migration of Jupiter and Saturn.

Abstract ID: 34920

Final Number: VGP23A-01

Title: A hierachial classification of perovskite super-group minerals

Presenter/First Author: Roger Howard Mitchell, Lakehead University, Thunder Bay,

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Co-authors: Anton Chakhmouradian, University of Manitoba, Winnipeg, MB, Canada; Mark Welch, , ,

Abstract Body: Some naturally-occurring oxides, fluorides, hydroxides, arsenides and silicates adopt crystal structures based upon, or which are derivatives of, the aristotypic cubic ternary perovskite structure (ABX_3), as exemplified by the synthetic compounds $SrTiO_3$ and $KMgF_3$ and their mineral counterparts, tausonite and parascandolaite. On the basis of the extensive studies of synthetic perovskite-structured compounds it is possible to derive a hierarchy of hettotype structures which are produced

by: (1) tilting and distortion of the BX_6 octahedra; (2) ordering of *A*- and/or *B*-site cations; (3) formation of *A*-, *B*- or *X*-site vacancies. This hierarchical scheme as applied to naturally-occurring minerals results in the proposed recognition of a perovskite super group. Sub-groups include: (1) single ternary (ABX_3) ideal (tausonite, isolueshite) and distorted (bridgmanite, perovskite, loparite, lueshite,lakargiite, megawite, neighborite, parascandolaite) perovskites, and others which exhibit second order Jahn-Teller distortions (macedonite, barioperovskite); (2) *B*-site cation ordered double ($A_2BB'X_6$) perovskites (elpasolite, cryolite, simmonsite, vapnikite); (3) Anion-deficient ($A_2B_2O_5$) perovskites (brownmillerite, srebrodolskite); (4) *A*-site vacant single- and double hydroxyperovskites (dzhalindite, bernalite, schönfliesite, stottite and mopungite subgroups); (5) *A*-site vacant quadruple perovskites (skutterudite subgroup); (6) *B*-site vacant double perovskites (diaboleite). Common ternary oxide perovskites typically exhibit space group variations resulting from solid solution between potential end-member compositions, and complete characterization requires single-crystal structure determination. In some ambiguous cases vibrational spectroscopy (Raman, infrared) can provide critical additional information that allows a correct choice of space group.

Abstract ID: 35571

Final Number: VGP23A-02

Title: Systematics Of Spin Crossovers Across The Rare-earth Cobaltites (RECoO3)

Presenter/First Author: Mehmet Topsakal, University of Minnesota Twin Cities, Falcon Heights, MN

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Co-authors: Renata M Wentzcovitch, University of Minnesota Twin Cities, Minneapolis, MN

Published Material: Paper was submitted to Physical Review B. The results will also be presented at APS March Meeting 2015.

Abstract Body: Using first-principles plane-wave calculations, we investigate the structural and electronic properties of rare-earth cobaltites ($RECoO_3$). Structurally consistent Hubbard U treatment was shown to essential for proper description of strongly correlated cobalt-d electrons. We successfully capture the experimentally observed structural trends and give first-principles insights on interesting phenomena related with the cobalt spin state change. It was demonstrated that increase of crystal-field splitting energy between e_g-t_{2g} orbitals and shrinking of unoccupied σ*-bonding e_g bands are responsible for the increase of onset spin-state transition temperature along the series. We believe that Hubbard U values presented in this study will allow further predictive studies of cobaltites.

Abstract ID: 35244

Final Number: VGP23A-03

Title: Crystal Chemistry of Chalcogenide Perovskites and Related Materials

Presenter/First Author: Nancy Ross, Virginia Tech, Blacksburg, VA

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Co-authors: Jing Zhao, , ,

Abstract Body: There have been numerous studies of oxide perovskites with ABO_3 stoichiometry that show how the flexible structure of perovskite can accommodate a variety of A and B-site atoms, yielding a variety of properties that are exploited in technological applications. Recently, there has been growing interest in ABX_3 (X=S,Se) perovskites including their potential use in photovoltaic applications [1]. Many ABX_3 chalcogenides have been reported that adopt the well-known $GdFeO_3$ perovskite structure with P*nma* symmetry. Examples of sulfide perovskites include $CaZrS_3$, $SrZrS_3$, $BaZrS_3$, $BaUS_3$, $CaHfS_3$, $BaHfS_3$, $EuZrS_3$, and $EuHfS_3$ [2]. Moreover, substitution of sulfur (and selenium) for oxygen in ABX_3 leads to a number of structure types not commonly observed in ABO_3 compounds, including the NH_4CdCl_3 structure which has been observed in $SnZrS_3$, $PbZrS_3$, $SnHfS_3$, $PbHfS_3$, Sn_2S_3, $EuZrS_3$, $LaCrSe_3$ [3 and references therein] and more recently reported in $SrZrS_3$ [4] and $SrZrSe_3$ [5]. In some cases such as $BaTiS_3$, a hexagonal phase belonging to space group P63/mmc with the $BaNiO_3$ structure has been reported [6]. In this presentation, we explore how substitution of A- and B-site atoms in ABS_3 compounds affects the stability of the perovskite and related structures. In addition, we will present bond valence that provide insight into the factors that affect the stabilities of these structures. Thirdly, we will apply the model that our group developed to predict the high-pressure behavior of ABO_3 perovskites [7] to chalcogenide perovskites. This model predicts the site compressibilities from site parameters defined in terms of their coordination number, average bond length at room pressure and bond valence parameters. We will use this model to predict possible high-pressure phase transitions in chalcogenide perovskites.

References: [1] Y-Y Sun, M.L. Agiorgousis, P. Zhang, S. Zhang (2015) *Nano Lett* 15:581-5; [2] R.R. Lelieveld, D.J.W. IJdo (1980) *Acta Cryst.* B36: 2223-6; [3] A. Meetsma, G.A. Wiegers, J.L. de Boer (1993) *Acta Cryst.* C49:2060-2; [4] C.-S. Lee, K.M. Kleinke,H. Kleinke, H. (2005) *Solid State Sci.* 7: 1049–1054. [5] L.J Tranchitella, B.-H.Chen, J.C. Fettinger, B.W.J. Eichhorn (1997) *Solid State Chem.* 130:20–27. [6] A. Clearfield (1963) *Acta Cryst.* 16:135–142. [7] J. Zhao, N.L. Ross, R.J. Angel (2004) *Acta Cryst.* B60: 263-271.

Abstract ID: 35880

Final Number: VGP23A-04

Title: Perovskites as an Exploration Tool

Presenter: Anton Chakhmouradian, University of Manitoba, Winnipeg, MB

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Abstract Body: Perovskite-group minerals are common accessory constituents of such economically important rocks as kimberlites, lamproites, carbonatites and agpaitic feldspathoid syenites. These minerals accumulate in clastic sediments and can be potentially used as an exploration tool. Because perovskites incorporate a wide range of trace elements specific to their parental magmas and crystallization conditions (including many of the isotopes routinely used in geochronology), mass-spectrometry analysis can be used to track the sources of clastic perovskites and search for unrecognized mineral deposits. In the present work, we conducted a detailed comparative analysis of trace-element distributions in loparite [$(Na,REE,Ca,Sr,Th)(Ti,Nb,Ta)O_3$] and perovskite [$(Ca,Na,REE,Sr)(Ti,Nb,Fe)O_3$] from several well-known occurrences of kimberlite, carbonatite, alkaline silicate and contact-metamorphic rocks. We identified a number of trace-element characteristics that can be used to discriminate among different source rocks, and applied these criteria to detrital perovskite and loparite from clastic sediments of Jurassic age in the eastern part of the East European craton (Veslyana basin, Perm Krai,

Russia). We also used U-Pb dating techniques to constrain the age of the Veslyana samples. Based on these data, the examined perovskite is derived from a Devonian carbonatitic source probably related to Mid-Paleozoic rifting of the margin of the East European platform. The loparite is derived from relatively primitive agpaitic syenites of Ediacaran age, which can be linked to widespread alkaline magmatism in the East European craton and elsewhere, heralding the final stage of Rodinia breakup.

Abstract ID: 33546

Final Number: VGP23A-05

Title: Equation of state and and phase transitions of (Mg,Fe)SiO3 perovskite and post-perovskites from quantum Monte Carlo and Density Functional Theory

Presenter/First Author: Ronald E Cohen, Carnegie Inst of Washington, Washington, DC

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Co-authors: Yangzheng Lin, , , ; Kevin P Driver, University of California Berkeley, Berkeley, CA; Burkhard Militzer, University of California Berkeley, Berkeley, CA

Published Material: 50% in Y. Lin, R. E. Cohen, S. Stackhouse, K. P. Driver, B. Militzer, L. Shulenburger, and J. Kim, Phys. Rev. B 90 (2014).; R. E. Cohen and Y. Lin, Phys. Rev. B 90 (2014).

Abstract Body: We have performed quantum Monte Carlo (QMC) simulations and density functional theory calculations

to study the equations of state and phase transition of MgSiO3 perovskite (Pv, bridgmanite) and post-perovskite (PPv) .[1] The ground-state energies were derived using quantum QMC simulations and the temperature-dependent Helmholtz free energies were calculated within the quasiharmonic approximation and density functional perturbation theory. Agreement with experiments is improved over DFT alone. Furthermore, we obtain statistical error bounds on the results, rather than the unconstrained errors of DFT. The Pv-PPv phase boundary calculated from our QMC equations of state is also consistent with experiments, and better than previous local density approximation calculations. In order to understand the H-phase reported in (Mg,Fe)SiO3 [2], we have performed evolutionary structure searching for FeSiO3.[3] We find a new structure type which may be consistent with the experimental observations. We are now performing QMC and DFT studies of FeSiO3 and (Mg,Fe)SiO3 perovskite and post-perovskites. This work is supported by NSF and the ERC Advanced Grant ToMCaT.

[1] Y. Lin, R. E. Cohen, S. Stackhouse, K. P. Driver, B. Militzer, L. Shulenburger, and J. Kim, Phys. Rev. B 90 (2014).
[2] L. Zhang et al., Science 344, 877 (2014).
[3] R. E. Cohen and Y. Lin, Phys. Rev. B 90 (2014).

Abstract ID: 34625

Final Number: VGP23A-06

Title: Clues about lower mantle chemistry from natural samples of bridgmanite

Presenter/First Author: Oliver D Tschauner, Univ Nevada, Las Vegas, NV

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Co-authors: Chi Ma, California Institute of Technology, Pasadena, CA

Published Material: Discovery of bridgmanite, the most abundant mineral in Earth, in a shocked meteorite, O. Tschauner, C. Ma, J. Beckett, C. Prescher, V. Prakapenka,G.Rossman, Science 346, 110-1102, DOI: 10.1126/science.1259369 (2014)

Abstract Body: Bridgmanite, $MgSiO_3$ in an ABO_3 perovskite structure, was established in 2014 as a mineral by means of structural and chemical characterization of a natural specimen (ref 1). This natural specimen was identified in a shock melt vein in the Tenham L6 chondrite. By now we have identified bridgmanite in a martian meteorite also. I will show that natural samples of brigdmanite provide a useful complement to experimetal studies of this mineral: Bridgmanite in clasts trapped chondrite shock melt veins inherits the composition of precursor pyroxenes and, thus, samples an extended compositional range, quite beyond of what has been synthesized. This provides relevant information upon endmember compositions and volumes.

Bridgmanite in martian meteorites occurs in assemblies that crystallized from or in contact to melt. These assemblies provide insights in minor-element distribution between melt and lower mantle rock forming minerals. I compare these findings to experimental results and discuss the possible implications for incompatible element differentiation in the mantle.

Ref 1: Discovery of bridgmanite, the most abundant mineral in Earth, in a shocked meteorite, O. Tschauner, C. Ma, J. Beckett, C. Prescher, V. Prakapenka,G.Rossman, Science 346, 110-1102, DOI: 10.1126/science.1259369 (2014)

Abstract ID: 35472

Final Number: VGP23A-07

Title: First-principles Study of Intermediate-spin Ferrous Iron in the Earth's Lower Mantle

Presenter/First Author: Han Hsu, National Central University, Kanagawa,

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Co-authors: Renata M Wentzcovitch, University of Minnesota Twin Cities, Minneapolis, MN

Published Material: About 70% of this talk is published in Han Hsu and Renata M. Wentzcovitch, Phys. Rev. B 90, 195205 (2014).

Abstract Body: Spin crossover of iron is of central importance in solid Earth geophysics. It impacts all physical properties of the Earth's lower-mantle minerals, including ferropericlase [(Mg,Fe)O] and Fe-bearing magnesium silicate ($MgSiO_3$) perovskite, altogether constituting ~95 vol% of the lower mantle, and ferromagnesite [$(Mg,Fe)CO_3$], a potential carbon carrier in the lower mantle. Despite great strides made in the past decade, the existence of an intermediate-spin (IS) state in ferrous iron (Fe^{2+}) (with total electron spin S = 1) and its possible role in the pressure-induced spin crossover in these lower-mantle minerals still remain controversial. Using density functional theory + self-consistent Hubbard U (DFT + U_{sc}) calculations, we investigate all possible types of IS states of Fe^{2+} in these minerals, and this talk will be particularly focused on $(Mg,Fe)SiO_3$ perovskite (also known as bridgmanite). Among the possible IS states in these minerals, the most probable IS state has an electronic configuration that significantly reduces the electron overlap and the iron nuclear quadrupole splitting (QS). These most probable IS states, however, are still energetically disfavored, and their QSs are inconsistent with Mössbauer spectra. We therefore conclude that IS Fe^{2+} is highly unlikely in the Earth's lower mantle.

Abstract ID: 33538

Final Number: VGP23A-08

Title: Transition metal chemistry meets the perovskite structure

Presenter/First Author: Catherine A McCammon, University of Bayreuth, Bayreuth,

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Abstract Body: The perovskite structure is remarkably versatile, incorporating more than half of the stable elements in the periodic table. The wide range of chemical and structural variations as well as possibilities for non-stoichiometry gives rise to a wealth of interesting physical properties, many with important commercial applications. Transition elements in particular provide the capability for variations in oxidation and spin state, enhancing possibilities for transformations brought about by changes in environmental variables such as pressure, temperature or oxygen fugacity. In a similar way that ionic radii provide a simple compositional guide to the stability of perovskite structure variants, crystal field theory can provide an indication of the stable electronic configuration of transition element cations. The lower mantle mineral bridgmanite offers multiple possibilities for iron (two sites times two oxidation states times three spin states) which has complicated the interpretation of results from experimental studies. The presentation will focus on crystal field theory analysis applied to recent bridgmanite data acquired at high pressures and high temperatures to elucidate the state of iron in the deep Earth's interior.

Abstract ID: 34583

Final Number: VGP24A-0398

Title: Exploring the Eruptive Sequence and Chemical Evolution of the AD 1730—1736 Timanfaya Eruption, Lanzarote, Canary Islands

Presenter/First Author: James Muller, CUNY Queens College, New York, NY

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Co-authors: Patrick Beaudry, CUNY Queens College, Flushing, NY; Marc-Antoine Longpre, CUNY Queens College, Flushing, NY

Abstract Body: The Timanfaya eruption is one of the largest historical basaltic fissure eruptions, producing an estimated 3—6 km^3 of lava along a 15-km, E-W trending fissure. Previous work identified (I) a preliminary eruption sequence, and (II) an unusual progression of magma composition from basanite to tholeiite, based on mapping and geochemical analysis of distal lava flows [1, 2].

In this work, we present preliminary tephrostratigraphy results and geochemical analyses to better define the eruption (including its volume) and its mantle source. New X-ray fluorescence analyses of tephras sampled at the vents suggest edifices correlate strongly with distal flows, consistent with the associations proposed by [1]. Data also confirm the trends from highly alkaline (1.5 wt% K_2O, ~15 wt% MgO, 42 wt% silica) to tholeiitic (0.5 wt% K_2O, ~7.5 wt% MgO, and 51 wt% SiO_2) compositions. A 1-m-thick, bedded tephra sequence located at a section 4 km south of the fissure is chemically homogeneous. Correlating best with fall deposits from the Caldera de los Cuervos (first and most primitive) eruptive phase, the strata identified thus likely represent intra-phase pulses instead. The identification of these tephras confirms the involvement of that vent in the Timanfaya eruption, despite the edifice's location off-axis of the fissure.

Incompatible trace element ratios, such as Zr/Y, display significant variations in the eruptive sequence that cannot be produced by fractional crystallization. Trace element data help test previous hypotheses on the origin of the syn-eruptive change in magma composition, including differing degrees of partial melting [1], different mantle source compositions [3], and crustal assimilation of sedimentary xenoliths [4].

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Abstract ID: 34699

Final Number: VGP24B-0400

Title: Plio-Pleistocene volcanic activity in a stable terrain: Implications on magma generation and regional tectonics

Presenter/First Author: James Cesar Avisado Refran, National Institute of Geological Sciences, University of the Philippines, Quezon City,

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Co-authors: Carlo A Arcilla, National Institute of Geological Sciences, University of the Philippines, Quezon City, Philippines

Published Material: Some data from Arcilla et al., 2003 (High-Nb Lavas from Northern Palawan: implications for high field strength enrichment in southern Philippine Arc).EGS - AGU - EUG Joint Assembly, Abstracts from the meeting held in Nice, France, 6 - 11 April 2003, abstract #3451

Abstract Body: The presence of volcanism in an island arc setting is often attributed to an ubiquitous subduction. Palawan island, Philippines has been long been a subject of studies involving its origin, aseismic nature (e.g. Yumul et al., 2008), and absence of active, subduction-related volcanism. North of the island, however, a large basaltic lava field is observed. Geomorphologically young (from previous works indicating a Plio-Pleistocene age), the lava flow overlies Permian chert (Pena,2008). Relatively flat topography suggests low viscosity of flow. Preliminary petrography and X-ray Diffraction analyses of rock samples reveal presence of olivine, plagioclase and minor pyroxenes. Total Alkali versus Silica plot falls within basalt to basaltic-andesite field. K_2O vs. SiO_2 - K_2O (from Peccerillo and Taylor, 1976), SiO2 –FeOt /MgO (from Miyashiro, 1974) and AFM ternary plots of samples fall within the Calc-Alkaline series. Spider plots (MORB-normalized, from Pearce, 1983) of basalt samples reveal unusual Nb-enrichment (~25ppm) not observed in typical island arcs (from previous data of Arcilla et al., 2003). Mechanism from Macpherson et al. in 2010 points to a possible small-degree partial melts of an OIB-like source, then interacting with high-degree partial melts from upper mantle (from Reagan and Gill,1989). This paper will restudy the occurrence of the enigmatic lava flow through additional petrographic approach supplementing previous information with recent geochemical data.

Abstract ID: 35131

Final Number: VGP24B-0401

Title: An isotopic insight into the role of tuffisite veins during volcanic degassing in rhyolitic systems

Presenter/First Author: Rebecca Paisley, McGill University, Montreal, QC

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Co-authors: Kim Berlo, University of Oxford, Oxford, United Kingdom; Bassam Ghaleb, Université de Québec à Montréal, Montréal, QC, Canada

Abstract Body: Magmatic degassing plays a fundamental role in the style of a volcanic eruption. A better understanding of the mechanisms involved in gas escape is essential for predicting eruption styles, and constraining the associated hazards. Highly silicic rhyolitic systems are prone to explosive activity because of their ability to trap gas bubbles, which expand on ascent and promote fragmentation. Effusive rhyolitic activity is thought to occur where gas can escape from the melt. However, Schipper et al. (2013) witnessed simultaneous effusive and explosive activity at the 2011-2012 eruption of Cordón Caulle, Chile. This suggests a complex open system degassing mechanism. Potential degassing mechanisms include interconnected bubble networks and fractures. These fractures can be infilled and preserved as tuffisite veins, consisting of fine-grained pyroclastic material. They have been shown to weld, heal and refracture in many rhyolitic systems, thus providing a reoccurring path for gas escape, but are they the main degassing mechanism?

We have conducted ^{210}Pb-^{226}Ra radioactive disequilibria analyses, by Alpha Particle Spectroscopy and Thermal Ionisation Mass Spectrometry, on rhyolitic samples from Cordón Caulle, Chile to constrain this. In volcanic rocks, disequilibria between ^{226}Ra and ^{210}Pb, members of the ^{238}U decay series, have been attributed to degassing and accumulation of ^{222}Rn, the gaseous precursor to ^{210}Pb. In the first study of its kind, early results indicate that tuffisite veins, from the 2011-2012 eruption, display ($^{210}Pb/^{226}Ra$) ratios greater than 1. Additionally, vesicular pumice and dense lava flow samples exhibit ^{210}Pb excesses. This indicates significant gas fluxing occurred through the shallow part of the Cordón Caulle system prior to the eruption of both effusively and explosively erupted magma. Further analyses and modelling will be undertaken to assess the relative gas fluxes in samples representing both the effusive and explosive stages of eruption.

Abstract ID: 35590

Final Number: VGP24B-0402

Title: Recent unrest at Campi Flegrei caldera: New signatures and comparison with previous large unrest episodes (1969-1984)

Presenter: Giuseppe de Natale, INGV - Osservatorio Vesuviano, Naples,

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Abstract Body: Campi Flegrei caldera, in the Neaples area which is marked by the highest volcanic risk in the world, has experienced, in the last 2000 years, up and down ground movements spanning about 20 m. The largest recent unrest episodes involving huge uplift (up to 3.5 m in 15 years) occurred since 1969 to 1984, but modern uplift episodes likely started in the 50's of the last century. Following the spectacular ground uplift culminated in 1984 (uplift rates up to 1m/year) about 20 years of general subsidence started, interbedded with some small uplift episodes (4-11 cm of maximum elevation) lasting 1-2 months. Such subsidence period ended at about 2004, when a general trend of slow uplift started, with peak rates in 2006, 2012, 2013 and 2014. Since 2011, maximum ground uplift measured at Pozzuoli Bay has been 21 cm. The new slow uplift phase has characters different from the 1969-1972 and 1982-1984 large unrests, because uplift rates are much lower (about two orders of magnitude) and seismicity is much weaker, both in frequency and magnitude of the events. However, geochemical signatures of the on-going unrest are more marked than in previous periods, because a linearly increasing trend of huge deep fluid injection into shallow aquifers is evident from ground emissions. The 'deep' (or magmatic) signature of such injected fluids is even higher than during the previous largest unrests. These contrasting characters of the new unrest phase, when compared with the large unrests experienced 30-45 years ago, call for detailed interpretations of these episodes to discriminate magmatic from deep geothermal effects. This work presents the observational evidences of these peculiar unrest episodes and provides a first attempt to discriminate between magma accumulation effects and deep geothermal fluids injection. Such interpretation, based on thermal-fluid-dynamical modelling, relies on accurate in-situ estimation of permeability at depth operated in the framework of the ICDP-CFDDP (Campi Flegrei Deep Drilling Project).

Abstract ID: 35666

Final Number: VGP24B-0403

Title: Investigating magmatic plumbing systems in an off-rift setting on Iceland with geothermobarometry and quantitative textural data

Presenter/First Author: David Burney, University of Iowa, Iowa City, IA

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Co-authors: David William Peate, University of Iowa, Iowa City, IA; Morten S Riishuus, University of Iceland, Reykjavik, Iceland

Abstract Body: The emplacement of tholeiitic magmas along two NE-SW trending rift zones is the dominant mechanism of crustal accretion on Iceland. Small volumes of transitional to alkaline magmas are also erupted through older crust in several off-rift settings, including the Snæfellsnes Peninsula in western Iceland where the basement is formed by 6-8 Ma flood basalts. In this study, we are investigating how these off-rift magmatic plumbing systems compare to those in the main rift zones, given the significant differences in crustal structure and degree of crustal extension, through application of quantitative textural analysis and mineral geothermobarometry. Our focus is Vatnafell, a sub-glacial eruptive unit (414 ± 11 ka) at the western end of the off-rift Ljósufjöll volcanic system in the Snæfellsnes volcanic zone. Samples are highly porphyritic (~14% macrocrysts), with large pheno/antecrysts (1-12 mm) of clinopyroxene, olivine, and plagioclase. Crystal size distributions for olivine and clinopyroxene both show kinked profiles, indicating two distinct populations. Glomerocrysts in which large clinopyroxene oikocrysts enclose smaller rounded olivine chadacrysts are common, and a small horizon strongly enriched in large (> 5 mm) olivine and clinopyroxene crystals was found near the base of the unit. These observations suggest incorporation of olivine gabbroic/wehrlitic cumulates by the host magma. Preliminary analyses show a bimodal composition for clinopyroxene (cores: mg# 83-88; rims/groundmass mg# 72-77), and initial calculations suggest crystallization of cores over a range of depths in the deep crust (based on variations in Al_2O_3: 4-7 wt%) More extensive analyses of mineral compositions are in progress and will be used to reconstruct the vertical geometry of an extension-limited off-rift magmatic plumbing system and allow a more detailed comparison with plumbing systems hosted by the extension-dominated main rift zones on Iceland.

Abstract ID: 35920

Final Number: VGP24B-0404

Title: A Geoelectrical Model of the Northern Flank of the Popocatepetl Volcano (Central Mexico): A First Approach to Major Structures

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Abstract Body: Popocatepetl volcano is an active stratovolcano located in the central portion of the Trans-mexican Volcanic Belt, approximately 60 km east of Mexico City, the largest city in the country with over 22 million inhabitants. In December 1994 it resumed its eruptive activity and since then many studies have been carried out in order to understand the eruptive behavior and to assess the volcanic hazard. Nevertheless, no study has been conducted in order to image the distribution of electrical resistivity below the volcano. Thus, this study contributes in expanding the knowledge of the structures of the volcano and their relation to the eruptive activity. Since 1994, eruptive events and seismic monitoring have been improved and it is known that most of the activity is concentrated underneath the southeastern flank and below the crater. However, the largest volcanotectonic event (Mc 4.1) on May 6, 2013 was detected beneath the northern flank. For this reason, we decided to perform a magnetotelluric survey on the northern area with the main goal of spotting the characteristic structures and their relationship to the recent activity. The inversion geoelectrical models show the resistivity distribution below the northern flank and were generated from eight magnetotelluric surveys acquired during May 2014. The results show the existence of a body of high resistivity, on the eastern side of the prospected area, which correspond with the position of the Tlamacas dome. Also, the eastern limit of this resistive anomaly coincides with the location of the hypocenter of the earthquake on May 6, 2013, and probably depicts the presence of a NE-SW fault.

Abstract ID: 33082

Final Number: VGP24B-0405

Title: Campi Flegrei Deep Drilling Project: an overview of main results and implications on caldera dynamic.

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Abstract Body: During December 2012, in the framework of the “Campi Flegrei Deep Drilling Project” (CFDDP) a pilot

borehole was sunk into the caldera, to a depth of 501 m, 4.5 km ESE along the coast from Pozzuoli. The

primary purpose of the drilling is the understanding of caldera dynamic and is preparatory for the deeper

drilling at 3.5km of depth. The Campi Flegrei caldera experienced periodic phase of uplift and subsidence

accompanied by small to very large eruptions in the past, since the most recent one, occurred in 1538. Since

then, two main episodes of unrest, in 1969-72 and 1982-84, have resulted in a maximum net uplift at

Pozzuoli of more than 3 m. The second episode was accompanied by elevated rates of local seismicity,

which produced more than 16,000 earthquakes with recorded magnitudes between 0 and 4. The persistent

seismicity damaged older buildings in Pozzuoli and eventually led to the evacuation of 40,000 people. The

caldera is still active and the related high volcanic risk pushed the scientist to improve the knowledge of its

dynamic. In this context the CFDDP is aimed to obtain deep geological, geophysical and geochemical data to

constrain the models of unrest. Here we show the main results obtained from the drilling such as,

stratigraphy inferred from cuttings and coring, new permeability and stress data attained from different bore-

hole hydraulic tests and geochemical data of deep fluids.

Abstract ID: 34105

Final Number: VGP24B-0406

Title: 2009-2013 ground deformation at Mt Etna observed with advanced DInSAR: Results and Modelling

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Published Material: Preliminary results will be presented at the 9th International Workshop Fringe 2015 Advances in the Science and Applications of SAR Interferometry and Sentinel-1 InSAR Workshop, Frascati, Italy between 23 and 27 March 2015.

Abstract Body: For studying ground deformation at Mt Etna we collected ascending and descending RADARSAT-2 Standard-3 (S3) data spanning January 2009 – June 2013. The advanced multidimensional small baseline subset method (MSBAS, Samsonov & d'Oreye, 2011) was used to obtain EW and vertical time series of ground deformation. Vertical deformation map revealed localized subsidence and horizontal deformation map revealed broad east-west motion at the fault located north of the volcano with rates <2 cm/year. The nonlinear inversion methodology by Camacho et al. (2011) was used for modeling 3D pressure and mass sources with a free geometry. The method assumes simple homogenous elastic conditions, and models the size and location of pressure/mass sources in a general model, fitting the entire geodetic data set within some regularity conditions. The approach (Camacho et al., 2011; Samsonov et al., 2014) works as a growth process that constructs a very general geometrical configuration. A general framework for the geometry of anomalous bodies is achieved by partitioning the subsurface volume into a dense 3-D grid of point sources. The geometrical description of the extended sources is developed by aggregation of point sources in a 3-D context, allowing for a very general description of the free geometry for the source bodies. For simplicity, it is assumed that anomalous pressure changes are nearly homogeneous within the sources. The inversion process fills cells with the prescribed pressure value (and/or density anomaly), giving rise to the aggregation structure. The nonlinear search is based on an exploratory approach. Simultaneously regional deformation patterns and sliding displacements are obtained. Measured displacement and modeling results are described.

References

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Samsonov S. & d'Oreye N., 2012, doi: 10.1111/j.1365-246X.2012.05669.x.

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Abstract ID: 34217

Final Number: VGP24B-0407

Title: Elemental Concentrations and ^{210}Pb Activity of a Growth-zoned Gypsum Stalactite generate Historical Volcanic Activity Record at Kawah Ijen's Crater Lake, Indonesia

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Published Material: Up to 15% of the total work, such as initial ideas and interpretations on a limited number of elemental concentrations and ^{210}Pb activity, have been reported in an oral presentation at the Cities on Volcanoes 8 Conference in Yogyakarta, Indonesia on 9 September 2014.

Abstract Body: The active Kawah Ijen stratovolcano in Indonesia hosts the world's largest hyper-acidic crater lake, with 32 million m^3 of hot SO_4-HCl brine [1]. The volcano has produced phreatic and phreatomagmatic eruptions, tephra, and lahars in the past [2]. This is exemplified by its 1817 eruption, which resulted in expulsion of the entire lake [3]. At the time, the area was scarcely populated, and the overall impact from the volcano was low. As population density around the volcano has raised dramatically, the risk to nearby inhabitants have also risen markedly. Hence, Kawah Ijen requires monitoring, and monitoring depends on having a continuous record of background activity to identify signals of impending eruptions. Unfortunately, there is currently a severely limited record of volcanic activity of Kawah Ijen available. Gypsum grows continuously on Kawah Ijen's western flanks [4], where it precipitates from crater lake seepage springs as stalactites in chemical equilibrium with its fluids. Given that the brine receives direct elemental input from the degassing magma, including elements such as Tl, As and Sb [4,5], we posit that gypsum can be used to reconstruct a continuous geochemical record of volcanic activity for Kawah Ijen. Trace elements were analysed in a cross-section of a growth-zoned stalactite, as was ^{210}Pb activity. Initial ^{210}Pb activity varies with that of its parent's, ^{222}Rn, flux from the degassing magma. When combining the timing information from growth zoning with concentrations and ^{210}Pb activity, we can produce a continuous geochemical record of activity over time. Sharp increases in volatile element ratios above baseline concentrations likely correspond to significant elemental input from the degassing magma, and hence increased activity. The record of $\delta^{18}O$ disequilibrium between the crystalline H_2O and SO_4[6] is shown to be preserved in gypsum, and thus can be used to track changes in the temperature of and flux through the hydrothermal system. Knowledge of background concentrations and how activity affects these, allows us to pinpoint geochemical signals of impending eruptions and aid the monitoring efforts at Kawah Ijen volcano.

[1] Delmelle and Bernard, 2004

[2] Mulyana et al., 2006

[3] Kemmerling, 1921

[4] van Hinsberg, 2009

[5] van Hinsberg et al., 2010

[6] Chiba and Sakai, 1985.

Abstract ID: 34411

Final Number: VGP24C-0408

Title: Model of Pattern Formation in Layered Igneous Intrusions

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Abstract Body: Oscillations in composition and grain size can sometimes be generated in magmatic intrusions, giving rise to characteristic centimeter to meter-scale patterns called cyclic layering. Understanding the genesis of these patterns is essential to understand the geological context in which these bodies are formed. We hypothesize that these patterns result from a nonlinear self-organization process in which the interplay between crystallization dynamics and diffusion causes mineral and crystal size segregation. The mechanism is similar to the one behind the formation of Liesegang bands and leads to comparable features, such as a geometric progression of the band positions. With the goal of obtaining a more complete description of the pattern formation process in

the context of a binary eutectic magmatic system in cooling contact with a host-rock, we present a one-dimensional numerical model of nucleation and growth that generalizes previously available versions. The model includes optionally Ostwald ripening, as well as tortuosity corrections for the porosity. The emergence of cyclic layering is described in terms of key parameters that control the solidification. Moreover, by using a spherically symmetric geometry, the model can be applied to the formation or orbicular granites.

Abstract ID: 35195

Final Number: VGP24C-0410

Title: Mantle petrology, mineralogy and major elements geochemistry of the northern Cache Creek terrane – Preliminary results

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Abstract Body: The northern Cache Creek terrane extends for more than 500 km in north British Columbia and south Yukon. This composite terrane comprises mafic and ultramafic complexes and carbonate and chert assemblages that were previously interpreted as accreted seamounts, spreading centers and rifted arc complexes. Our observations show that mantle facies dominate and are often structurally capped by brecciated hypabyssal and volcanic rocks, with only rare occurrences of mafic and ultramafic cumulates. Geochemical signatures suggest an arc affinity for most volcanic and hypabyssal rocks. Variably serpentinized and metamorphosed mantle rocks were sampled at King Mountain, Dease Lake, Hardluck and Peridotite peaks, Mt. Barham, Atlin and Marsh Lake. Primary mineralogy and textures are often preserved. Foliated mantle harzburgite tectonite dominates, with about 25-35% of porphyroclastic orthopyroxene and subordinate chromite, often with holly-leaf morphology. Chromite shows a wide spectrum from translucent to opaque facies, suggesting a wide range of Cr/Al and variable melt depletion signatures. Rare orthopyroxenitic to websteritic layers are interpreted to be transposed dykes. Dunite dykes are common but subordinate in abundance and contain sub-euhedral chromite. Gabbroic dykes are also common. At Mt. Barham the peridotite shows spectacular anthophyllite dendrites near a late granitic intrusion. Detailed mantle petrology, mineralogy and major elements geochemistry will be used to establish a coherent regional geologic framework for the Cache Creek terrane and its tectonic reconstruction.

Abstract ID: 35254

Final Number: VGP24C-0412

Title: Petrogenesis of Mantle Xenoliths in Alkaline Basalts in Southeastern British Columbia

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Abstract Body: Tertiary alkaline basalts diatremes in Southeastern British Columbia are host to a variety of mantle xenoliths, predominantly spinel lherzolites with associated dunites and pyroxenites. Mineralogically, they are composed mainly of olivine, orthopyroxene, clinopyroxene and spinel characterized by forsterite (Fo_{87-93}), enstatite (En_{90-92}), diopside (En_{45-50}-Wo_{40-45}-Fs_5) and Cr-spinel (6-11 wt. % Cr), respectively. All mantle xenoliths are coarse-grained and show triple junctions. Clinopyroxene and spinel show evidence for chemical reactions with percolating melts.

The mantle xenoliths are characterized by 42.8-45.2 wt. % SiO_2, 37.5-42.7 wt. % MgO, 8.2-9.7 wt. % Fe_2O_3. Al_2O_3 (0.85-4.61 wt. %) and TiO_2 (0.02-0.16 wt. %) show moderate variations, resulting in super-chondriting Al_2O_3/TiO_2 (21-72) ratios. CaO values range from 0.61 to 3.8 wt. %, whereas the CaO/Al_2O_3 possess a narrow range (0.54-0.92). They have rather restricted Mg-numbers (89-92). They are strongly depleted in incompatible elements (Ba = 2-12 ppm; Sr = 3-31 ppm; Zr = 6-21 ppm, K_2O = 0.01-0.07 wt. %) and variably depleted in transitional metals (V = 41-94 ppm; Sc = 6-17 ppm). Yttrium (1-3 ppm) is also strongly depleted. On the basis of chondrite-normalized REE patterns, samples are divided into three groups: (1) LREE- depleted (La/Yb_n = 0.34-0.82) samples; (2) moderately LREE- enriched (La/Yb_n = 1.11-1.78) samples; (3) and LREE- enriched (La/Yb_n = 2.20-3.00) samples. N-MORB-normalized trace element patterns display negative Nb and Ti anomalies but exhibit positive Pb, Sr and Zr anomalies. These geochemical characteristics are consistent with a variably metasomatized sub-continental lithospheric mantle source, originated in a subarc mantle wedge.

Abstract ID: 35606

Final Number: VGP24C-0413

Title: Stratification within the granophyre of the South Range of the Sudbury Igneous Complex

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Abstract Body: The Sudbury Igneous Complex (SIC) was formed by a meteorite impact, which generated a large quantity of impact melt in a single pulse. Fractionation and crystallization of the impact melt sheet led to formation of three units of the Main Mass of the SIC. On the South Range of the SIC the Main Mass comprises norite cumulates capped by granophyric residues. These two units are separated by a zone called the Transition Zone quartz gabbro which represents a change from plagioclase+orthopyroxene to alkali feldspar+quartz+clinopyroxene+biotite+Fe oxide+apatite crystallization followed by a rapid increase in the amount of trapped liquid.

Mapping and sample collection during the summer of 2013 led to the identification of a lithological reversal expressed as a layer of gabbro exposed near the middle of the granophyre unit. Its mineralogical make up corresponds to that of transition quartz gabbro zone but it occurs more than 1 km above the top of the TZ quartz gabbro. We have mapped this layer over a continuous strike length greater than 5 km between Whitewater Lake and Moore Lake. The contact is a sharp transition from pink granophyre to coarse-grained quartz gabbro with stellate textured clinopyroxene and a sharp increase in the mafic mineral abundance. Geochemically it is characterised by a drop in silica content to 51.72% and an increase in MgO to 2.56% in comparison to the 72.28% silica and 0.55% MgO content of Lower granophyre layer. Subsequent samples were collected (XRF results pending) in order to substantiate field observations. Modeling using MELTS software will be performed for the purpose of evaluation of possible sources of the upper gabbro layer. Existence of the reversal in the lithology of the Main Mass implies a greater complexity in process of evolution of the SIC than has been previously assumed, possibly indicating that the magmatic system evolved as a stably stratified body throughout its existence.

Abstract ID: 36167

Final Number: VGP24C-0414

Title: Mineralogy and Geothermometry of the mid-Jurassic Trail Pluton, Southeastern British Columbia

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Abstract Body: The Trail pluton, located in southeastern British Columbia, is part of a suite of mid-Jurassic granitic rocks of probable continental arc affinity that were transported eastwards as a result of Cordilleran tectonics. Previous work on the nearby Nelson Batholith has suggested that magmatic rocks in this area were subjected to substantial post-equilibration rotation and tilting, possibly as a result of movement on listric faults. Twenty-five samples were collected from the Trail pluton for the purpose of mineralogical description and amphibole-plagioclase thermometry using the HB-PLAG program by Holland and Blundy (1994). The average modal mineralogy of the samples is: quartz 13%, plagioclase 33%, potassium feldspar 20% (late in the magmatic crystallization history), amphibole 14%, biotite 10%, titanite 1%, and a minor amount of alteration minerals such as chlorite and epidote. Many samples show evidence of localized strain, including comminution of grain size in quartz and feldspars and folding of biotite. Most plagioclase crystals fall within the composition range An_{39} to An_{31}. The potassium feldspar is low in Na, suggesting a lower crystallization temperature. All amphiboles are calcic, ranging from magnesiohornblende to tschermakite to pargasite. Nearly all amphiboles have $Al^{vi} > 1.0$, giving them the prefix alumino. Preliminary thermometry calculations using the edenite-tremolite end-member system give an average result of 745°C for amphibole-plagioclase equilibration at P = 5 kbar. This result agrees well with calculations by Ghent et al. (1991) for both the Nelson Batholith and Bonnington pluton. Further work on this project will include barometric calculations as well as an examination of possible differential uplift and tilting of the Trail pluton.

Abstract ID: 36395

Final Number: VGP24C-0415

Title: Fe–Ti oxides in the lower crustal xenoliths recording significant magmatic events in the crust–mantle transition zone (North China)

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Abstract Body: Ilmenite and rutile are found to be common accessory minerals in the lower crustal xenoliths from the Cenozoic Hannuoba basalts, northern North China Craton. Detailed petrography, major chemical composition and trace elements of these Fe–Ti oxides in four pyroxenite xenoliths are studied. The Fe–Ti oxides occur mainly in the interstice of silicates or as inclusions in pyroxenes, and three types are representative: (1) single rounded homogeneous grain; (2) intergrowth of rutile and ilmenite; (3) slender needle-like grains. The ilmenite is especially rich in MgO (6.36~13.1 %) and poor in Fe^{3+} ($Fe^{3+}/\Sigma Fe$, 0~0.063), which is clearly different from the Mg-poor titanomagnetite (MgO, 2.9~3.31 %) in host basalts. The ilmenite on the rims of rutile grains indicates the reaction of rutile and accessional Fe^{2+}, which possibly came from interstitial melts or melting silicates. This can be evidenced by the needle-like ilmenite penetrating into the partly-melted pyroxenes. These crustal xenoliths have two-pyroxene equilibrium temperatures of 834~884°C, and ziconium-in-rutile temperature of ~825°C (at 1.2 GPa), which suggest that the xenoliths were derived from the crust–mantle transition zone (~24–33 km), and experienced later magmatic reheating events. Hence, the petrological and geochemical characteristics of the Fe–Ti oxides in the pyroxenite xenoliths record significant geological processes in the continental lower crust beneath Hannuoba, and give insights into the tectonic evolution of the North China Craton.

Abstract ID: 36758

Final Number: VGP24C-0416

Title: Selfrag: An Effective Tool in Sample Preparation for Geological Research

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Abstract Body: Extraction of a pure mineral from a geological sample is often vital to analytical techniques ranging from elemental analysis to radiometric dating. The Selfrag instrument uses high-voltage pulsed power discharges to fragment geological material along grain boundaries, conserving morphology and liberating minerals of interest. A series of case studies prove the Selfrag to be a versatile tool. 1) Athabasca Basin sandstones are composed of over 98% quartz. The minor clay constituent retains a geochemical signature of the near-surface environment that can reflect fluid evolution and uranium mineralization at depth. X-ray diffraction of clay-sized material prepared using conventional methods such as disc-mill crushing and centrifugal clay separation displays significant quartz contamination. The Selfrag liberates the clay minerals with minimal quartz contamination, making the sample ideal for subsequent analysis for trace elements and isotopic ratios. 2) The Kiyuk Lake gold deposit is unusual in that it is hosted in Paleoproterozoic sediments, contrary to metamorphosed Archean terranes that typically host significant Canadian gold deposits. Large crystals of actinolite, quartz, calcite, and magnetite were hand-picked from fragmented samples and imaged using scanning electron microscopy. Each mineral was analysed for $\delta^{18}O$ and $\delta^{2}H$ to further understanding of the chemical evolution of the deposit. 3) MacMillan Pass is home to several sedimentary-exhalative deposits hosted in Late Devonian sediments. Barite and pyrite from a typical vent complex were successfully fragmented for geochemical analysis to determine potential use as vectors in mineral exploration. 4) Typical crushing methods destroy vital spatial information within minerals that display zonation, such as garnets or zircons. Whole zircons from rhyolitic tuffs and eclogites have been extracted for subsequent radiometric dating and geochemical analysis. Whole garnets from mica schists and eclogites have been extracted for trace element analysis and tomography. The Selfrag is capable of simplifying the process of extracting minerals of interest from a complex matrix, and improves confidence in any analytical method that assumes a mono-minerallic material.

Abstract ID: 33360

Final Number: VGP24C-0417

Title: Zoisite Eclogites From Faro Area, Yukon: Pressure-Temperature- Fluid Composition Attending Metamorphism

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Abstract Body: Eclogite occurs as metre-sized lenses within metasedimentary schists and gneisses near Faro, Yukon Territory, Canada. The mineral assemblage in eclogite is quartz-garnet-zoisite-Ca-amphibole-clinopyroxene-rutile-phengite. Secondary minerals include epidote-titanite-chlorite-glaucophane-calcite-K-feldspar and albite. Eclogites have undergone strong deformation, locally producing a mylonitic matrix. Garnet is relatively fresh but contains numerous fractures and little retrogressioni.Estimates of peak pressure (P) and temperature (T) attending metamorphism used Fe^{2+}-Mg fractionation between clinopyroxene and garnet, Zr in rutile, clinopyroxene-garnet-phengite equilibria and isochemical phase diagram sections (also known as pseudosections). Peak P-T conditions are difficult to estimate. Using Zr in rutile the temperature ranges from 580 to 595°C at 20 kbar, with no difference between rutile included in garnet and rutile in the matrix.
For 1.0, the lack of stable lawsonite suggests P<~18 kbar at T~600°C. The P-T path during unroofing and cooling is difficult to estimate but the occurrence of albite suggests that some of the P-T path was in the albite stability field. The host metasedimenary rocks contain zircon-quartz-rutile but suggest equilibration temperatures of about 545°C. Post-peak penetrative deformation promoted some retrogressive reactions but the coarser peak porphyroblasts survived this deformation and retrogression. This implies lack of extensive fluids during cooling and deformation.

Abstract ID: 33548

Final Number: VGP24C-0418

Title: Geochemistry and Petrogenesis of the Basement Rocks from Barapaharpur, Rangpur: Implications for Crustal Evolution of the Shallow Basement in the North-West Bangladesh.

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Abstract Body: Bangladesh is one of the world's largest deltaic plains, almost entirely covered by Tertiary and Quaternary sediments without any surface outcrops of igneous and metamorphic rocks. The crystalline basement drillcore samples from Barapaharpur, Rangpur area in the northwest Bangladesh have been investigated through core logging, petrographic and geochemical study to constrain their origin and to propose a crustal evolution and geodynamic model for the area. The Barapaharpur basement rocks were encountered at a depth of ~1200ft and comprises mostly of diorite, which is dissected by minor granodiorite gneiss and hornblendite dykes. The felsic rocks of Barapaharpur basement are metaluminous with low ASI index, calc-alkaline and have high K_2O and Rb contents. They show progressive depletion in P_2O_5 with increasing silica reflecting a typical internal fractionation trend of I-type granitoid. The Barapaharpur granitoid is characterized by strong enrichment in LREE and distinct negative Nb and Ti and zero to weakly negative Eu anomalies. The source melt of Barapaharpur granitoid has been suggested to have generated in an ocean-continent subduction zone. High La/Yb_{CN} ratios (16.17-17.67) and positive correlation between Sr/Y and La/Yb ratios of the felsic samples imply a deep source melting (upper mantle) at high pressure (10-12Kbar). Dykes of hornblendite suggests a mantle origin, at deeper level than the parental melt of the diorite. This mafic melt occupied the fissure or weak zones within the I-type granitoid forming the late dykes. Comparison between the studied Barapaharpur granitoid and Maddhapara granitoid (55km NW to Barapaharpur) reveals that both of them share remarkably similar geochemical and petrographic signatures, pointing toward a similar source of parental melt for both granitoids. From the geodynamic study based on gravity-magnetic mapping, the location of the granitoids fall within the regional micro-continental block (Dinajpur Block) suggested by a previous work and these two granitoid basements are considered to have represented an unreported part of Palaeoproterozoic supercontinent Columbia. However, U-Pb precise geochronology and high precision geophysical study of the Barapaharpur granitoid are required to establish the precise age, and limit of this new microcontinental block.

Abstract ID: 33738

Final Number: VGP24C-0419

Title: Combined Geochemistry and Geochronology Constrains Coupled Subduction of Oceanic and Continental Crust in the Huwan Shear Zone, Central China

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Published Material: Part of the materials present here have appeared in the latest issue of American mineralogist.

Abstract Body: The exposure of the eclogites derived from oceanic subduction and continental subduction at the surface of Earth today record provide different P-T-t records of the subduction process. In this study, Lu-Hf garnet, U-Pb zircon, and Ar-Ar mica ages are combined with geochemical data to understand the origin of two coexisting eclogite bodies exposed along the Xuehe River in the Huwan Shear zone. In total, the results indicate that the two eclogites have different protoliths but experienced a similar metamorphic history. This observation requires new tectonic model for the coupled subduction of oceanic and continental crust in subduction zones. Combined geochemistry and zircon U-Pb geochronology suggest distinct oceanic and continental affinities for the eclogite protoliths. The Lu-Hf dates of the continental-type eclogite and the oceanic-type eclogite reflect garnet growth and are interpreted to closely approximate the age of eclogite-facies metamorphism. Therefore, both the geochemically oceanic- and continental-type eclogites underwent the same episode of Permian eclogite-facies metamorphism. The Permian Lu-Hf ages of *ca*. 262 Ma and the obtained Triassic Ar-Ar ages of the oceanic-type and continental-type eclogites imply coupled subduction and exhumation of oceanic and continental crustal materials in the Hong'an orogenic belt during the Permian and the Triassic. Though limited, the geochemical and geochronological results of this study, together with the discrepant Carboniferous dates for the nearby eclogites of previous studies, apparently suggest that the Huwan shear zone was not always a single coherent unit but instead comprises different tectonic slices that were metamorphosed at different times before final assembly. Some slices of the oceanic and continental crust underwent two subduction cycles during the Carboniferous and the Permian, whereas some eclogites registered only a single subduction-exhumation loop during the convergence between the South China Block and the North China Block in the Huwan shear zone.

Abstract ID: 33924

Final Number: VGP24C-0420

Title: Tourmaline's record of fluid history in the Pfitscher Joch, Western Tauern Window

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Published Material: Some of the data was presented in September 2014 at the Deutsche Mineralogische Gesellschaft (DMG) annual meeting in Jena as a poster presentation.

Abstract Body: The Pfitscher Joch is a petrologically well-investigated area of the Western Tauern Window in the Eastern Alps. Its basement comprises pre-Variscan amphibolite, serpentinite, and garnet-graphite schist and gneiss intruded by two late Variscan granitoids (Tux and Zillertal Zentralgneis). In the late-Permian to Mesozoic, a sequence of sediments were deposited, starting with conglomerates, fining upward to psammites-pelites, including carbonate-rich schists, possibly interrupted by a horizon of rhyolite. Together, they form part of the Subpenninic nappes, the former European distal margin. In the Alpine orogeny, this succession was folded between the Tux and the Zillertal granitoids, forming a WSW-ENE oriented syncline. During Alpine metamorphism, fluids were released and probably channelled in the Greiner Shear Zone, which runs subparallel to the folded sequence, leading to complex fluid flow in the whole Pfitscher Joch region. Whereas the geodynamics of the area have been well constrained, the fluid flow history is not yet understood.

A striking mineralogical feature in many lithologies of the Pfitsch formation is the presence of black, prismatic tourmaline (schorl-dravite solid solution). It is particularly pervasive in a ~ 25 m thick unit of tourmaline-feldspar-rich gneiss, which is associated with feldspar-dominated segregations. The largest and most abundant tourmalines are in the segregations, suggesting a link between tourmaline crystallization and their formation. These crystals record three growth stages, distinguished by major element chemistry and inclusion mineralogy. Outside the segregations, multi-stage compositional growth zoning is rare and individual grains match usually only one growth stage of the segregation-hosted tourmaline. Comparison of data from different horizons of the Pfitsch formation shows a bulk-rock compositional control on the Fe content of the hosted tourmaline. Conversely, the Ca/Na of the tourmaline is independent of the host rock, and is interpreted as a fluid signature.

The Pfitscher Joch is an example locality of tourmaline serving as a powerful petrogenetic indicator mineral. A combination of textural, isotopic, and major and trace element analysis of tourmaline has allowed part of the Pfitscher Joch's fluid history to be revealed.

Abstract ID: 34019

Final Number: VGP24C-0421

Title: Re-Os Geochronology of Bitumen from the Northern Longmen Shan Thrust Belt, Southwest China

Presenter/First Author: Zeyang Liu, Geological Society of America, Wuhan,

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Co-authors: Chuanbo Shen, . Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan, China; David S Selby, University of Durham, Durham, DH1, United Kingdom; Xiaoyan Ruan, , , ; Shouzhi Hu, , , ; Jiayi Du, , ,

Abstract Body: The bitumen Re-Os geochronology as a novel technique has the good potential for wider use to constrain hydrocarbon generation especially in the marine carbonate basin, to identify source units and to determine the activity age of fault within bitumen filling. Six bitumen samples from the Lower Cambrian Changjianggou formation in the northern Longmen Shan thrust belt were selected for Re-Os analysis. Re and Os contents are ~283.3–563.3 ppb and ~4058.2–15347.3 ppt, respectively. These values are significantly elevated from those of the average continental crust and previously reported bitumen samples from both hydrocarbon and metalliferous systems, and also the majority of marine and lacustrine organic-rich sedimentary rocks (REFS), which has also been shown by previous studies. The $^{187}Re/^{188}Os$ values are high, ranging from ~ 230.7 to 718.4, and the Os isotopic composition is radiogenic, with $^{187}Os/^{188}Os$ ratios ranging from 2.79 to 3.48. Repeat analysis yield similar Re and Os concentrations, and $^{187}Re/^{188}Os$ and $^{187}Os/^{188}Os$ values.

All the Re-Os data yield an isochron age of 158 ± 77 Ma with an initial $^{187}Os/^{188}Os$ value of 1.85 ± 0.61 (2σ; MSWD = 76). Calculated initial $^{187}Os/^{188}Os$ ratios at 158Ma are variable and can be divided to two groups. One yield a Re-Os date of 162 ± 14 Ma with an initial $^{187}Os/^{188}Os$ value of 1.87 ± 0.12 (2σ; MSWD = 0.95). The remaining samples yield a Re-Os date of 172.7 ± 8.1 Ma with an initial $^{187}Os/^{188}Os$ value of 1.655 ± 0.056 (2σ; MSWD = 0.000).

Two different initial $^{187}Os/^{188}Os$ values suggest that all the oil generated from different source horizons with different Os isotope compositions. The Re-Os bitumen geochronology was coeval with intense thrust fault movement of the northern Longmen Shan thrust belt, which also provides a new direct absolute age evidence for the Late Mesozoic deformation of the northern Longmen Shan thrust belt.

Abstract ID: 34027

Final Number: VGP24C-0422

Title: Early Permian Peperites in the Beishan Region, NW China: Implications for Regional Tectonic and Palaeoenvironmental Setting

Presenter/First Author: Shi Chen, China University of Petroleum, Beijing,

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Co-authors: Zhaojie Guo, Peking University, Beijing, China; Jiafu Qi, College of Geosciences, China University of Petroleum,, Beijing, China; Yuanyuan Zhang, , ,

Abstract Body: Peperites have been identified at the Lower Permian Upper Zhesi group in Beishan, China, which is significant for the reconstruction of Late Paleozoic evolution in the southern part of the Central Asian Orogenic Belt. Five types of peperites are distinguished in the Hongliuhe and Liuyuan profiles and interpreted as the products from basaltic lava bulldozing into wet, unconsolidated sediments at their basal contacts. Laser $^{40}Ar/^{39}Ar$ dating of the basalt yielding an age of 274±11Ma, as well as the occurrence of Early Permian brachiopod fossils in the carbonate sediments interbedded with the basalt confirm that the peperites formed in Early Permian. Identification of the peperites reveals that the basaltic lava flows were derived from autochthonous basaltic magmatism and formed as part of the Lower Permian succession. The peperites also distinguish these subaqueous basaltic lava flows are not dismembered ophiolitic components, formed as a product of oceanization in Early Permian. The clastic rocks in the Lower Zhesi group underlying the basaltic lava and peperites in the Hongliuhe and Liuyuan areas show a general fining-upwards sequence, indicating that they were deposited in a progressively deepening basin overlying the Devonian Hongliuhe suture zone. Therefore, the peperites were probably originated in a progressively subsiding-basin environment as a result of advanced rifting during Early-Middle Permian in the Beishan region. Subaqueous volcanism in rift basins, accompanied by coeval deposition of carbonate sediments and mudstones, built up the peperite-bearing volcanogenic-sedimentary successions. A detailed investigation of Permian peperites in the Beishan region provides a typical application in determining palaeoenvironment and thus constraining regional tectonic setting.

Abstract ID: 33172

Final Number: VGP24C-0424

Title: Lithostratigraphy of Nigeria An-Overview

Presenter/First Author: Kazeem A Shitta, Geotechnical Nigeria Limited, Ibadan,

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Co-authors: Kazeem A Shitta, , ,

Published Material: World Environmental and Water Resources Congress 2009: Great Rivers

Abstract Body:
Nigeria lies very close to the equator (hot country) West coast Africa between latitude 4N and 14 N degree and longitude 2 E and 15 E degree. The country is located at the Northern end of Eastern branch of west coast of Africa rift system. Nigeria geological set up comprises broadlysedimentary formation and crystalline basement complex, which occur more or less in equalproportion all over the country. The sediment is mainly Upper Cretaceous to recent in age whilethe basement complex rocks are thought to be Precambrian. The studied area lies between latitude12.4" and 11.11"W and longitude 13.81" and 14.13" S. The studied area is underlain byPrecambrian basement complex of southern western Nigeria .The major rock in the area is charnokite and granite rock. The granite rock which are member of the older granite suite occupy about 65% of the total area .The principal granite is petrographic variety are recognized .The fine grained biotite -granite medium coarse, non porphyritic biotite-hornblende granite and coarse-porphyritic biotite-hornblende granite. Also three main textural type of Charnokitic rock are alsodistinguished are coarse grained, massive fine grained and gneissic fine grained .The mode of occurrence of rock is three (1) core of the granite rock as exemplified by study area and few smaller bodies (2) Margin of the granite bodies as seen in Ijare and Uro edemo-idemo Charnokitic bodies and (3) Discrete bodies of the gneissic fine grained Charnokitic rock within the country gneisses as seen in Ilaro and Iju and Emirin village. All the charnokite in the region are dark-greenish to greenish -gray rocks with bluish quartz and greenish feldspar.

Abstract ID: 34158

Final Number: VGP31A-01

Title: Controls on the chemical composition of flood volcanics

Presenter/First Author: Nicholas T Arndt, , Meylan,

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Published Material: The broad ideas have been published in several publications, but new ideas are introduced in this talk

Abstract Body: Continental LIPs are made up of two main types of mafic magma, referred to as high-Ti and low-Ti. The two types are the result of mantle melting under contrasting conditions, and the magmas behaved differently during their ascent through the crust.

High-Ti magmas have high contents of incompatible trace elements and strongly fractionated REE patterns. They result from low-degree melting of a possibly enriched portion of the mantle source – a mantle plume in most cases. Volatile components like H2O and CO2 act like incompatible elements and they are strongly concentrated in the melt. Their presence decreases melt density which drives the magma rapidly into the crust and the ascent accelerates once CO2 exsolves near the base of the crust. These magmas interact minimally with wall rocks and partly for this reason do not contain Ni-sulfide deposits.

Low-Ti magmas have lower contents of incompatible trace elements accompanied by the chemical signature of crustal contamination (negative Nb-Ta anomalies, high 87Sr/86Sr, negative epsilon Nd). They result from high degrees of melting of the hotter parts of the mantle source. Their low volatile content and more primitive composition imparts high densities that cause the magma to be trapped at density discontinuities at the base of, and within, the crust. In magma chambers, the magmas differentiate to less dense evolved melts that continue towards the surface and assimilate wall rocks, a process instrumental to the formation of Ni-sulfide ore deposits.

This type of model explains the geochemical characteristics of magmas in most continental LIPs, including Siberia, Emeishan, Deccan, Karoo and Ethiopia. The Bushveld Complex consists of low-Ti magma that assimilated massive amounts of crustal rock. Interaction with the continental lithospheric mantle had little impact on the major and trace element contents of flood basalts, but might have influenced the concentrations and isotopic compositions of platinum-group metals.

Abstract ID: 36218

Final Number: VGP31A-02

Title: Linkages between the Neoproterozoic Natkusiak basalts and Franklin sills on Victoria Island, Arctic Canada

Presenter/First Author: Charles Duncan Beard, McGill University, Montreal,

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Co-authors: Dominique Weis, University of British Columbia, Vancouver, BC, Canada; Jean H J Bedard, Geological Survey of Canada, Quebec, QC, Canada; James S Scoates, University of British Columbia, Vancouver, BC, Canada; Trent A Dell'Oro, , ,

Published Material: Yes, these data were partially presented by J. Bédard at Goldschmidt 2012, also in Montréal. The interpretations have been refined and revised since this date. A manuscript has been prepared from these data, which will be submitted to Journal of Petrology before the end of January 2015.

Abstract Body: The 724–716 Ma Franklin Large Igneous Province extends >2500 km from Siberia to Greenland and is associated with break-up of Rodinia. On Victoria Island, the Natkusiak flood basalts cap the carbonate-dominated Shaler Supergroup (also with shale, sandstone and sulphate evaporite), which hosts the coeval Franklin sills. The basal Natkusiak basalt unit (50–100 m) is dominated by discontinuous flows and volcaniclastic rocks, and is overlain by voluminous sheet flow basalts (up to 800 m preserved thickness). The layered Type 1 sills have similar chemistry to the basal basalts, whilst the diabasic Type 2 sills resemble the sheet flow basalts. The former are restricted to deeper parts of the intrusive plumbing system.

Weak continental geochemical signatures, such as negative Nb–Ta anomalies, are ubiquitous in the intrusions and basalts, indicating that the Franklin magmas were pervasively, albeit subtly, contaminated during transit through the lithosphere. The basal basalt unit and Type 1 sills are the most contaminated with the lowest initial ε_{Nd} and ε_{Hf} (-6 to +8; -4 to

+5). Basal and sheet flow basalt units define separate trends in trace element plots and cannot be related by closed or open system fractional crystallisation or variable degrees of melting of a single mantle source.

The initial ε_{Nd} and ε_{Hf} of the northernmost Natkusiak basalts (-6 to +5; -4 to +16) are positively correlated along the OIB mantle array, whereas rocks from three southern volcanic sections are displaced toward more radiogenic Nd compositions (ε_{Nd} +4 to +12). The isotopic compositions of the Franklin sills exposed in the Minto Inlier correlate with the northern section basalts. The radiogenic Nd signature of the southern basalts is consistent with source contributions from old oceanic crust. We attribute this geographical control on melt composition to a long-lived heterogeneity in the Neoproterozoic mantle source(s) that was preserved in the basalts by a compartmentalized plumbing system.

Abstract ID: 33794

Final Number: VGP31A-03

Title: Newly discovered 1550 Ma mafic magmatism in the Tobacco Root Mountains, MT USA: An end to the North American Magmatic Gap?

Presenter/First Author: Chris Rogers, Carleton University, Ottawa, ON

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Co-authors: Richard E Ernst, Ernst Geosciences, Ottawa, ON, Canada; Brian Cousens, Carleton University, Ottawa, ON, Canada; Stephen Harlan, Nation Science Foundataion, Arlington, VA; Ulf Söderlund, Lund University, Lund, Sweden

Abstract Body: A new baddeleyite U-Pb age of 1552 ± 6 Ma for a dyke in the Tobacco Root Mountains (TRM) falls in the middle of a “magmatic gap” that was previously noted to exist between 1500 and 1600 Ma in western North America (Ross et al. 2003) based on the detrital zircon record of Proterozoic sedimentary rocks (Finney et al. 2005). Dykes of this age offer a potential local source for ca. 1550 Ma detrital zircons found within the Belt-Purcell Basin. The 1552 Ma age is significantly older than 1470-1430 Ma U-Pb mafic sills within the Belt-Purcell Supergroup and is unknown elsewhere in the Wyoming craton. The new U-Pb age for these intra-plate mafic dykes indicate that this magmatic event may have preceded 1470 to 1400 Ma extension and deposition of the Belt-Purcell Supergroup.

In the TRM, Proterozoic mafic dykes are subvertical, strike NW, and cut foliation of the Archean basement. Geochemical analyses of mafic dykes from the southern TRM and the Ruby Range (RR) by Wooden et al. (1978) identified distinct geochemical groups that they termed A, B, and C. We concur that there are three distinct groups of dykes within the TRM and RR. However, we revised the original groups based on more extensive and modern geochemical analysis. We propose A, B and C group dykes be renamed the Ramshorn Creek Group (RCG; 1552 Ma date applies), 780 Ma Gunbarrel dykes, and the yet undated Mammoth Group (MG), respectively. The very similar geochemical signatures of the RCG and MG dykes indicate deeper melting, more lithospheric contribution and different source(s) than the Gunbarrel dykes.

Paleomagnetic studies by Harlan and others (2005, 2008) yielded dual polarity magnetizations for both the RCG and MG dykes that are supported by both normal and reverse polarity baked contact tests. The definition of a 1550 Ma RCG pole from the southern TRM dykes would contribute to enhanced definition of the Laurentian apparent polar wander path during the Mesoproterozoic.

Abstract ID: 34519

Final Number: VGP31A-04

Title: Chigu Tso intrusions in the remnant Comei large igneous province, SE Tibet: implication for Early Cretaceous Kerguelen plume-Eastern Gondwana lithosphere interaction

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Abstract Body: Chigu Tso intrusions are found within the Jurassic strata of the remnant Comei large igneous province (LIP), SE Tibet, providing an opportunity to explore how the Early Cretaceous Kerguelen mantle plume interacted with the Eastern Gondwana lithosphere. Chigu Tso intrusions consist of three series: 1) a pyroxenite to low-P_2O_5 gabbro fractional crystallization group; 2) a transitional medium-P_2O_5 diabase-norite-gabbro group; and 3) a high-P_2O_5 gabbro to diorite group. Zircon U-Pb age dating of Chigu Tso intrusions (pyroxenite 130 ± 2 Ma, gabbro 132 ± 1 Ma; Zhu et al., 2009; diorites 132.4 ± 1.0 Ma, 133.7 ± 1.4 Ma; this study) suggest that Chigu Tso intrusions should be part of the magma plumbing system of the remnant Comei LIP. The low $\varepsilon_{Nd}(t)$ value of the pyroxenite (-1.8) is similar to SCLM-derived ultramafic rocks in Sylhet Traps (pyroxenite, -0.1 to -4.2; lamproite, -2.4 to -6.4; and kimberlites,-2.6 to -3.2; Ghatak et al., 2013). Isotope work in progress will resolve between the models of fractional crystallization of high-P_2O_5 gabbro and fractional melting of pyroxenite for the petrogenesis of the diorites. The presence of SCLM-derived ultramafic rocks and a crustal signature in the remnant Comei LIP, Bunbury basalts, Rajmahal-Sylhet traps, and Southern Kerguelen Plateau, suggest that the Eastern Gondwana lithosphere played an important role in the origin of this portion of Kerguelen plume-related magmatism.

Abstract ID: 34283

Final Number: VGP31A-05

Title: A Geochemical Proxy Approach to LIP Forensics

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Co-authors: Richard E Ernst, Ernst Geosciences, Ottawa, ON, Canada; David William Peate, University of Iowa, Iowa City, IA

Published Material: Some background material is taken from Pearce J.A. (Lithos, 2008). Otherwise unpublished.

Abstract Body: One effective way to carry out forensic examination of LIPs is by using geochemical proxies for parameters such as mantle temperature, mantle composition, nature and degree of partial melting, crustal composition, and assimilation-fractional crystallization. In the ideal world, each geochemical proxy would highlight just one petrogenetic variable. Here, we investigate in detail the utility of three immobile element proxies: Th/Nb as a proxy for crustal input (via subduction or assimilation); Ti/Yb in basic rocks as a proxy for the role of garnet in the melting process; and either Sc or Co (depending on melting history) as a proxy for the degree of fractional crystallization. The Th/Nb ratio distinguishes LIP lavas with no crustal input, and hence low ratios typical of MORB and OIB, from those with crustal involvement and hence higher ratios. Of the latter, the crustal input may represent a subducted crustal component stored in sub-continental lithospheric mantle (SCLM), or continental crust assimilated by fractionating magma. Combining the

crustal proxy with the fractionation proxy, provides an opportunity to distinguish between the SCLM and assimilation options in many cases. The Ti/Yb proxy is based on the fact that high ratios are indicative of residual garnet, i.e. of thick lithosphere and/or relatively low mantle potential temperatures. A further consequence is that unusually low Ti/Yb ratios result from remelting of mantle preconditioned by earlier melting in the garnet facies. There are wide variations in the values of these proxies, both within and between individual LIPs. Between LIPs, differences in crustal assimilation, SCLM involvement, and mantle and melting parameters highlight differences in setting and geodynamics. Within LIPs, spatial and temporal variations in both crustal and mantle variables are common and, where exposure and reconstructions allow, these can be highlighted through geochemical mapping based on the Th/Nb and Ti/Yb proxies.

Abstract ID: 34919

Final Number: VGP31A-06

Title: New insights into the relationship between the Central Atlantic Magmatic Province (CAMP) and the End-Triassic extinction from CAMP U-Pb zircon and baddeleyite dates.

Presenter/First Author: Joshua Davies, University of Geneva, Geneva,

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Abstract Body: The Central Atlantic Magmatic Province (CAMP) is a sequence of flood basalts, dyke swarms and sill complexes , emplaced predominantly into the Triassic and Jurassic basins of Pangea. The exact extent of the flood basalts is unknown, but it is thought to be one of the largest outpourings of basalt magma onto the continental crust during the Phanerozoic Eon. Consequently, the basaltic eruptions has been linked with the End-Triassic extinction, the initiation of Pangea breakup and the opening of the Central Atlantic Ocean. However, the link between the CAMP basalts and the End-Triassic extinction is still unclear, which is in part, due the basalts being stratigraphically above the extinction horizon in all of the basins where they have been discovered. A negative carbon isotope excursion and a spike in fern spore abundance mark the extinction horizon and these are below the lowest basalts in North America, and also just below the basalts in Morocco, where the oldest CAMP basalts are thought to outcrop.

Here we present high precision U-Pb TIMS dates for zircons from the Moroccan and North American CAMP successions that suggest that there was CAMP magmatic activity before the eruption of the first basalts. Antecrystic zircons from a basalt flow in North America suggest a long pre-eruption history of magmatism associated with the CAMP. Baddeleyite and zircon from a dyke in the Moroccan CAMP also suggest a similar pre-eruptive history. Both the zircon and baddeleyite were extracted from coarse gained sections of the flow and dyke in an attempt to avoid zircons crystalizing in late melt segregations which are usually the target for basalt U-Pb dating. We also present hafnium isotope data from the zircons and baddeleyites to support our conclusions. The identification of zircon and baddeleyite antecrysts provide an insight to the pre-eruptive history of the CAMP and have significant implications for the relationship between the CAMP and the End-Triassic extinction.

Abstract ID: 34899

Final Number: VGP31A-08

Title: Lyra Basin and Louisville Seamount Chain: Two Suspects for the Ontong Java Plateau Hotspot Trail?

Presenter/First Author: Maria Luisa G Tejada, JAMSTEC Japan Agency for Marine-Earth Science and Technology, Yokosuka,

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Published Material: This abstract highlights some findings from three submitted papers: two on Lyra Basin have been accepted for publication in the GSA Special Volume on Oceanic LIPs and one is under review for G-cubed. Partial results (about 50% each) from these papers were presented at IAVCEI in Japan (2013) and at Goldschmidt in Florence (2013).

Abstract Body: The Ontong Java Plateau (OJP) is believed to have formed during the initial or plume-head stage development of a huge mantle upwelling, but its hotspot trail has not been unequivocally defined or found. One of the longest-lived hotspot traces in the Pacific, the Louisville Seamount Chain (LSC), has long been suspected of representing the trail of the OJP. The International Ocean Drilling Program Expedition 330 is one of the more recent attempts to uncover this link between OJP and LSC. Re-Os isotope and platinum group element investigation of samples from three of the five drilled sites give a very weak lead to the possibility of a plume head to tail relationship between the OJP and the LSC [1]. Meanwhile, the less known Lyra Basin in the western margin of the OJP has been shown by geophysical studies to be underlain by unusually thick oceanic crust, believed to result from emplacement of massive flows from the plateau. Geophysical survey and dredging was conducted by Japan Agency for Marine-Earth Science and Technology to test the relationship between Lyra Basin and OJP. Geochemical and geochronological investigation of the dredged rocks from the basin instead show that younger alkalic rocks, which are geochemically akin to those of alkalic rocks and alnoites in Malaita, Solomon Islands in the southern margin of the OJP, may have covered older plateau crust in the basin [2]. Although not directly related to the main plateau volcanism at 120 Ma, the geochemical data and modeling suggest that the origin of the Lyra Basin alkalic rocks may be genetically linked to the mantle preserved in the thick lithospheric root imaged beneath the OJP, with magmatic contribution from the Rarotongan hotspot [3]. Combined with the other alkalic volcanism on and around the plateau, the Lyra Basin alkalic rocks could represent part of the late-stage magmatic development of the OJP.

References: [1] Tejada, M.L.G., T. Hanyu, A. Ishikawa et al., G-cubed, submitted; [2] Shimizu, K., T. Sano, M.L.G. Tejada et al., GSA Spec. Vol., in press; [3] Tejada, M.L.G., K. Shimizu, K. Suzuki et al., GSA Spec. Vol., in press.

Abstract ID: 35943

Final Number: VGP32A-01

Title: Changes in the Thermal and Compositional Structure of the Earth's Mantle, High-Mg LIP Magmatism, and Magmatic Ni-Cu-PGE Deposits Through Time

Presenter/First Author: C Michael Lesher, Laurentian University, Sudbury, ON

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Published Material: Gave a talk on the temperature changes at the "Great Plume Debate" a few years ago, and have published some of the ideas on the ore deposits. This is an update and overview requested by the convenors.

Abstract Body: There was an abrupt change in the maximum MgO content of mantle-derived magmas at the Archean-Proterozoic boundary: from

Archean high-Mg komatiites with up to 33% MgO erupted at up to 1660^oC (or more if superheated), to Proterozoic low-Mg komatiites/ferropicrites with up to 22% MgO erupted at up to ~1440^oC and Phanerozoic low-Mg komatiites/high-Mg picrites with up to 23% MgO erupted at up to ~1460^oC. The ~10% MgO change in composition corresponds to a ~200^oC change in eruption T and a 170^oC change in the potential temperature of the mantle source regions. The abrupt decrease in maximum magma temperature, along with a wide range of other fundamental changes that occurred at the end of the Archean, indicate a fundamental and irreversible change in the thermal and/or compositional structure of the mantle at that time from one that could produce much hotter plumes but that involved only nominally hotter upper mantle. The origin is still being debated, but the most widely discussed scenarios are: 1) generation of a thermal/compositional boundary layer along the core-mantle boundary, 2) a change from whole-mantle to 2-layered convection, and 3) a change from 2-layered to whole-mantle convection. Regardless of the precise origin, the change profoundly influenced the viscosity of the magmas, their ability to ascend through the crust and therefore their volcanic/subvolcanic settings of emplacement, and the composition of associated magmatic Ni-Cu-PGE mineralization. Archean deposits are predominantly predominantly volcanic to very high level subvolcanic with higher Ni/Cu and lower Pd/Ir, Proterozoic deposits are volcanic with intermediate Ni/Cu and Pd/Ir, and Phanerozoic deposits are subvolcanic to plutonic with lower Ni/Cu and higher Pd/Ir. Most deposits, regardless of age, exhibit relatively flat mantle-normalized metal patterns and appear to be derived from primarily peridotitic mantle sources, but some are enriched in Co-Ni-Cu relative to Au-PGE and appear to be derived from pyroxenitic sources.

Abstract ID: 34139

Final Number: VGP32A-02

Title: A Petrogenetic Model for LREE-Enriched Basalt and Gabbros in the Coldwell Alkaline Complex, Midcontinent Rift, Ontario

Presenter/First Author: David John Good, University of Western Ontario, London, ON

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Co-authors: Pete N Hollings, Lakehead University, Thunder Bay, ON, Canada; Cundari M Robert, , , ; Doreen E. Ames, , Ottawa, ON, Canada

Abstract Body: The Coldwell Alkaline Complex (CAC) is associated with the Midcontinent rift event. The eastern and northern margin of the CAC consists of numerous cross-cutting gabbroic to ultramafic intrusions that are associated with magma conduit style Cu-Pd deposits. A package of basalt flows that overlie syenite near the centre of the CAC is linked to the gabbroic bodies by common geochemical characteristics. This study presents a petrogenetic model for the mafic rocks based on a comprehensive geochemical and isotopic study of the basalt and gabbroic bodies.

Observations are centred on the highly unusual LREE abundances in the basalt, and on trend lines for La vs. Zr or La vs. Th variation diagrams that resemble effects due to contamination, but evidence suggests contamination did not occur by assimilation of crustal material, as follows: (a) there is a negligible increase in Th, Zr and SiO_2 with increasing La; (b) absolute abundances of HFSE in basalt are comparable to E-MORB; and (c) Nd and Sr isotopic signatures are near CHUR. The evidence suggests LREE enrichment occurred at the time of partial melting from a LREE enriched mantle source, and not by crustal contamination.

Excluding LREE abundances, the composition of the initial Coubran basalt magma is interpreted to be comparable to Mamainse Point volcanic group 1. This interpretation is supported by similar Th/Nb and Tb/Yb values, and similar abundances of LILE, HREE, HFSE, and major elements. However the extruded Coubran basalt magma must have undergone fractional crystallization at depth in order to explain the present low Ni and Mg Numbers.

A proposed geochemical model for fractional crystallization of various basalt magma compositions that lie along the La-Zr or La-Th trajectories can explain the trace element compositions of five prominent gabbroic bodies in the CAC (Two Duck Lake gabbro, layered troctolite sill, Geordie Lake gabbro, gabbroic anorthosite and layered olivine gabbro).

Abstract ID: 35619

Final Number: VGP32A-03

Title: Black Thor Intrusive Complex in the 2.7 Ga McFaulds Greenstone belt, Superior Province: a feeder system of an Archean Large Igneous Province?

Presenter/First Author: Heather J. E. Carson, Laurentian University, Sudbury, ON

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Abstract Body: The Ring of Fire Intrusive Suite (RoFIS) encompasses coeval ultramafic- and mafic-dominated intrusions, interpreted to represent the subvolcanic parts of a large igneous province that has either eroded away or not yet been identified due to limited outcrop in the region. The RoFIS contains world-class chromite deposits (e.g., Black Thor, Big Daddy, Blackbird), significant Ni-Cu-(PGE) mineralization (e.g., Eagle's Nest), and potentially significant Fe-Ti-V mineralization (e.g., Thunderbird). The Black Thor Intrusive Complex (BTIC) of the RoFIS is dominated by olivine ± pyroxene-rich cumulate rocks, contains an aggregate thickness of 100m chromite mineralization (much more than in typical stratiform chromite deposits) and is derived from a komatiitic magma with 22-23 wt% MgO. Mass balance calculations indicate that the BTIC contains ~30% more Ol and ~6% more Chr than the parental magma (i.e., 12x more Chr than cotectic proportions), indicating that the BTIC represents a feeder system in which Ol and Chr accumulated. The BTIC is at least 15 km long x 1.5 km wide x 1 km deep (open at depth). Combined with abundant nearly contemporaneous mafic-dominated ferrogabbroic intrusions and the missing volume of evolved magma required to mass balance BTIC cumulates, the volume of the magmatic system is inferred to be greater than 32,000 km3. Ni-Cu-(PGE) ores occur within magmatic feeders and along basal contacts of the ultramafic-dominated intrusions and formed early in the magmatic history of the system, chromite ores occur in the middle parts of the ultramafic-dominated intrusions and formed at an intermediate stage, and Fe-Ti-V mineralization occurs in mafic-dominated intrusions, more evolved parts of the entire system. Together these imply the presence of both deeper fractionation chambers (to produce the ferrogabbros) and overlying evolved lavas (fractionates of BTIC cumulates).

Abstract ID: 36135

Final Number: VGP32A-04

Title: Mafic-Ultramafic Magmatism in the Bird River/Uchi/Oxford-Stull/La Grande-Eastmain Superdomain: Potential Remnants of Meso- and Neoarchean LIPs in the Northern Superior Province

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Abstract Body: The discoveries of world-class Cr deposits, significant Ni-Cu-PGE deposits, and numerous Fe-Ti-V occurrences in the McFaulds Lake (a.k.a. "Ring of Fire") area of northern Ontario have greatly renewed interest in orthomagmatic mineralization associated with mafic-ultramafic intrusions in the Superior Province. Cr-(PGE) deposits and, to lesser extent, Fe-Ti-V and Ni-Cu-(PGE) deposits/occurrences, occur predominantly in the northern part of the Superior Province within Meso- to Neoarchean supracrustal successions along the margins and within the cores of the Bird River–Uchi–Oxford-Stull–La Grande–Eastmain domains (i.e., BUOGE "superdomain").

Ultramafic to mafic magmatism of various types (e.g., komatiitic, tholeiitic, alkalic) extended over a period of more than 200 Ma within the BUOGE superdomain, from ~2.88 to 2.66 Ga. However, only two main intervals (ca. 2810 Ma and ca. 2735 Ma) are recognized to have generated major magmatic events across the superdomain. Although limited in size, emplacement of large amounts of ultramafic to mafic magmas over a short period of time, locally combined with komatiite-tholeiite successions, argues in favor that these intrusions could represents remnants of Archean LIPs. The broader Neoarchean magmatic event that includes the intrusive suites of the Bird River in Manitoba (ca. 2743 Ma), the Ring of Fire in Ontario (ca. 2734 Ma), and several but more localized ultramafic intrusions within the La Grande domain in Québec (ca. 2754 Ma), is by far the best candidate to represent an Archean LIP that consist of at least three magmatic pulses over 20 My associated with the emplacement of Cr-PGE, Ni-Cu-PGE deposits, and significant Fe-Ti-V occurrences.

This superdomain defines a major Cr-Ni-Cu-PGE-V metallotect within the Superior Province that appears to be fundamentally different from other parts, such as the Abitibi greenstone belt or the apparently relatively unmineralized North Caribou core, Island Lake, and Goudalie domains. Ongoing work aims at establishing geological settings and characteristics of these orthomagmatic deposits in many of these areas, to help constrain the likelihood of discovering additional mineral resources in the BUOGE superdomain, but also in other frontier areas throughout the Canadian Shield.

Abstract ID: 34275

Final Number: VGP32A-05

Title: Hf Isotope Constraints on the Origin of the Bushveld Magmatic Province

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Abstract Body: The Bushveld Magmatic Province (BMP) contains >30 individual mafic-ulramafic to felsic bodies that were intruded into the northern half of the Kaapvaal craton of South Africa and Zimbabwe, between 2.05 and 2.06 Ga. The initial Hf isotope compositions of zircon from the Bushveld Igneous Complex (BIC) and Phalaborwa Carbonatite Complex (PCC), two large bodies in the BMP, are unradiogenic, internally homogeneous, and similar to one another ($\varepsilon Hf_{(2.06\ Ga)}$ = -8.6 ± 2.6 and -7.5 ± 2.4 for the BIC and PCC, respectively). We have previously interpreted this to mean that the BIC and PCC parent magmas were produced by melting of a geochemically enriched source within the ancient subcontinental lithospheric mantle (SCLM). We are now determining the Hf isotope compositions of zircon by LA-ICP-MS from related rocks in the region to constrain the geographic distribution of this SCLM source and the extent to which it was involved in the generation of other bodies in the BMP. The Marble Hall diorite, a small intrusion situated near the BIC's geographic center but whose structural relationship to the BIC remains unclear, yields a range of $\varepsilon Hf_{(2.06\ Ga)}$ from -1.3 ± 0.9 to -6.2 ± 1.9 (Avg. = -3.7 ± 2.8; n = 15). This more radiogenic composition relative to the BIC and PCC may indicate that the SCLM source of these intrusions is more heterogeneous than initially thought, or that the Marble Hall diorite was derived from a different source altogether. In the southeastern part of the BMP, the Schurwedraai alkali granite, a ~2.05 Ga peralkaline to peraluminous intrusion exposed in the northern collar of the Vredefort Dome, yields $\varepsilon Hf_{(2.06\ Ga)}$ from -18.6 ± 2.0 to -30.4 ± 3.0, (Avg. = -22.6 ± 6.4; n = 29). This unradiogenic composition is consistent with melting of Archean continental crust, suggesting that the heat source that induced melting of the SCLM to produce the BIC and PCC parent magmas also resulted in anatexis.

Abstract ID: 33215

Final Number: VGP32A-06

Title: Tapping of the Bushveld magma chamber: Experiments on the parental magma to the Upper Zone

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Co-authors: Saskia Hövelmann, , , ; Olivier Namur, University of Hannover, Hannover, Germany; André Stechern, , , ; Francois Holtz, Leibniz University of Hannover, Hannover, Germany

Abstract Body: The Bushveld layered intrusion covers ca. 65.000 km² in South Africa and is made up of a 7-9 km thick cumulate sequence. The upper 2 km of the intrusion (upper part of the Main Zone and Upper Zone) is known for the abundance of Fe-Ti-V±P ore deposits. The bottom of this sequence is characterized by a 2-3 m thick layer of orthopyroxenite known as the 'Pyroxenite Marker'. It is considered as the last major influx of magma (ferrobasalt) in the Bushveld magma chamber. In this study, we have performed crystallization experiments and MELTS calculations on various estimates for parental magmas to the 'Upper Zone and Upper Main Zone' of the Bushveld Complex. Our experimental data constrain phase equilibria and the liquid line of descent during the evolution from evolved basalt to rhyolite. We also aim at constraining the composition of the parent magma after the Pyroxenite Marker by comparing experimental data and the continuous crystallization record in the Bellevue and Bierkraal drill-cores. Experiments were conducted at 200 MPa and 1160-1100°C in internally heated pressure vessels on selected compositions proposed in the literature, varying essentially in SiO_2 (50-55 wt%), CaO (7-11 wt%) and Mg-number (37-48). The stability fields of the pyroxenes and olivine are very sensitive to small compositional differences in the starting materials, producing a variety of pyroxenes from orthopyroxene, pigeonite, sub-calcic augite to augite. The formation of orthopyroxene at the base of the sequence requires a parental magma that corresponds to the bulk cumulate composition of the Upper zone to which 25-40% monzonite/rhyolite is added. Little evidence exists for the occurrence of this amount of evolved material in plutonic environment. It is more reasonable to consider open-system evolution of the Bushveld magma chamber that was regularly tapped during the crystallization of the Upper Zone, possibly erupted at the surface as the Rooiberg suite.

Abstract ID: 34155

Final Number: VGP32A-07

Title: Geochemistry of small differentiated intrusions and associated large igneous provinces: controls on the formation of magmatic sulfide ore deposits

Presenter/First Author: Peter C Lightfoot, Vale, Sudbury, ON

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Abstract Body: The formation of magmatic sulfide ore deposits is often considered to be the result of the saturation of mafic and ultramafic magmas in sulfur, and the formation of dense immiscible sulfide melts which segregate from the magma, concentrate metals, and form ore deposits. The triggers for saturation are widely considered to be contamination by the assimilation of S-rich crust, whereas the as important in the formation of world class ore deposits like Noril'sk. Several controls remain less well understood; viz: 1. Does the composition of the source and the depth of magma generation control mineral potential?; 2. Is the pathway of magma transportation an important control on ore formation?; 3. Are magmatic sulfides actually transported from the site of formation into the intrusions?; 4. What is the relationship of small differentiated intrusions to the large volumes of mafic magma that erupt in rift settings and as continental flood basalts?; 5. What relationships exist between ore formation and the stage of formation of large igneous provinces (LIPs)?

This presentation uses geochemical data for basaltic volcanic rocks and differentiated intrusions to look at process controls in the Siberian, Deccan, West Greenland, and Emeishan flood basalt provinces, the Keweenawan Mid-continent Rift (MCR), and the Nain Plutonic Suite (NPS). In the cases of the Deccan and NPS, composition of the source appears to control the availability of precious metals, nickel and copper. Mineralized differentiated intrusions in the Siberian Trap, MCR, and Emeishan occupy space created by trans-tension in strike-slip structural zones, and have geochemical and petrological features which support the emplacement of sulfide-laden magmas. The stage of formation of the mineralized intrusions often links to the early rifting and faulting of the crust in response to far-field tectonic events; this is illustrated by mineralized intrusions associated with the Siberian, West Greenland, and Emeishan LIPs. Although ore systems are genetically related to LIP events, the geochemical signatures of ore formation are found in discrete packages of comagmatic flood basalt erupted in depo-centers along the structural zones.

Abstract ID: 36823

Final Number: VGP32A-08

Title: Minor Ultramafic-mafic Intrusions of Devonian Altai-Sayan LIP (South Siberia): Petrogenesis and Ore Potential

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Co-authors: Andrey Izokh, , , ; Gleb Polyakov, , , ; Maria Cherdantseva, , ,

Published Material: Partly reported on IPS12 in Yekaterinburg last year and LIPs of Asia in Hanoi in 2013, under review in Mineralium Deposita special issue

Abstract Body: There are several hundred minor ultramafic-mafic and mafic bodies of Early Devonian age in the central part of the Altai-Sayan folded area (part of Central Asia Orogenic Belt). It is assumed that they are derived from one of the earliest and most primitive melts formed during the formation of the Altai-Sayan LIP. Altai-Sayan LIP formed simultaneously with Vilyui LIP (NE Siberia), the bulk of which are intracontinental rift basalts filled large depressions like Minusa and Tuva troughs. We have studied more than 20 minor intrusions of this age in the Tsagaan Shiveet Ridge in NW Mongolia. Rocks composition varies greatly and there are different types of intrusions: minor homogeneous, layered and minor differentiated. However, the geochemical characteristics of these rocks are relatively close to each other, and in this way are significantly different from the bodies of the Cambrian age also situated in the area, suggesting a common mantle source, but different ways of evolution of the initial melts. In one of the intrusions a small occurence of Cu-Ni ores with PGE mineralization was found. The total content of PGE in the samples is about 750 ppb, with 0.35 wt.% Cu and 0.5 wt.% Ni. Thus there is potential to find similar deposits in other intrusions of this age.

This works were funded by Russian Foundation for Basic Research (grants 12-05-00435, 13-05-01132, 13-05-00951 and 13-05-12056).

Abstract ID: 33628

Final Number: VGP32B-01

Title: Get Good Data: Establishing Optimal Measurement Precision and Practical Detection Limits for Portable XRF

Presenter/First Author: Pim van Geffen, REFLEX Geosciences, Vancouver, BC

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Co-authors: Cindy Collins, , ,

Abstract Body: The data quality of field-portable and handheld X-Ray Fluorescence devices has made huge leaps over the past decade, most notably in improved analytical precision. More sensitive detectors and higher count rates provide greater spectral resolution. Spectral interferences and other matrix effects aside, the technique provides reliable quantification of elemental compositions within the detectable energy range (Mg to U) and some elements can be confidently measured as low as single ppm. However, the ultimate data quality relies mostly on the instrument's operator. Decisions about sample collection, preparation, presentation and instrument settings are critical, as is observing a thorough QA/QC protocol to assess contamination, precision and accuracy. Most critical of these parameters is the precision. The accuracy can be adjusted by post-process calibration, provided the precision is acceptable and a sufficient number of appropriate certified reference materials have been included in the analytical sequence. Given the chemical complexity of typical geological samples, it is imperative to assess the actual measurement precision, from sampling error (field duplicates) to analytical error (detection). Because of aforementioned interferences and matrix effects, most elements may not have quite as low detection limits as could be achieved in clean, homogenous substances. Fortunately, we can derive practical detection limits for each element in an analytical sequence, based on the recorded measurement-error distributions.

Abstract ID: 34053

Final Number: VGP32B-02

Title: Combining pXRF Analysis with pXRD Data Provides Truly Quantitative and Qualitative Sample Characterisation

Presenter/First Author: Yulia Uvarova, CSIRO Australian Resources Research Center, Perth,

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Published Material: Partially reported at the IMA 2014 meeting

Abstract Body: Portable X-ray fluorescence (pXRF) spectrometry has numerous applications in a wide range of studies, including: non-destructive analyses in the alloy metals industry, particularly scrap metal sorting and material identification; archaeometry; environmental sciences for conducting contamination characterization, removal, and remedial operations at hazardous waste sites; archaeology; non-invasive analysis of museum artefacts; rapid screening of toxic elements in various products, goods and media; and soil analysis and agriculture. In the last decade, pXRF analysis has emerged as an important analytical technique for exploration and mining. Portable XRF offers rapid and cost-effective analysis of geologic samples and provides data of high quality and accuracy where appropriate calibration and quality assurance/quality control protocols are followed. Conversely, until now powder X-ray Diffraction (XRD) has been a technique that is used mainly in research. With the advancement in hardware technology, namely X-ray tubes, detectors and processors, and more powerful and sophisticated software packages, X-ray diffraction has become a qualitative and quantitative tool for the identification of crystalline materials, and has tremendous potential applications in exploration and mining. With the current progress in development and implementation of automated algorithms for data processing, XRD has the potential to become a routine technique for analysis of geologic materials. Ultimately, combined portable XRF and XRD instrument analyses will allow rapid chemical and mineralogical characterisation of a sample. The current study illustrates that coupled pXRF-pXRD analysis can be performed on a large set of complex geological samples and the techniques complement each other. In this study we also give a few practical examples from various industrial applications.

Abstract ID: 36078

Final Number: VGP32B-03

Title: Assessing the Interpretability of Soil Geochemical Surveys from Site Duplicate Sampling: Measures and Metrics

Presenter/First Author: Charles Beaudry, Retired, Toronto,

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Published Material: Parts of conference were presented at the AIGS Symposium https://www.appliedgeochemists.org/index.php/events/aag-events/2-uncategorised/115-26th-international-applied-geochemistry-symposium in Rotorua, NZ, in 2013.

Abstract Body: Strong evidence exists in the recent literature on partial and selective extraction soil geochemistry to show that these methods can detect blind mineral deposits covered by transported overburden that should normally preclude detection, at least according to any conventional understanding of how soil geochemical anomalies form. However in routine applications these methods tend to produce high proportions of false positive and false negative anomalies hindering interpretation of results and preventing their widespread adoption.

To understand why these methods are difficult to work with one must consider a soil geochemical survey from the perspective of a measurement system. The variance of results is a combination of the variance of the survey and the variance of the measurement system (which includes all sources of variance from the point of collection of the sample to the analysis itself and is cumulative). Conceptually this is the partitioning of variance between sources and can be measured in principal, albeit with difficulty, by collecting sample site duplicates. For an acceptable measurement system the variance of site duplicates should be less than 30% of the variance of the survey and the lower this number the better it will be able to detect variations in the survey results and hence able to detect reliable anomalies if present. As a comparison, surveys in residual soils based on aqua regia digestion typically give values below 10% but partial/selective extraction methods in Abitibi clay covered areas often have sampling variance exceeding 50% of the survey variance. This leads to excessively noisy data making interpretations very difficult. Methods exist to reduce the variance of sampling but unfortunately in some instances it is the variance itself that is anomalous and may be signaling the presence of mineralization.

The method presented here based on the Gage R&R analysis, available in any commercial statistical software package, allows us to calculate measures of fitness of any survey dataset containing a standardized set of site duplicates and metrics to measure performance of the survey including minimum anomaly thresholds for any analysed component.

This approach is probably even more essential when using field portable instrumentation such as XRF analysers.

Abstract ID: 34311

Final Number: VGP32B-04

Title: HH-XRF: A decision tool for exploration success, the example from Sirios' gold Cheechoo project

Presenter/First Author: Réjean Réjean, Geoscientists IOS Services Inc, Saguenay, QC

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Abstract Body: Hand held X-ray fluorescence analyzer (HHXRF) were made available to mineral exploration industry about 10 years ago, and then regarded as high-tech toy for gizmo lovers, trigging dreams ofexploration efficiency. However, when properly used, HH-XRF analysers are powerful decision making tools. As example, a HH-XRF has been used in the course of a humus geochemistry program where provided quick analyses, although of lesser quality, prior that sample being to submitted for conventional ICP-MS assaying. Although definitively less sensitive and accurate, HHXRF detected reliably the presence of the main pathfinder elements for gold, such as arsenic, tungsten and cobalt. Obtaining fast results enabled Sirios Resources to convey an effective prospecting program upon the detected anomaly within the same summer. HH-XRF lead to the discovery of the first gold bearing occurrence on their Cheechoo project located in James Bay, northern Québec. All the significant anomalies were subsequently confirmed by ICP-MS analysis after Na-pyrophosphate digestion.. Anomalies were related to minutely disseminated pyrite, arsenopyrite and scheelite in subjacent bedrock, barely distinguishable by the naked eyes, and grams per ton gold grades. Although HHXRF has not detected subtleties, it proved effective to detect the major signatures, and saved almost a year in the exploration cycle. A review of the analytical results and reliability, with inter-elements and inter-methods comparison will be presented. The Cheechoo project host a broad low-grade gold mineralization hosted within an Archean tonalite near Goldcorp's Eleonore mine, a context interpreted as a reduced intrusion hosted deposit. This type of mineralization is notorious for being difficult to detect.

Abstract ID: 34032

Final Number: VGP32B-05

Title: The Application of pXRF and benchtop SEM (bSEM) to Characterize the Igneous Stratigraphy and Cu-Pd Mineralization in the Eastern Gabbro, Coldwell Alkaline Complex

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Abstract Body: The current study involves the application of pXRF and bSEM to characterize the igneous stratigraphy and Cu-Pd mineralization on the north edge of the Eastern Gabbro of the Coldwell Alkaline Complex. The Midcontinent Rift-related Coldwell complex intruded into the Schreiber-White River Archean greenstone belt, which consists of low-grade metamorphic volcanic and sedimentary rocks. The Eastern Gabbro occurs along the outer margin of the complex and consists of the Fine Grained, the Layered and the Marathon magmatic series. The Marathon Series hosts several Cu-Pd occurrences in the area, including the Geordie Lake and Marathon Cu-Pd deposits.

Comparisons between portable analyses and lab-based analyses were carried out first to confirm their data quality. For example, pXRF data and bSEM-EDS data were compared to traditional XRF and ICP data and electron microprobe data, respectively. Our results show that both portable techniques are comparable with their lab-based counterparts. In addition, the comparison among EDS measurements on unpolished blocks, polished blocks, and carbon-coated thin sections was conducted to evaluate the necessity of different amounts of sample preparation.

Distinguishing the different gabbro units is a key to Cu-Pd exploration, however, it is difficult to identify the different series of gabbros in the field, in particular for magnetite- and plagioclase-rich augite melatroctolite in the Layered Series, and the magnetite melatroctolite in the Marathon Series. The combination of pXRF and the bSEM successfully differentiated these units: The pXRF was used to differentiate the different igneous units using P_2O_5, Fe_2O_3, TiO_2, Ba, and V. The bSEM was applied to characterize different units using Mg# of olivine and clinopyroxene, and the An content of plagioclase. The combination of these two techniques demonstrates that field-portable methods can be used to map igneous stratigraphy, which is a key component of future Cu-Pd exploration.

Abstract ID: 34321

Final Number: VGP32B-06

Title: Comparison of portable XRF performance on unprepared drill cores and on powders for “whole rock” analysis

Presenter/First Author: Alexandre Bourke, INRS-ETE, Quebec City, QC

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Published Material: The content of this presentation is found in an article submitted in november 2014 to the journal Geochemistry: Exploration, Environment, Analysis. It is still waiting for acceptance.

Abstract Body: Portable (including handheld) XRF devices (pXRF) are fast gaining in popularity in the mining and exploration industries. They can acquire quickly and *in situ* (a) concentrations of elements of economic interest and (b) “whole rock” analysis for major oxides and trace elements. But since pXRF is a relatively new and rapidly evolving technology, analytical protocols and instrumental performances are not yet well known. In particular, the question of whether a rock core sample should be crushed and pulverized or not prior to analysis has not been systematically studied. Considering that sample preparation is time-consuming and that it destroys the cores, is it worth it?

This presentation compares pXRF data quality on unprepared rock cores and on powders for “whole rock” analyses, examining the instrumental precision (relative standard deviation, RSD, of a series of measurements on the same spot), the sample precision (for unprepared samples, RSD of a series of measurements on different spots on the core) and the accuracy. We also test for instrumental drift.

Our tests use two Olympus Innov-X Delta Premium pXRF analyzers and samples of dense Precambrian volcanic and intrusive cores from the Abitibi Subprovince. In general, we find that: (1) sample preparation does not improve instrumental precision, and may even degrade it for some elements; (2) mineralogical heterogeneity effects can be attenuated, and even canceled for some elements, by averaging closely spaced *in situ* data taken during the same amount of time required for pulverizing a sample; (3) accuracy is much worse on powders for three oxides, namely Al_2O_3, MgO and SiO_2, it is improved for Cu and Zn on powders, and it is comparable on both media for the other elements. Finally, we find no significant instrumental drift within a day, or between different months.

Abstract ID: 33963

Final Number: VGP32B-07

Title: Handheld XRF for quartz quality control for ferrosilicon industry

Presenter/First Author: L Paul Bedard, University of Quebec at Chicoutimi UQAC, Chicoutimi, QC

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Co-authors: Dany Desroches, , , ; Samuel Lemieux, , , ; Kim H Esbensen, Geological Survey of Denmark and Greenland, Copenhagen, Denmark

Abstract Body: Gunbarrel magmas display similar geochemical characteristics to known economic LIPs of Canada, including a range of chalcophile element depleted magmas and (Cu/Zr)PM vs. (Th/Yb)PM trends towards crustal input which suggests possible S-saturation and sulphide immiscibility. This makes Gunbarrel intrusions a potential economic target for Ni-Cu-PGE exploration.

Abstract ID: 34554

Final Number: VGP34A-0413

Title: Modelling the Structure and Composition of Layered Intrusions in Plume Center Regions using Potential Field Data

Presenter/First Author: Jennifer Blanchard, Carleton University, Ottawa,

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Abstract Body: Economic concentrations of Ni-Cu-PGEs are commonly emplaced in layered mafic-ultramafic intrusions. These intrusions can be linked with Large Igneous Provinces (LIPs), suggesting that LIPs should be primary exploration targets. Furthermore, it has been proposed that layered intrusions located within a few hundred kilometers of the plume center are the most prospective mining targets.

Intrusions are often associated with prominent gravity and magnetic anomalies, allowing for their detection using geophysical methods. We assessed the plume center regions of 17 LIPs and have catalogued possible layered intrusions in about half of these. At least two styles of geophysical anomalies are recognized. The first is the more common occurrence of a large gravity high adjacent to the plume center, typically associated with a magnetic anomaly (eg., 1270 Ma Mackenzie LIP, Canada) . The second type is a large magnetic anomaly coincident with a weak gravity signature (e.g., 130-80 Ma High Arctic LIP). These anomalies are being modelled to determine their source depth, shape and composition based on joint modelling of gravity and aeromagnetic data.

A prominent +700 nT sub-circular magnetic anomaly with a diameter of about 60 km, likely linked with the High Arctic LIP, is situated on Ellesmere Island, Arctic Canada. Preliminary modelling infers the presence of an intrusive body that extends to a depth of approximately 15 km and is composed of an upper felsic and a lower mafic component, with intermittent magnetite-rich horizons.

Systematic modelling of the catalogued anomalies associated with plume centers will help quantify the proportions of felsic, mafic and ultramafic components in each intrusion. This will be a guide to help better understand the magmatic plumbing system of LIPs as well as the economic potential of these intrusions.

Abstract ID: 35302

Final Number: VGP34A-0414

Title: Evidence for the extension of the 180 Ma Karoo LIP of southern Africa northward into Zambia and Tanzania

Presenter/First Author: Richard E Ernst, Ernst Geosciences, Ottawa, ON

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Abstract Body: The Uvinza dyke of a N-trending mafic dyke swarm in Tanzania (Swarm III in Halls et al., 1987, Geol. Assoc. Canada SP 34) yields a 181 Ma U-Pb baddeleyite age. This is a match to the widespread Karoo Large Igneous Province (LIP) of southern Africa. A previous aeromagnetic interpretation by Halls et al. (1987) shows that Swarm III dykes extend south from Tanzania for 500-800 km, but can possibly be traced for another 500 km through Zambia. This new geochronology and age estimates based on the previous aeromagnetic study by Halls et al. (1987) suggest that a major arm of the Karoo LIP extends northward into Zambia and Tanzania.

Abstract ID: 35100

Final Number: VGP34A-0415

Title: Forensic geochemistry of a basaltic flow and tabular intrusions of the High Arctic LIP: The case of South Fiord, Axel Heiberg Island, Nunavut

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Abstract Body: The High Arctic Large Igneous Province (HALIP) consists of mafic dykes, sills and lava flows that were emplaced mainly during two major episodes of igneous activity (c.130-120 and c. 100-90 Ma). Near South Fiord on western Axel Heiberg Island, Nunavut Canada, two basalt flows (10 & 2 m thick) exists within the Isachsen formation (older episode). About 7 km east of the field area, a thick >100 m sequence of Strand Fiord formation flood basalts (younger episode) crops out.

In this contribution, geochemical signatures of a lava flow and intrusions sampled in the vicinity of South Fiord are used to discriminate between the two pulses of Cretaceous magmatism. New geochemical data on 40 samples from tabular intrusions and the 10 m thick basalt flow from South Fiord are compared with published data on Strand Fiord and Isachsen formation flows. On Nb/Y vs. Zr/Ti and AFM diagrams, all South Fiord samples are subalkaline tholeiitic basalts apart from one tholeiitic basaltic andesite. Chondrite-normalized REE data show consistent shallow slopes, signifying partial melting of spinel lherzolites in the shallow mantle. There are distinct chemical differences between the basalt flow and intrusions around South Fiord. The tabular intrusions are more enriched in Zr at given Zr/Y. In addition, the basalt flow displays lower Ce/Yb than many intrusions with similar Mg#. There are also distinct differences between the basalt flow and nearby Strand Fiord formation basalts. In Zr/4-2Nb-Y ternary space, the basalt flow plots within VAB whereas the Strand Fiord basalts plot in an elongate cluster straddling the VAB and E-MORB fields and the trajectory is nearly orthogonal to that of the basalt flow. In addition, the basalt flow along with previously described Isachsen data from Axel Heiberg and Ellesmere Islands show higher Zr/Y when compared with Strand Fiord formation basalts. Our new data indicate that the basalt flow at South Fiord is likely part of the older Isachsen Formation flows that are chemically distinct from intrusions exposed around South Fiord. The chemistry of these intrusions is identical to lavas and intrusions of the Strand Fiord formation, suggesting that they were feeders of the Strand Fiord formation flows and part of the younger episode of HALIP.

Abstract ID: 34975

Final Number: VGP34A-0416

Title: A New Method to Quantify Sulfur Concentration in Basaltic Melts Based on Crystal/Melt Partition Coefficients

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Abstract Body: Knowledge of the volatile concentrations in magmas provides insight into processes as the formation of magmatic sulfide ore deposits, the explosivity of eruptions, and the role of large igneous provinces (LIPs) on mass extinctions. Traditionally these concentrations have been determined through analysis of melt inclusions, but these are rare and formed under rapid crystal growth conditions that may not result in the capture of representative melt aliquots. An alternative method to constrain volatile concentatrations in magmas is to use the partition coefficients of volatiles between crystals and melts and then to measure the volatile concentration in natural crystals and combine that with the partition coefficients to calculate concentrations in the melt. We chose to investigate the partitioning of sulfur between crystals and melts because of its suggested role in mass extinctions caused by LIPs. We previously defined the partition coefficient of S between clinopyroxene and basaltic melt at low oxygen fugacity and applied it to rocks from three LIPs (Callegaro et al., 2014, Geology 42:895). Our previous measurements were made under the conditions appropriate for LIPs, but to constrain partition coefficients applicable to a broad spectrum of common igneous compositions we performed a new set of experiments to investigate the effect of oxygen fugacity, water concentration, and melt composition on

the partitioning of sulfur between magmatic melts and nominally anhydrous (and sulfur-free) minerals (NAMs). We performed piston cylinder experiments at 800 or 1000 MPa and temperatures from 1350° to 1000°C, using andesite and dacite glass powders doped with pyrrhotite, and a Mid Ocean Ridge Basalt (MORB) powder as starting materials. Experiments were performed at different oxygen fugacities, one low enough that all S was present in the melt as sulfide and the other high enough that all S in the melt was present as sulfate. Hydrous experiments at the different oxygen fugacities were also performed and contain approximately 5 wt.% H_2O in the system. Partition coefficients for augite, pigeonite, olivine, orthopyroxene and plagioclase have been measured and allow us to use these phases to calculate the sulfur concentrations in the coexisting melts.

Abstract ID: 33804

Final Number: VGP34A-0417

Title: The Ste Sophie dyke swarm: A chemically distinct facies of the Grenville Swarm

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Abstract Body: About 20 diabase dykes up to 5 m wide occur in an area of ~100 sq kms about 50 km of Montreal near the village of Sainte-Sophie. Most are approximately vertical and E-W. Initially, it was thought that these dykes were part of the much more extensive Grenville dyke swarm which occurs just to the west. However, there are petrographic and geochemical differences: All dykes were vesicular, typically with 2-5% spherical vesicles 0.1-1 mm in diameter, and up to 10 mm for one dyke. Margins are always fine-grained and in one case glassy over 5 mm which suggest emplacement very close to the present surface. The most common phase is plagioclase (1-2 mm, exceptionally 10 mm), followed by olivine and, in one dyke, pyroxene. Alteration is extensive: plagioclase is partly sericitised, olivine is serpentinised, and zeolites and carbonate are developed in the vesicles and matrix. The bulk chemical compositions of the Ste Sophie dykes are also clearly distinct from those of the Grenville dykes: They have lower SiO_2 contents, 44-48%, and higher K2O contents, mostly around 1%, with two at about 6%. On a TAS diagram most of the dykes are subalkaline. Ar-Ar dating of plagioclase and whole-rock samples was not easy but indicated an age of 592±3 Ma, which is within the range of the Grenville dykes. The age, location and orientation of the dykes suggest that they may be a component of the much larger Grenville dyke swarm that was fed from a chemically distinct, somewhat enriched, source. This source may have been the same one that produced the alkali Monteregian intrusions some 470 million years later in the same region. If these dykes are part of the Grenville event then the use of chemical fingerprints to identify this swarm must be used with caution.

Abstract ID: 36444

Final Number: VGP34A-0418

Title: New Data on Igneous Rocks in the Adriatic Sea: a Possible Indicator of the Pangea Supercontinent Disintegration

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Published Material: Preliminary data from this research was presented as a poster at EGU 2014 conference.

Abstract Body: Occurrences of igneous rocks (mainly gabbro to diorite) on the Adriatic Sea islands are few - this research focuses on two known igneous islands (Jabuka and Brusnik) and on a previously unknown underwater shoal locality (Brusnik Shoal). All three localities are part of the Adriatic microplate that hosts the Mesozoic Adriatic Dinaridic Carbonate Platform (ADCP) and is mostly comprised of carbonates.

Previously published ^{40}K-^{40}Ar (Balogh et al., 1994, Geologia (Bologna), 56, 13-25) and ^{40}Ar-^{39}Ar ages (Palinkaš et al., 2010, Acta Mineralogica-Petrographica, 8, 1-15) constrain the emplacement of gabbroitic rocks in ADCP to 276-200 Ma. The Central Atlantic Magmatic Province (CAMP) formed 200 Ma ago (Blackburn et al., 2013, Science, 340, 6135, 941-945) during the rifting of the supercontinent Pangea, whilst the Adriatic microplate migrated northward through the Tethys Ocean. Sedimentation on the ADCP continued and covered the igneous rocks with a thick succession of Mesozoic limestone. We determined that the major and trace element signature of the gabbros indicate a non-primitive parental magma in an active continental marginal setting with significant contribution from a recycled continental crust.

Considering the wide age data ranging from 276-200 Ma, question arises whether these occurrences of igneous rocks in the Adriatic Sea are connected to CAMP due to their past vicinity and could they be a remnant of the initial stages of disintegration of the supercontinent Pangea. If so, these rare localities within the Adriatic Sea could be the easternmost occurrences of CAMP-like rocks and possibly an important source of information about the initial processes that accompanied the disintegration of Pangea. Geochemical data from previously published work and the new geochemical data were compared to Moroccan gabbros related to CAMP (Bensalah et al., 2011, Comunicações Geológicas, 98, 15-27) indicating a plausible connection. Mineral chemistry of orthopyroxene, clinopyroxene, magnetite, ilmenite, amphibole, plagioclase and prehnite together with microstructural relations observed on BSE images reveal a complex set of syn- to post-kinematic reactions inside igneous body and preliminary constrain its temperature evolution and emplacement depth in accordance with scarce field observations.

Abstract ID: 33194

Final Number: VGP34C-0421

Title: ^{187}Re- ^{187}Os Nuclear Geochronometry of Diamond Sulphide Inclusions: Constraining the Chemical Evolution of the SCLM

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Abstract Body: Nuclear geochronometry [1-2] is a new research field constrained by other scientific fields like cosmology, cosmochemistry and nuclear theory. It connects geochronology with nuclear astrophysics. Based upon terrestrial signatures from at least two rapid (r) neutron-capture processes [3], so-called nucleogeochronometric TPI ages are calculated by means of two-point-isochrones (TPI). Because of identified Re/Os nuclear production ratios ≈ 1 and ultra-subchondritic initial $^{187}Os/^{188}Os$ ratios, it is argued that Earth's inner core (IC) contains isotopic signatures of a 13.78 Ga old component, as it can be found within the komatiitic basalt [5085 BasKom] (Onverwacht Group, South Africa) [4]. The other signatures are assigned to the Earth's outer core (OC), due to at least one gravitational collapse of the old component ≈ 3.48 Ga [2]. $^{187}Os/^{188}Os_i$ ratios of sulphide inclusions from eclogitic diamonds usually plot above an r-process chronometer evolution line in an $^{187}Os/^{188}Os$ evolution diagram, the eclogite field [5] showing a pronounced bulge contemporaneous with the Great Oxidation Event ≈ 2.22 Ga – 2.46 Ga. This coincides with an

$^{187}Re/^{188}Os$ fractionation event ≈ 2.3 ± 0.3 Ga, constrained by TPI ages for the Ellendale (Australia) peridotitic diamond sulphide inclusions EL50 and EL23 reported in the literature [6]. Contrary to eclogitic sulphide inclusions, $^{187}Os/^{188}Os$ ratios of most peridotitic sulphide inclusions [6] plot below the r-process chronometer evolution line, pointing to significant Re losses of the r-process reservoir. From the emerging pattern it may be concluded that $^{187}Os/^{188}Os_i$ ratios of eclogitic diamond sulphide inclusions between 3 Ga and 1 Ga are due to episodic mixing, mingling and fractionation of IC/OC isotopic signatures and redistribution of Re during the evolution of the SCLM. This could explain the difficulty to obtain reliable conventional model or isochrone ages for these inclusions, a problem which may be solved by means of nuclear geochronometry.

[1] Roller (2014), *GSA Abstr. with Programs*, **46**, 323. [2] Roller (2014), *Abstract S51B-4444*, Fall Meeting, AGU 2014. [3] Burbidge *et al.* (1957) *Revs. Mod. Phys.* **29**, 547 – 650. [4] Birck *et al.* (1994), *EPSL* **124**, 139 – 148. [5] Shirey et al. (2011), *Science* 333, 434 – 436. [6] Smit et al. (2010) *GCA* **74**, 3292 - 3306.

Abstract ID: 35651

Final Number: VGP34C-0422

Title: Salty kimberlites, magmatic or contaminated? Insights from sulfur isotopes on the source of alkalies in kimberlite magmas

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Abstract Body: Kimberlites are volatile-rich rocks of alkaline composition containing abundant olivine crystals. Rare but widespread, they carry diamonds and mantle xenoliths from great depths to the surface, thus providing information on the composition of the mantle underneath cratons. However, the strong hydrous alteration of most kimberlites, as reflected by the common serpentinization of olivine, raises questions over the pristine composition of kimberlite magmas. Indeed, common characteristics of kimberlites such as low Na and high water content may relate to post-magmatic alteration involving external meteoritic or hydrothermal waters. The Udachnaya East kimberlite pipe of the Siberian craton preserves a diversity of kimberlite types ranging from a hydrous and serpentinized breccia, to a unique occurence of serpentine-free kimberlite with unusually salty (Na_2O and Cl both up to 6 wt.%) and dry compositions (<1 wt.% H_2O) [1]. These kimberlites were emplaced through a portion of crust saturated with brines, and could thus have acquired their ususual Na, K, Cl and S-rich chemistry by contamination [2]. Alternatively, a magmatic origin for the salts is supported by the similar compositions of alkali carbonate and chloride minerals throughout the salty kimberlites, from minerals in the groundmass, melt inclusions in olivine, to chloride-carbonate "nodules" [1]. In the groundmass of the Udachnaya kimberlites, sulfates and sulfides are both present and were characterized by electron microprobe. In this contribution we will present the sulfur isotope compositions ($d^{34}S$) of sulfides and sulfates present in 3 types of kimberlites that coexist at the Udachnaya locality, including dry salty kimberlites containing fresh olivine (n=5), wet non-salty kimberlites containing fresh olivine (n=4), and brecciated kimberlite containing serpentinized olivine (n=1). We will compare these results to the canonic S-isotopic composition of the mantle [3], the surrounding hydrothermal deposits (n=4) and siberian cambrian carbonaceous sediments (e.g. Chukuck suite). In light of our S-isotope measurements, we will discuss the magmatic or contaminated origin of the kimberlites from the Udachnaya pipe.

[1] Kamenetsky et al. (2014), *Earth-Sci. Rev.*; [2] Kopylova et al. (2013), *Earth-Sci. Rev.*; [3] Labidi et al. (2014), *Nature*.

Abstract ID: 34918

Final Number: VGP34C-0423

Title: Diamond Resorption Morphology and Applications: a Review

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Published Material: This review referes to some published or submitted experimental data. However, the content and findings of this presentation have not been published or submitted.

Abstract Body: Diamond resorption morphology reflects the conditions of diamond reaction with the host kimberlite magma and with metasomatic agents in the mantle. During the last decade experimental studies combined with application of new analytical method of atomic force microscopy (AFM) provided new quantitative data and notably extended our understanding of this process. I will discuss types of morphological transformations of diamond, what do we know from experiments and see on natural stones, and what can we learn about the conditions in natural diamond-hosting environments from diamond morphology. The study uses experimental data simulating three stages in diamond history: 5 – 7 GPa runs examine conditions during the mantle residence, 1- 3 GPa runs examine conditions during kimberlite emplacement, and runs at 0.1 MPa examine diamond resorption in near surface conditions after the emplacement. Diamond resorption causes transformation of crystal morphology and development of etch feature on the crystal surface. The type of morphological changes depends on the composition of the reacting media, whereas the degree of rounding depends on the pressure and gives an estimate of the depth of the fluid exsolution in different kimberlite magmas. The surface features include negative trigons, as well as positive trigons, tetragonal and circular pits, terraces, and cavities with surface graphitization. AFM based classification of the trigons reflects their evolution, the reaction conditions, and gives an estimate of H2O:CO2 ratio and the temperature of the reacting fluid. Positive trigons are a feature of near-surface resorption and occur only in limited number of diamond populations, and the circular pits can serve as indicators of low-pressure aqueous fluid. Morphology of natural diamonds is used to assess the importance of their reaction with carbonatitic melts, silicate aqueous melt / fluid, and CHO fluid (with variable H2O:CO2 ratio) on diamond road from the mantle to the surface.

Abstract ID: 35289

Final Number: VGP34C-0424

Title: Micro-morphology and Resorption of Diamonds from Snap Lake and Ekati Mine Kimberlites (Canada) as an Indicator of the Fluid and Emplacement History

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Abstract Body: Natural diamonds develop resorption features due to partial dissolution in kimberlites and mantle metasomatism. Experimental data shows that diamond resorption features strongly depend on the presence and composition of kimberlitic fluid. Atomic force microscopy (AFM) can be used to quantitatively examine individual features on diamond to put robust constraints on their resorption conditions. Thus, diamond morphology can be a proxy of magmatic and mantle fluids and the emplacement conditions of kimberlite magma. This study examines dissolution features on diamonds from kimberlite localities with presumably different fluid and emplacement histories - Snap Lake kimberlite dyke and pipes with volcaniclastic and coherent kimberlite facies from Ekati Mine. The results are compared to the dissolution features produced in controlled experiments. Optical microscopy and SEM study of resorption on 251 micro-diamonds from Snap Lake and several hundred of micro-diamonds from six Ekati kimberlites, allowed dividing them into morphological groups. Selected crystals studied with AFM provided quantitative data on the geometry of diamond micro-features. The results were compared to the AFM data for diamonds after resorption in experiments at 0.1 MPa in H_2 – CO_2 gas mixture and at 1 – 3 GPa in CHO fluid with H_2O:CO_2 = 1, 0.5, 0.35, 0.1, 0. Snap Lake diamonds show widespread development of positive trigonal pits in addition to the common negative trigons, indicating severe etching at the near-surface conditions and evolved composition of the reacting fluid during the early (deep) and late (shallow) resorption. Ekati diamonds show only negative trigons implying deeper resorption. The AFM data show significant variation in H_2O:CO_2 ratio between the kimberlites. Application of the new AFM-based method to examine conditions during kimberlite emplacement using diamond resorption helps to better constraint of the nature of kimberlitic fluids and evaluating diamond preservation.

Abstract ID: 34741

Final Number: VGP34C-0425

Title: An *in situ* Technique for U-Th-Pb-He Chronometry with Applications to Diamond Exploration

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Published Material: Submitted for publication in Geochimica et Cosmochimica Acta in December 2014. Under review.

Abstract Body: Zircon U-Pb and (U-Th-Sm)/He 'double dating' can distinguish deep mantle source lithologies from upper crustal source lithologies and can be used in geochemical exploration for diamonds (Evans et al., 2013). However, improved data production efficiency was required before it could be considered a practicable tool for industry. We present a new laser-based technique for rapid, quantitative and automated *in situ* microanalysis of U, Th, Sm, Pb and He for applications in geochronology, thermochronometry and geochemistry. This novel capability permits a detailed interrogation of the time-temperature history of rocks containing apatite, zircon and other accessory phases by providing both (U-Th-Sm)/He and U-Pb ages (+trace element analysis) on single crystals. *In situ*laser microanalysis offers several advantages over conventional bulk crystal methods in terms of safety, cost, productivity and spatial resolution.

We developed and integrated a suite of analytical instruments including a 193 nm ArF excimer laser system (RESOlution M-50A-LR), a quadrupole ICP-MS (Agilent 7700s), a quadrupole helium mass spectrometry system (ALPHAchron) and swappable flow-through and ultra-high vacuum analytical chambers. The analytical protocols for zircon require the following steps: mounting/polishing in PFA Teflon using methods similar to those adopted for fission track etching (e.g., Zaun and Wagner, 1985); laser He extraction and analysis using a 2 s ablation at 5 Hz and 2-3 J/cm^{2}fluence; He pit volume measurement using confocal laser scanning microscopy or atomic force microscopy, and U-Th-Sm-Pb (plus optional trace element) analysis using traditional laser ablation methods. A freeware application has been developed for determining (U-Th-Sm)/He ages from the raw analytical data and Iolite software was used for U-Pb age and trace element determination.

*In situ*double dating has successfully replicated conventional U-Pb and (U-Th)/He age variations in xenocrystic zircon from the diamondiferous Ellendale lamproite pipe, Western Australia and increased zircon analytical throughput by a factor of 50 over conventional methods.

References:

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Evans, N.J., et al., 2013. Mineralium Deposita, 48, 413-421.

Abstract ID: 33413

Final Number: VGP41A-01

Title: Compositional and Thermal Characterization of Basinal Fluids in the Athabasca Basin: Implications for Unconformity-related Uranium Deposits

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Published Material: Chu, H., Chi, G., Scott, R. 2014. Thermal Profiles Inferred from Fluid Inclusions and Illite Geothermometry - Implications for Fluid Flow Patterns in the Athabasca Basin. Saskatchewan Geological Survey Open House 2014 (Dec 1 – 3, 2014, Saskatoon). The results are being prepared for a scientific journal but not yet have been under review now.

Abstract Body: The Athabasca basin hosts the largest high-grade unconformity-related uranium deposits in the world. It is generally agreed that the mineralizing fluids were basinal brines of evaporitic origin, which became enriched in U and Ca through fluid-rock interactions. However, it remains controversial whether these metals were extracted from the basin or the basement, and what driving forces were responsible for fluid flow. In order to address these problems, fluid inclusions entrapped in quartz overgrowths as well as authigenic illite from four drill cores in the central part of the Athabasca basin (DV10-001, Rumpel Lake, WC-79-1 and BL-08-01), away from any known mineralization, were examined in this study.

Liquid-vapor inclusions have $T_{m\text{-}ice}$ from -17.0^o to -50.0^{o}C, with salinities from 20.2 to 31.0 wt.%; Halite-bearing inclusions have $T_{m\text{-}halite}$ from141^o to 218 ^{o}C, with salinities from 29.3 to 32.9 wt.%. Low $T_{m\text{-}ice}$ values suggest the potential existence of Ca^{2+} and this was confirmed by cryogenic Raman spectroscopy with clear Ca-hydrates peaks and calculated NaCl/ (NaCl+$CaCl_2$) molar ratios from 0.2 to 0.8. Homogenization temperatures for all the inclusions range from 50^o to 250^{o}C. Temperatures estimated from illite geothermometry were mostly from 200 ^{o} to 250 ^{o}C and documented the maximum burial temperatures. No systematic changes in temperature were observed vertically within individual cores or laterally from core to core.

These results suggest that basinal fluids in the Athabasca basin are characterized by high salinities and elevated Ca, which are similar to those found in the uranium deposits. The presence of Ca-rich brines in area away from the basement, which is common in many sedimentary basins, suggest that at least some Ca in the ore fluids may have been derived from the sediments within the basin.The absence of horizontal and vertical thermal gradients may be best explained by basin-scale dynamic thermal convection.

Abstract ID: 33417

Final Number: VGP41A-02

Title: The Effects of Basement Faults on Fluid Convection in the Athabasca Basin and Significance for Localization of Uranium Mineralization

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Abstract Body: A common feature of the unconformity-type uranium deposits in the Athabasca Basin is their close spatial association with reactivated basement faults intersecting the unconformity surface. It has been proposed that the fluid flow related to uranium mineralization in this basin was driven by thermal convection; however, little is known regarding how basement faults influence fluid convection and how this may affect the localization of mineralization. These questions are addressed through simulations of thermal convection with various configurations of basement faults using the FLAC3D software. Our numerical modelling indicates that the location, spacing and networks of basement faults influence the size and location of thermally-driven fluid convection. In a model with a single, isolated fault, the fault coincides with an upwelling plume. When the fault is moved from the centre laterally, the upwelling plume shifts accordingly. In the case of two faults, the faults may coincide with upwelling flow or alternatively be centrally located below convection cells, depending on fault spacing. In the latter case, the size of the convection cells tends to get larger and fluid may flow into and out of individual fault zones. In contrast, for connected faults, either in a pop-up or imbricated pattern, fluid may flow into one fault zone and out of the other, correlating closely with real-world attributes of unconformity-type deposits (i.e., ‘ingress’ versus ‘egress’ deposits). Collectively, this exploration of the relationship between thermal convection and faults (position, spacing and network) will shed light on why some faults are more favourable for fluid flow than others, which will in turn help to evaluate whether a given structure has the potential to host mineralization.

Abstract ID: 35207

Final Number: VGP41A-03

Title: Principal Component Analysis and Mineralogical Studies of Sandstones Overlying the Phoenix U Deposits and REE-rich Maw Zone, Athabasca Basin, Saskatchewan

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Published Material: Saskatchewan Geological Open House 2014, Dec, 2014

Abstract Body: The Denison Mines’ Phoenix deposits, with indicated resources of 70.2 M lbs U_3O_8, occur at the unconformity and along steeply dipping fault in the basement, at ~ 400 m depth. The Maw Zone, REE-rich breccia with surface exposure of 300 x 200 m, consists of highly silicified, hematitized, dravitic tourmaline-rich rocks with high REE (<8.1 wt% as total REE oxides). The Maw Zone is ~ 4 km SW from the south end of Phoenix uranium deposits, but rocks in the Maw Zone do not show significantly high U (< 7.8 ppm in most rocks). Elemental plots suggest that major alteration minerals in sandstones above the Phoenix and in Maw Zone are illite, sudoite, tourmaline and kaolin. The ratios of Mg/Fe above the Phoenix deposits are generally higher than those in the Maw Zone. At the Phoenix site, the ratios of Mg/Fe are higher in deeper sandstones closer to the deposits.

Principal Component Analysis (PCA) of sandstones overlying the Phoenix deposits shows that U is associated with Heavy REEs (HREE)+Y, Light REEs (LREE) and Pb, and inversely correlated with Ti, Zr, Al, and Th. The Maw Zone displays different element groupings: U is strongly correlated with V, Cr, Fe, Ni, Cu, Cd, Na, Li and Ba, but very weakly correlated with HREEs+Y, and inversely with LREEs and P. Relative enrichment of HREEs, Y, and P in the sedimentary units, MFb, MFc and MFd, suggesting that xenotime as the predominant host of the HREEs. The association of LREEs+Sr+Th+P suggests the occurrence of monazite and/or APS minerals. A mineralogical study confirmed xenotime and APS minerals as the major host of HREEs and LREEs, respectively. Xenotime rims zircon grains and forms fine dissemination with magesiofoitite. These REE minerals precipitated from hydrothermal fluids during the brecciation of hematitized sandstones. The positive association between U and Fe in the PCA plot in the Maw Zone suggests that U was transported by oxidized fluids. The absence of U mineralization in the Maw Zone is explained by low U in the oxidizing fluids. Alternatively, the oxidizing fluids did not encounter reduced fluids to precipitate U.

Abstract ID: 36771

Final Number: VGP41A-04

Title: Organic Carbon-rich Sulfide-rich Metasediments from the Fraser Lakes Zone B Uranium-thorium-rare earth element (U-Th-REE) Deposit, northern Saskatchewan (Canada): Trace-metal Concentration Data, Paleoredox Environment, and Implications for the Metal Source of U/C-type Uranium Deposits

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Abstract Body: The U-Th-REE mineralization at Fraser Lakes Zone B is hosted by ca. 1800 Ma granitic pegmatite/leucogranite sheets intruding the tectonic decollement between basal Paleoproterozoic Wollaston Group pelitic (+/-graphitic) gneisses and underlying Archean granitoid orthogneisses. These pelitic gneisses are inferred to be metamorphosed black shales deposited in a back-arc continental margin marine environment. The "Rossing-type" Zone B deposit and its host rocks are located ~20-25 km southeast of the Athabasca Basin (eastern Wollaston Domain, northern Saskatchewan), and provide evidence for being both

potential economic ore and a source rock for unconformity-type (U/C-type) uranium deposits. Although U/C-type uranium deposits have been studied extensively, questions still remain, including the origin of their transition metals (e.g. Cr, Co, Cu, Mo, Ni, V, and Zn). Using trace-metal geochemical data from the metamorphosed sulfide-rich black shales at Fraser Lakes, we present new insights into Paleoproterozoic shale formation and their metal potential for U/C-type deposits.

The graphite-sulfide-bearing pelitic gneisses are highly variable in composition, with C and S ranging from 0.5 to 7.5 and 0.2 to 16.0 wt%, respectively, with varied metal concentrations. However, the highest Ni (2600 ppm), Cu (1500 ppm), Mo (1740 ppm), Zn (943 ppm), and Co (137 ppm) are hosted in the most S-rich rocks; whereas the highest Cr (259 ppm) and V (815 ppm) occur in the most Fe-rich rocks. Uranium (up to 100 ppm) and Th (up to 557 ppm) are enriched relative to the North American Shale Composite (NASC) with values of 2.66 ppm U and 12.30 ppm Th. The abundances of Co, Cr, La, Mo, Ni, Th, U, V, and Zn are comparable to, but much higher than, those of post-Archean shale.

After assessing the degree of element mobility, we conclude the wide range of chemical variation in the fresh graphitic pelitic gneisses reflects original sedimentary facies variations of metal content and constrains original paleoredox conditions. This study documents that pre-Athabasca metal enrichments in the basal Wollaston Group represent the most likely metal source for U/C-type deposits.

Abstract ID: 36619

Final Number: VGP41A-05

Title: Petrographic and Raman spectroscopic study of graphite alteration in the Phoenix uranium deposit, southeastern Athabasca Basin, northern Saskatchewan

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Abstract Body: The Phoenix unconformity-type uranium (U) deposit, located in the southeastern Athabasca Basin, is associated with a NE-trending, moderately SE-dipping reverse fault crosscutting the unconformity between the Athabasca basin and the Archean – Paleoproterozoic basement. Graphite is well developed in metapelite and locally in pegmatitic rocks in the basement, and is spatially associated with U mineralization; however, as in most other unconformity-related U deposits, its role in mineralization is still unclear. It is uncertain whether graphite acted as a direct reductant to precipitate uraninite, or as the precursor of hydrocarbons that caused uraninite precipitation. It is also unclear whether fluid – graphite interactions left a signature in the graphite that may be used as a mineralization indicator. In this study, a series of graphitic metapelite samples were collected from the alteration zones hosting mineralization near the unconformity down to the unaltered basement. Petrographic study of the graphite was undertaken and followed by Raman spectroscopic analysis. Preliminary petrographic observations indicate that graphite flakes near the mineralization zone are relatively discontinuous and locally have a corroded crystal shape. The Raman spectra of all samples show a prominent G band (~1580 cm^{-1}) in the first-order region. However, graphite in samples closer to the mineralization has more obvious D1 and D2 bands (~1350cm^{-1} and 1620 cm^{-1}), attributed to defects in the graphite. The spectra in the second-order region are similar among the samples, but the samples closer to the U mineralization have stronger S2 bands than those farther away from it. These observations indicate that there is a gradual loss of the structural ordering of graphite toward the U mineralization zone, which may be related to increasing reactivity between fluids and graphite.

Abstract ID: 34149

Final Number: VGP41A-06

Title: Characterization of Fluids Associated with Uranium Mineralization in the Beaverlodge Uranium District, Northern Saskatchewan: Field, Petrographic, Fluid Inclusion and C-O Isotope Studies

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Published Material: This presentation was reported in Saskatchewan geological survey open house at 2nd. Dec. 2014 in Saskatoon. Findingd are not under review and accepted.

Abstract Body: The Beaverlodge uranium district north of Lake Athabasca in northern Saskatchewan is known for vein-type uranium mineralization in the pre-Athabasca basin basement. Most of the uranium deposits are distributed along major structures, and hosted by granitic rocks of various ages (and albitite derived from them) and by the ca. 2.33 Murmac Bay group amphibolite, both of which are unconformably overlain locally by deformed but unmetamorphosed redbeds of the ca. 1.82 Martin group. The uranium mineralization is mainly developed in breccias and carbonate±quartz veins. Three types of fluid inclusions were found in the veins, liquid-dominated biphase, vapour-dominated biphase, and vapour-only monophase, suggesting boiling or phase separation. The liquid-dominated fluid inclusions have homogenization temperatures from 57^o to 329 ^{o}C (mainly 150^o – 200 ^{o}C) and salinities from 0.2 to 31.4 wt% NaCl equivalent (clustered in two ranges, 0.2 – 7.0 and 20.0 – 31.4). Mass spectrometric analysis of bulk fluid inclusions shows that the volatiles are dominated by H_2O, with minor amounts of CO_2, CH_4 and H_2; the data plot in an area overlapping those of basinal brines and meteoric water. The $\delta^{18}O$ and $\delta^{13}C$ values of carbonates in the veins range from -22.5 to -6.6‰ (PDB) and from -10.1 to +1.1‰ (PDB), respectively. $\delta^{13}C$ values from the Martin group (-2.7 to +1.1‰) are among the highest, whereas those from some deposits are relatively low (-10.1 to -8.2‰). The calculated $\delta^{18}O$ values of the parent fluids mainly range from 0 to +5.0‰ (SMOW), lower than magmatic and metamorphic fluids. These data suggest that the uranium mineralization was formed in a relatively shallow environment, where brines from the Martin Lake basin and meteoric water may have been channelled along high permeability zones produced by structural deformation and albitization, and mixed with fluids from the basement containing Fe^{2+} and methane. Fluid mixing, fluid-rock interaction, and boiling may have caused precipitation of uraninite.

Abstract ID: 34432

Final Number: VGP41A-07

Title: The Potential of Rare Earth Elements for Revealing the Conditions of Uranium Deposit Formation and their Subsequent use for Exploration and Uranium Forensic Issues

Presenter/First Author: Julien Mercadier, CNRS, Vandoeuvre-lès-Nancy,

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Abstract Body: Uranium deposits are known to be formed in a wide range of geological settings including deep metamorphic/magmatic to surficial

conditions and range in age from Archean to recent time. These temporal and spatial variations have given rise to an extreme diversity of U deposits. However, understanding their genesis and thereafter exploring for uranium deposits have remained challenging. In particular, very limited link between trace elements or isotopic composition of uranium oxide and the conditions for their accumulation to economic grades have been clearly established.

Natural uranium oxides (UO2) bear variable quantities of minor and traces elements (< 1 ppm and up to several pourcents) which have been more and more used to better understand the primary conditions of ore formation but also alteration processes which have potentially posteriorly affected them. Consequently, the quantification of trace elements in UO2 and the measurement of their isotopic ratio(s) have been a major research direction to better understand geologically the uranium deposits but also to fight against nuclear proliferation via forensic programs.

The present contribution aims to synthetize the recent developments in the use of Rare Earth Elements (REE) to uranium geological and forensic applications. The first part will emphasize on the last analytical developments to measure this group of elements by in-situ techniques (SIMS and LA-ICP-MS). The second part will present case studies of application of these techniques on several deposits to demonstrate that the REE contents of uranium oxides are very specific to each deposit type, regardless of the age or variations in local geological settings, and that the REE abundances reflect directly the mineralising processes specific to each deposit type. An evaluation of the first order parameters (T, REE sources and fluid composition) controlling the REE behaviour in each mineralized system is proposed. The last part will present some results and potential developments on the use of REE for forensic issues with comparison between some ore mineralization and the subsequent Yellow Cake to consider the limits of this technique in helping tracking the U production.

Abstract ID: 33760

Final Number: VGP42A-01

Title: Evidence of Middle Jurassic Magmatism within the Seychelles Microcontinent: A Possible Connection to the Initial Rifting between East Gondwana and Africa

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Abstract Body: From the Middle Mesozoic to Early Cenozoic numerous continental and microcontinental blocks of Gondwana have dispersed. East Gondwana, comprising Madagascar-Seychelles-India-East Antarctica, started to rift from eastern Africa during the Middle Jurassic with sea-floor spreading occurring by Late Jurassic to Early Cretaceous (i.e. ~140 Ma). Antarctica separated from Madagascar-Seychelles-India by ~120 Ma followed by the rifting of Madagascar by ~90 Ma and finally the rifting of Seychelles from India by ~64 Ma. New *in situ* LA-ICP-MS zircon U/Pb dating of a rhyolite from Silhouette Island, Seychelles, yielded a range of zircon $^{206}Pb/^{238}U$ ages from Neoproterozoic to Late Cretaceous. Thirteen zircons produced a mean age of 64.9 ± 1.6 Ma which is within error of reported ages of the neighbouring silicic plutonic rocks of Silhouette (i.e. 64.0 ± 0.6 Ma and 64.6 ± 0.8 Ma) and North Island (i.e. 63.8 ± 0.8 Ma and 63.6 ± 0.9 Ma) and is interpreted as the eruption age of the rock. A single Neoproterozoic inherited zircon yielded an age of 807 ± 20 which is contemporaneous with the bedrock geology and indicates that the Late Cretaceous magmas passed through the ancient basement of the Seychelles microcontinent. In addition to the Late Cretaceous and Neoproterozoic zircons, a set of 21 zircons produced a mean $^{206}Pb/^{238}U$ age of 163.8 ± 1.8 Ma and a smaller subset produced a mean age of 147.7 ± 4.5 Ma. The new Middle Jurassic ages reported from inherited zircons are contemporaneous with the opening of the Somali proto-ocean basin and the initial rifting between eastern Africa and East Gondwana whereas the Late Jurassic age may be correlative with mafic magmatism in Madagascar just prior to sea-floor spreading between East Gondwana and Africa. The Middle Jurassic zircons are the first evidence of rift magmatism in the Seychelles microcontinent attributed to the in the initial stages of plate separation between Africa and East Gondwana.

Abstract ID: 34836

Final Number: VGP42A-02

Title: Avalonia, The Missing Link between the Timarides (Baltica) and Arctic Alaska/Chukotka: Igneous T_{DM} Age and Detrital Zircon Constraints

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Co-authors: Fraser Keppie, , , ; Jaroslav Dostal, , ,

Published Material: J. D. Keppie and D. F. Keppie, "Ediacaran-Middle Paleozoic oceanic voyage of Avalonia from Baltica via Gondwana to Laurentia: paleomagnetic, faunal and geological constraints," Geoscience Canada, vol. 41, no. 1, pp. 5–18, 2014.

Abstract Body: T_{DM} ages of igneous rocks represent a bulk average composition of the source and can be used as a tracer of the pre-Ediacaran basement of these regions, which is generally not exposed. The origin of Avalonia has been a puzzle for many years, with most opting for a peri-Gondwanan provenance of northwest Africa and Amazonia being favoured. Paleomagnetic data has been complicated by periods of true polar wander, whereas faunal provinciality has generally concentrated on affinities with major cratons. Reassessment of Ediacaran and Cambrian paleomagnetic data suggest that Greater Avalonia (Suwannee terrane in Florida, NW Avalonia, Ganderia, Iberia, Armorica, and Bohemia) is an island chain that lay at ca. 20°S, which is similar to the Bolshezemel block in the NE Timanides of northeastern Baltica. Greater Avalonia is characterized by a Neoproterozoic island arc (700-600/550 Ma) overlain by post-arc sedimentary and alkalic-tholeiitic, within plate, volcanic rocks. Ediacaran, Cambrian and Early Ordovician fauna in Avalonia are mainly endemic, which suggests that Greater Avalonia was an island chain. The higher degree of Ediacaran deformation in the Bolshezemel block is interpreted to be the result of continent-continent collision between Baltica and Arctida, and suggests that Greater Avalonia lay outside this collisional zone. Greater Avalonia and the Bolshezemal block have 840–1760 Ma T_{DM} model ages. Supporting evidence is provided by 1–2 Ga and 760–590 Ma detrital zircon grains in Greater Avalonia from Baltica and the Bolshezemel block. These ages are similar to those from the Arctic Alaska – Chukotka terrane, which evolved from an arc (700-600 Ma) to rifting (ca. 565-540 Ma). This suggests that, rather than originating on the southeastern side of Baltica as suggested by several authors, Greater Avalonia formed the missing link between the Bolshezemel block and Arctic Alaska – Chukotka terrane forming part of the same active plate margin.

Abstract ID: 35897

Final Number: VGP42A-03

Title: Archean to Phanerozoic Subcontinental Lithospheric Mantle and Relationships to the Mantle Components.

Presenter/First Author: John D. Greenough, University of British Columbia, Okanagan, Kelowna , BC, BC

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Abstract Body: Isotopes and trace element ratios identify three end-member types of mantle in oceanic island basalts (OIB). Trace-element-enriched (EM1 and EM2) and high U/Pb (HIMU) component types may reflect subducted sediment (enriched sources) or basaltic ocean floor (HIMU), in OIB sources, but recent work suggests they represent subcontinental lithospheric mantle (SLM) in the convecting oceanic mantle. Using > 3700 GEOROC whole-rock analyses from 10 continental flood basalt (CFB) provinces we test these hypotheses. Based on 65 similarly-incompatible element ratios (SIER; representative of mantle source ratios), exploratory statistics suggests that all CFB are distinct from OIB, and CFB associated with Archean lithosphere are distinct from those passing though Proterozoic/Phanerozoic lithosphere. Using transition metal (Fe, Mn, Sc, V, Cr, Ni, Co, Cu, Zn) concentrations in primitive (Mg#~0.72) CFBs extruded through Archean lithosphere resemble EM1 and EM2 OIB and those from Proterozoic/Phanerozoic lithosphere have HIMU-like compositions. Although the exploratory transition metal results appear different from those based on SIER, plots of individual SIER (e.g. Nb/Pb versus Ba/Nb) reveal a symmetry in compositions; values for CFB from Proterozoic lithosphere versus Archean lithosphere show relative values the same as the relative values for HIMU versus EM1. However, the CFB values are all more extreme. OIB component signatures may represent SLM signatures diluted by mixing with depleted mantle. It has been proposed that mafic intrusions bearing ore deposits (Ni, Pt, Cr etc.) may form from melting Archean EM1-like SLM. Our results do not suggest that Archean EM1-like sources have higher transition metal concentrations indicating that other factors (e.g. high % melting) make these magmas prone to forming deposits.

Abstract ID: 35262

Final Number: VGP42A-04

Title: Terrestrial Mantle Domains and Changing Tectonic Settings Through Time

Presenter/First Author: Kent C Condie, New Mexico Institute of Mining and Technology, Albuquerque, NM

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Abstract Body: Incompatible element distributions in modern oceanic basalts reflect three major mantle domains: enriched (EM), depleted (DM), and hydrated mantle (HM). As long as Earth was in a plate tectonic regime, these three domains can be traced into the geologic past and can be useful in constraining, but not unambiguously identifying, tectonic settings. Although there is overlap in the basalt populations, the three-fold division of mantle sources seems to remain in tack to at least 1 Ga and probably to 2.2 Ga. Although the earliest evidence for the three mantle domains appears in Archean basalts, it is not until after 2.2 Ga that basalts with these geochemical characteristics become widespread in the geologic record. The widespread appearance of DM and EM coincides with rapid propagation of plate tectonics between 3 and 2.5 Ga as shown by Hf and Nd isotopic models for continental growth. This suggests that mantle heterogeneity was increased at this time as crustal components were recycled into the mantle by widespread subduction.

So are EM, DM and HM mantle domains diagnostic of plate tectonics? No, because primitive crust (> 4 Ga) and residue of this crust with EM and DM signatures, respectively, may have been recycled into the deep mantle and rarely contribute to the sources of younger basalts. Although the HM geochemical signature (Nb-Ta-Ti depletion) is widely accepted in identifying ancient convergent margins, it also may have been produced in a stagnant lid regime by vertical recycling of lithosphere (for instance in heat-pipes), and hence even the HM geochemical signature is not sacred to plate tectonics. Because Earth is an evolving planet with changing tectonic regimes, extreme caution must be exercised in using incompatible element distributions to identify ancient tectonic settings and especially Archean and Hadean tectonic settings. It is only the convergence of evidence from greenstones that includes rock associations, stratigraphic variations, sediment types and provenances, information from syntectonic granitoids, and geochemistry of all rock types that we can make progress in understanding ancient tectonic settings.

Abstract ID: 36476

Final Number: VGP42A-05

Title: Geochemical and isotopic signatures as proxies for source mantle composition in a post-collisional tectonic setting: an example from SW England

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Published Material: GAC-MAC 2014, FrederictonGSA Annual Meeting 2014, Vancouver

Abstract Body: The geology of SW England has long been interpreted to reflect Variscan collisional processes associated with the closure of the Rheic Ocean and the formation of Pangea. The Cornish peninsula is composed largely of Early Devonian to Late Carboniferous volcano-sedimentary successions that were deposited in pre- and syn-collisional basins and were subsequently metamorphosed and deformed during the Variscan orogeny. Voluminous Late Carboniferous granitic magmatism (Cornubian Batholith) is broadly coeval with the emplacement of ca. 290-300 Ma lamprophyric dykes and flows. Although these lamprophyres are well mapped and documented, the processes responsible for their genesis and their relationship with regional Variscan tectonic events are less understood.

Syn-rift basalts have intra-continental alkalic affinities, and have REE profiles consistent with derivation from the spinel-garnet lherzolite boundary. εNd values for the basalts range from +0.37 to +5.2 and T_{DM} ages from 595 Ma to 705 Ma. The lamprophyres are extremely enriched in LREE and LILE, and depleted in HREE suggesting a deep, garnet lherzolite source that was previously metasomatised. They display εNd values ranging from -1.4 to +1.4, I_{Sr} values of 0.706, and T_{DM} ages… from 671 Ma to 1031 Ma, suggesting that metasomatism occurred in the Neoproterozoic.

Lamprophyres and coeval granite batholiths of similar chemistry to those in Cornwall occur in other regions of the Variscan orogen, including Iberia and Bohemia. By constraining the evolution of the mantle beneath SW England and the processes associated with the formation of these post-collisional rocks, we may be able to gain a more complete understanding of mantle processes during the waning stages of supercontinent formation.

Abstract ID: 33857

Final Number: VGP42A-06

Title: Neoproterozoic and Paleozoic igneous events in the Ossa Morena Zone (SW Iberia): A record of Gondwana amalgamation, Gondwana breakup and Pangea amalgamation

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Abstract Body: Neoproterozoic and Paleozoic igneous rocks are widespread in the Ossa Morena Zone (OMZ) of the Iberian Massif (W European Variscan orogen). They cluster in three main periods corresponding to rather distinct geodynamic scenarios. Plutonic, subvolcanic and volcanic rocks exist in all three periods of igneous activity.

- Neoproterozoic-Lowermost Cambrian (ca. 630-535 Ma) rocks are dominated by subduction-related calcalkaline types and record an initial period of continental (West-African affinity) arc growth followed by post-collisional types during arc accretion to Gondwana mainland (Cadomian orogeny).
- A second emplacement of igneous rocks in the OMZ took place soon after, from ca. 530-470 Ma (Cambrian-Lower Ordovician), and was related to a rift event. An *early* (ca. 530-525 Ma*) event,* dominated by crust-derived peraluminous rocks associated to mid/upper crust anatexis, was succeeded by a *main (*bimodal) *event*, in which tholeiitic, alkaline (peralkaline) mantle-derived rocks coexisted with minor crust-derived calcalkaline rocks. This rifting is thought to have culminated in opening the Rheic Ocean, leaving the OMZ at the outer margin of N-Gondwana.
- Finally, a third period of igneous activity affected the OMZ from mid-Devonian through early Permian times. Three main peaks of activity with distinct characteristics may be distinguished: 1) subduction-related rocks at the southern OMZ characterizing growth of a modest arc during N-directed subduction of the remaining Rheic Ocean (ca. 385-345 Ma); 2) a bimodal set of tholeiitic and calcalkaline rocks coeval to extension and HT-LP metamorphism in the southern OMZ (ca. 340-335 Ma); 3) a set of post-collisional felsic rocks (ca. 320-290 Ma). These sets of igneous rocks characterize various events and environments during Rheic Ocean closure (set 1), an event of thermal doming and extension, probably related to development of a slab window beneath the OMZ (set 2), and finally the collision of this part of Gondwana with Laurussia and its subsequent orogenic collapse (set 3). All together these three events characterize the Variscan orogeny in this part of the belt that culminated the amalgamation of Pangea.

Abstract ID: 36362

Final Number: VGP42A-07

Title: Ancient mantle lithosphere beneath the Khanka massif in Russian Far East: Re-Os evidence for the Siberia affinity

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Published Material: Under review (major revisin) by the journal Terra Nova

Abstract Body: The Os isotope compositions of sulfides in mantle xenoliths from the Sviyaginsky volcano, Russian Far East, reveal the presence of Proterozoic subcontinental lithospheric mantle (SCLM) beneath the Khanka massif. In this study, we document the Os-isotopic compositions of mantle sulfides in peridotite xenoliths to (1) date thermal/tectonic events recorded in the SCLM beneath the region; (2) confirm the existence of a Precambrian microcontinent within the eastern CAOB complex and (3) clarify that origin of the Khanka massif might have tectonic affinity to the Siberia Craton. Both their T_{MA} and T_{RD} model ages reveal similar peaks at 1.1 and 0.8 Ga suggesting later thermotectonic events in the SCLM, whereas T_{RD} model ages give the oldest age of 2.8 ± 0.5 (2s) Ga,. The events recognized in the SCLM are consistent with those recorded in crust of the Khanka massif. The sulfide Os-isotope data show that the SCLM beneath the the Khanka massif had formed at least by the Mesoproterozoic, and was subsequently metasomatised by juvenile crustal-growth events related to the evolution of the Altaids.

Abstract ID: 36783

Final Number: VGP42A-08

Title: Discovering a Polar Transform Zone in the Geological Record of the Mesozoic Mediterranean

Presenter/First Author: Duncan F Keppie, Fraser Keppie, Halifax, NS

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Published Material: Keppie, D. Fraser (almost accepted in Geology) How the closure of Paleo-Tethys and Tethys oceans controlled the early breakup of Pangaea

Abstract Body: Tuzo Wilson noted in 1966 that transform deformation is an essential feature of plate tectonics on Earth. In theory, Wilson noted two ways transform deformation could occur in plate tectonics: (1) by linking complementary rift and subduction zones along a strike-slip fault: i.e., a transform fault, or (2) by connecting complementary rift and subduction zones across a tectonic rotation pole: i.e., a polar transform. In application, however, reported examples of polar transforms have been rare in interpretations of the terrestrial rock record when compared with the relatively ubiquity of transform faults. One can ask whether this discrepancy reflects a fundamental property of plate tectonics on Earth or whether key markers of polar transforms in the geological record have been systematically misinterpreted. Reconciliation of this question is critical to understanding how systems of complementary rift zones and subduction zones evolve through time. In this study, I consider the example of Mediterranean tectonics during the Jurassic and early Cretaceous periods. Global boundary conditions indicate that the Mediterranean region hosted a polar transform zone or a near-pole transform fault system during this time. However, classic interpretations of the regional rock record are inconsistent with this requirement. The Mesozoic Mediterranean may represent a key area where the geological record has been misinterpreted and a polar or near-polar transform zone awaits discovery.

Abstract ID: 34057

Final Number: VGP42B-01

Title: Chemical Variations in Uraninites from Various Types of Uranium Deposits

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Abstract Body: Uraninite, with an ideal formula UO_2, is the most common uranium mineral. It has been shown that natural uraninite contains such elements as Pb, Th, Zr, rare earth elements (REE), Y, Ca, Fe, and Si. Moreover, uranium in uraninite can be in U^{4+} and U^{6+} oxidation states, which makes its formula not so simple: $(U^{4+}_{1-x-y-z}U^{6+}_{x}REE^{3+}_{y}M^{2+}_{z})O_{2+x-y-z}$ (Janeczek and Ewing 1992, Finch and Murakami 1999). Conventional electron-microprobe analysis (EMPA) and laser-ablation inductively-conducted plasma mass spectrometry (LA-ICP-MS) studies show that natural uraninite is chemically heterogeneous at the micrometer scale in regard to major elements, but (1) it has not been established in what form 'impurity' elements occur in uraninite and where they reside, *i.e*. which elements substitute for U in the crystal structure of uraninite and which ones form micro-inclusions of other minerals such as zircon, thorite, thorianite, or galena, nor (2) has the variability of trace elements been well studied. Additionally, the U^{6+}/U^{4+} ratio in uranium minerals has been overlooked despite the fact that this ratio is a superb tracer of redox conditions. Combining results of electron microprobe analysis (EMPA) with element mapping, performed with the use of field emission gun scanning electron microscopy (FEG SEM) and synchrotron X-ray fluorescence microscopy (SXRF), allows to document rare micron-scale features and the distribution of trace elements in heterogeneous natural uraninites, and provides important information in which mineral phases elements reside and with which other trace elements they are associated. This in turn, aids in understanding the element mobility and constraining fluid chemistry and genesis of uraninites from various types of uranium deposits.

Abstract ID: 35962

Final Number: VGP42B-02

Title: Sulfur Isotope Fractionation in Bacterially and Chemically Controlled Roll-Front Deposits

Presenter/First Author: Gretchen Ann Hough, University of Wyoming, Laramie,

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Abstract Body: Redox mechanisms driving uranium precipitation in roll-front deposits have been debated for decades with minimal evidence confirming either bacterial or chemical models. In order to resolve the issue, naturally occurring deposits that represent each endmember need to be identified and compared. Two deposits in Wyoming have been selected as likely redox endmembers. One deposit contains abundant organic material; the other has almost none. Organic material is essential to host a sulfur reducing bacteria colony, and its presence would favor bacterial redox. However, without organic material present, the environment would be inhospitable to bacteria and chemical redox would be favored. Several other distinctions between the two deposits are also striking: associated with abundant organic material is abundant pyrite precipitation and locally uranium vanadates; in deposits lacking appreciable organic material only minor pyrite is present and the predominant uranium mineralogy is uraninite and coffinite. Distinguishing between redox mechanisms may therefore be key in understanding the wide variations in uranium mineralogy.

Sulfur isotope fractionation in ore-zone pyrite should vary with redox mechanism. Chemical redox should produce lower $\delta^{34}S$ than biogenic redox processes. Because of the constant addition of sulfate to the system, bacterial redox may produce high $\delta^{34}S$ values. In contrast, oxidation of pyrite as it is cycled across the roll-front continuously produces ^{34}S-enriched sulfate that is removed from the system, leaving ore zone pyrite with low $\delta^{34}S$. Further, fractionation in a chemical deposit would show a trend of decreasing $\delta^{34}S$ across the ore zone from unaltered to altered sandstone. Cores from the Wyoming deposits have been collected that span the ore horizon. Sulfur isotope values will be analyzed across the roll-front for each deposit using SIMS to confirm redox drivers and expected trends to positively differentiate between bacterial and chemical redox.

Abstract ID: 36590

Final Number: VGP42B-03

Title: Examining three oxygen isotope mass-dependent fractionation in Uraninite

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Abstract Body: On a plot of $\delta^{17}O$ vs. $\delta^{18}O$ values for terrestrial samples define a line with slope of ~0.52 because equilibrium isotope theory predicts that variations in $\delta^{18}O$ caused by nearly any process on Earth (physical, chemical or biological) are approximately twice as large as variations in $\delta^{17}O$. This is known as mass-dependent fractionation. The ratios of logarithms of partition function ratios for oxygen compounds thus fall in a narrow range from about 0.520 to 0.530 over a range of temperatures. Kinetic processes can be examined in the same way as equilibrium processes to determine the proportionality between $^{18}O/^{16}O$ variations and $^{17}O/^{16}O$ variations for diffusion, in which the relative rates of isotopic species are inversely proportional to the square-root of the mass of the diffusing species. For example, the mass-dependent fractionation for oxygen atoms will define a line with a slope of 0.5232 whereas for SO_2 molecules the slope is 0.5087. It is evident that the fractionation ratio depends on the molecular weight of the diffusing species. Since the fractionation ratios both for equilibrium and for kinetic processes depend on the particular molecules, it is expected that terrestrial minerals, which form by various processes and reactions will yield a slope on a graph of $\delta^{17}O$ vs. $\delta^{18}O$, which is an average of the many individual slopes for individual processes. A value of 0.520 is generally chosen for mass-dependent fractionation in terrestrial samples. Here we suggest that the slope of the line that defines mass-dependent fractionation in uraninite (UO_2) significantly deviates from a slope of 0.52 because U-O molecules are significantly heavier than Si-O or Al-O molecules. We will compare the calculated value for the slope for UO_2 (0.5019) to the measured slope defined by uraninite that was overprinted by meteoric water and a synthetic uraninite.

Abstract ID: 35769

Final Number: VGP42B-04

Title: *Evaluation of the application of Diffusive Gradients in Thin Films (DGT) technique in water, soils and sediments as a monitoring tool in uranium mining environments*

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Abstract Body: In France, uranium mining activities in 1945-2001 led to the production of 76,000 t of uranium. To date, all these sites have been rehabilitated and a site-specific survey is performed by AREVA, local and public authorities. AREVA has undertaken R&D studies to perform hydro-geochemical modelling of these storage sites. Although the radiological impact of uranium is determined by the total concentration; the aquatic chemistry, its toxicity and bioavailability are determined by chemical speciation. The technique of Diffusive Gradients in Thin Films (DGT) is an *in situ* monitoring tool for the bioavailable fraction, as it provides the time-averaged concentrations of labile metal species in solution. The technique is also applied to soils and sediments, revealing high resolution porewater profiles and remobilization rates from the solid phase. The evaluation of the technique was performed in laboratory and in field conditions. The mining sites in France with different geochemical characteristics and water treatment technologies were investigated. DGTs were deployed in stream water upstream and downstream of the mining sites; within the various stages of the water treatment, in a wetland and in lake sediments. A device displayed high resolution profiles in sediments and soils up to a 1.5 m depth. The DGT technique was compared to filtration/ultrafiltration techniques and geochemical speciation. In the laboratory, different binding phase for U (Chelex®-100, Metsorb™, Diphonix®) in the DGT devices were evaluated. The different resins were compared across a wide pH (3-9) and ionic strength (0.001-0.7 M $NaNO_3$) range. Possible interferences with Ca^{2+} (up to 12.5 mM), PO_4^{3-} (up to 0.05 mM), SO_4^{2-} (up to 2.1 mM) and HCO_3^- (up to 8.2 mM) on U-DGT uptake were investigated. The laboratory and field studies along with speciation modelling allows better understanding of the applicability of DGT as a monitoring and speciation tool in mining environments.

Abstract ID: 35307

Final Number: VGP42B-05

Title: Trapping Processes of Uranium at Low Temperature

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Published Material: These data were partly published (Mineralium Depposita, ES&T, American Mineralogist)

Abstract Body: There is a growing interest in uranium geochemistry and mineralogy at low temperature, in order to get an accurate picture of the processes that can act on the mobility of this important element. This may be relevant to the modeling of uranium migration in the environment, in the perspective of remediation strategies, as well as to increasing our knowledge on U-concentration under low-temperature conditions. We will review some recent results concerning the behavior of uranium in epithermal volcanic deposits of the Sierra Peña Blanca (Mexico) as well as in mine tailings from Gunnar (Saskatchewan) and in granitic waste rocks around a former U-mine from Massif Central (France). These examples illustrate the diversity of the trapping processes, encompassing (i) biological activity, indicated by a geochemical signature of biogenic reducing conditions favoring uranium mineralization in an epithermal deposit, (ii) metastable, nanoscale uranate crystals that enlarge the diversity of low-temperature U-phases, (iii) pH-sensitive inner-sphere surface complexes bound to ferrihydrite and associated clay minerals and (iv) precipitation of secondary U-phases, e.g. (nano-) uranyl phosphates, under subsurface conditions. Unique information on the timescale characteristic of uranium mobilization and migration/trapping is provided by environmentally relevant sites such as mine tailings and mine wastes.

Abstract ID: 34438

Final Number: VGP42B-06

Title: Isotopic and Chemical Tracing of Uranium Ores Through Processing to Nuclear Fuels

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Abstract Body: Oxygen, Sr, Pb and U isotopic and chemical compositions of uranium ore concentrates (UOC) and resulting processed materials are examined where UOC is converted to UO_3 and subsequently to UF_6. There are significant variations in the U, Sr, Pb and O isotopic compositions of UOC samples, although each source tends to a distinct isotopic composition. Digestion of the UOC in nitric acid results in a significant increase in the $^{207}Pb/^{206}Pb$ ratio from 0.1538 to 0.4015 and a slight decrease in the $^{87}Sr/^{86}Sr$ ratio from 0.71314 to 0.71274 as a result of contamination. The resulting UO_3 product has lower Pb contents and much less radiogenic $^{207}Pb/^{206}Pb$ ratios than the UOC and much higher $^{238}U/^{235}U$ ratios because of loss of ^{235}U during the boildown and oxygen isotopes are also affected because of the preferential loss of ^{16}O . The contents of most elements are diminished in the UO_3 product, although B, Pb, Cr and Co levels are similar to those in the original UOC and thus behave "conservatively". Reduction of the UO_3 to UO_2 does not appreciably affect Pb or U isotopic compositions, but does affaect the oxygen isotopes. Conversion to UF_6 results in a decrease of most element contents, but also a change in the isotopic composition of uranium whereby ^{235}U is lost.

Abstract ID: 35340

Final Number: VGP42B-07

Title: Spectroscopic Investigation of Actinides (U, Np) and Zr in Nuclear Glasses

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Abstract Body: Vitrification of high-level radioactive waste in borosilicate glasses is currently used on an industrial scale in several countries. The fundamental properties of the waste forms are their chemical and mechanical durability against the forcing conditions represented by chemical alteration or internal/external irradiation. The waste immobilized in glass is composed of over 30 different nuclear fission and activation products, as well as minor actinides. The oxidation state and local coordination of long-lived radionuclides are important parameters during glass elaboration but also help model the actinide behavior during glass alteration or irradiation. We will present a short overview of the local structure around actinides and Zr in the inactive analog of the French nuclear glass SON68. X-Ray absorption spectroscopy has been used to probe the local environment around uranium and neptunium in these glasses. The surrounding of Zr, a waste directly inherited from zircalloy claddings, has been also investigated for comparison in these glasses. Together with UV-visible spectroscopy used to get information on the different oxidation states of U in glasses, our spectroscopic data show that these elements occur in glasses in a peculiar surrounding, with significant differences with those encountered in crystalline compounds, as well as in the alteration gels. Element speciation is then an important parameter to follow the evolution of structural properties during long–term aging of nuclear glasses.

Abstract ID: 36533

Final Number: VGP43A-01

Title: Insights into ore-forming process through integration of evaporate mound chemistry with traditional microthermometry: Methodology and applications

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Published Material: Part of this has been presented at the PACROFI 2014 meeting, but this presentation presents new research data and it is presented to a very different audience.

Abstract Body: The composition of ore fluids is an important and integral part of understanding ore-forming processes. Traditionally the use of Tm(ice), inconjunction with the liquidus surface in the H_2O-NaCl binary, is used to estimate to bulk salinity (i.e., wt. % equiv. NaCl) of fluid inclusions (FI). That ore fluids are more complex mixtures of solutes is appreciated, but calculating bulk compositions using the apparent temperatures for eutectics (e.g., H_2O-$CaCl_2$)and hydrate melting (e.g., hydrohalite) can be challenging, hence this is not widely applied in FI studies where material and FI are challenging. Although newer analytical methods, such as LA ICP-MS, can fully characterize solute chemistry to low detection limits, the method is time intensive, costly and such facilities not widely accessbile. An alteranaitve method, which is relatively faster, less costly, and more accessible, is the evaporate mound technique. The method overheats FI such that the homogenizaed fluids released upon FI rupture generate evaporate salt mounds on the surface of the waffer hosting the FI. These mounds are subsequently imaged and analyzed with a coupled SEM-EDS system using conventional protocol. Integration of mound chemistry with salinity data (i.e., using salinity as an internal standard) also permits the quantification of solute abundance. The analysis of groups of mounds (i.e., mound fields), similar to the FI assemblage approach used for microthermometry, provides a means to document and characterize discrete compositional fluid events (e.g., Na-K vs. Na-Ca). In addition, where metastability is an issue, fluid composition can still be determnined.Widespread application of this method to a variety of ore systems (e.g., pegmatites, carbonatites, porphyry Cu-Mo, vein Sn-W, orogenic gold, epithermal, MVT) will illustrate how such elemental data, both cation (Na, K, Ca, Fe, Mg, Ba, Sr) and anion (Cl, F, S), that is not readily available with other methods provides a more robust interpretation of the fluid evolution in ore systems.

Abstract ID: 33591

Final Number: VGP43A-02

Title: Application of sulfide and silicate melt inclusion chemistry to determine the Ni-Cu-PGE potential of the Caribou Lake Gabbro, Northwest Territories

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Abstract Body: The Caribou Lake Gabbro (CLG) comprises the western intrusive suite of the Early Proterozoic Blachford Lake Intrusive Complex, which intrudes sedimentary rocks of the Archean Yellowknife supergroup, the Morose granite, and the Defeat granodiorite. The CLG is located approximately 90km southeast of Yellowknife, NT. Magmatic Ni-Cu-PGE mineralization consists of disseminated to massive pyrrhotite+chalcopyrite+pentlandite+pyrite with minor sulfarsenide and telluride phases. Metal grades within the CLG are subeconomic, with the highest Ni and Cu values at 1.7 and 1.4 wt%, respectively.

Trails of small (≤30µm) secondary sulfide melt inclusions (SI) occur in plagioclase and apatite and in olivine and ilmenite as larger (≤500µm) secondary inclusions. The SI are polyphase, consisting of pyrrhotite (90-99 volume %), chalcopyrite (≤8%), and Co–pentlandite (≤5%). In apatite, SI co-exists with silicate melt, indicating that a sulfide and silicate liquid coexisted. LA-ICP-MS analyses of SI hosted in plagioclase and apatite indicate that they have low PGE and Au contents and base metal concentrations of 1840 ppm Co (n=50), 1900 ppm Ni (n=36) and, 7260 ppm Cu (n=49). Sulfur isotope analysis of the pyrrhotite phase in SI trapped in olivine and ilmenite ($\delta^{34}S=0.2\pm0.5$‰; n=15), have compositions consistent with a mantle S source, but we cannot rule out S contamination from the Yellowknife supergroup ($\delta^{34}S=0.2\pm0.4$‰; n=10). Primary silicate melt inclusions (SMI) are preserved within cumulus apatite in a medium-grained gabbro. Minimum trapping temperatures of 1120-1230°C were determined by measuring the final melting temperature of solid phases in the inclusions. LA-ICP-MS analyses of SMI indicate that they trapped a Fe-tholeiite melt with Ni and Cu generally below detection limits (<60; ≤40 ppm). SMI have base metal tenor well below MORB, which could indicate that the silicate melt was initially metal depleted, or a sulfide liquid had already separated at the time of melt entrapment.

Abstract ID: 34830

Final Number: VGP43A-03

Title: Tin-Tungsten Mineralizing Processes in Tungsten Vein Deposits: Panasqueira, Portugal

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Published Material: Goldschmidt 2014

Abstract Body: Tungsten has a high heat resistance, density and hardness (tungsten carbides), which makes it widely applied in industry (e.g. steel). Tungsten deposits are typically magmatic-hydrothermal systems. Despite the economic significance of tungsten, there are no modern quantitative analytical studies of the fluids responsible for the formation of its highest-grade deposit type (tungsten vein deposits). Panasqueira (Portugal) is a

tungsten vein deposit, one of the leading tungsten producers in Europe and one of the best geologically characterized tungsten vein deposits.

In this study, compositions of the mineralizing fluids at Panasqueira have been determined through combination of detailed petrography, microthermometric measurements and LA-ICPMS analyses, and geochemical modeling has been used to determine the processes that lead to tungsten mineralization. We characterized the fluids related to the various mineralizing stages in the system: the oxide stage (tin and tungsten mineralization), the sulfide stage (chalcopyrite and sphalerite mineralization) and the carbonate stage. Thus, our results provide information on the properties of fluids related with specific paragenetic stages. Furthermore we used those fluid compositions in combination with host rock mineralogy and chemistry to evaluate which are the controlling factors in the mineralizing process.

This study provides the first quantitative analytical data on fluid composition for tungsten vein deposits and evaluates the controlling mineralization processes helping to determine the mechanisms of formation of the Panasqueira tin-tungsten deposit and providing additional geochemical constraints on the local distribution of mineralization.

Abstract ID: 34600

Final Number: VGP43A-04

Title: Re-evaluation of the Raman densimeter for determining CO_2 density based on splitting of the Fermi diad

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Abstract Body: During the last 20 years several groups have presented equations relating splitting of the Raman Fermi diad as a function of the density of CO_2. The results have been used to estimate the concentration of CO_2 in fluids trapped in different geological settings, including the CO_2 content of melt inclusions. In some settings in which the relative amount of CO_2 in the fluids is small, such as epithermal precious metal deposits, oceanic vents and some melt inclusions, the density of CO_2 in the vapor bubble is low. Moreover, these densities are lower than those used to develop most of the various published densimeters, resulting in relatively large errors in estimating CO_2 densities and concentrations of CO_2in the fluid calculated from these densities.

To address this problem, we measured the splitting of the Raman Fermi diad at 22±1°C and pressures ranging from 9 psi (0.062 MPa) to the pressure on the CO_2 liquid-vapor curve (~880 psi, or 6.07 MPa) using a High Pressure Optic Cell (HPOC). These data were used to develop a dependent equation relating the splitting of the Fermi diad to CO_2 density and pressure. The resulting equation was compared to other published equations for the Raman densimeter. At 22°C, our revised densimeter predicts CO_2densities that are in general agreement with results from Fall et al. (2011), Song et al. (2009) and Rosso and Bodnar (1995). Densities predicted by the equation of Kawakami et al. (2003) are significantly higher than those predicted by our revised equation, whereas those from Wang et al. (2011) are slightly lower.

Fall et al. (2011), GCA, 75, 951-964; Kawakami et al. (2003), Appl. Spectrosc., 57, 1333-1339; Ross and Bodnar (1995), GCA, 59, 3961-3975; Song et al. (2009), Acta Geol Sin, 83, 932-938; Wang et al. (2011), GCA, 75, 4080-4093.

Abstract ID: 34768

Final Number: VGP43A-05

Title: Deciphering Compositions of Saline, Multicomponent Fluid Inclusions from Combined Microthermometric and Microanalytical Data: Approaches for Interpreting Fluids Containing Multiple Major Salts

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Abstract Body: Fluid inclusions (FI) commonly provide the best available information on the compositions of geologic fluids. FI compositions are estimated based on the dissolution temperatures of one or more solid phases during heating from subsolidus temperatures. Such microthermometric data are commonly interpreted using model chemical systems such as H_2O-NaCl, H_2O-NaCl-KCl or H_2O-NaCl-$CaCl_2$. The advent of microanalytical techniques applied to individual FI, particularly laser ablation ICP-MS analysis, has permitted unprecedented new insights into the diversity of cation budgets in geologic fluids, demonstrating that Fe, Mn and other cation chloride concentrations sometimes approach or exceed those of Na, K or Ca chlorides. Nevertheless, challenges remain for rigorous coupling of microthermometric measurements with microanalytical data to quantitatively constrain concentrations of numerous salts simultaneously for inclusions with complex compositions. On the one hand, concentrations of some major cations such as Ca and Fe exhibit relatively large uncertainties by chemical microanalysis, and may be more precisely estimated by microthermometric measurements. On the other hand, the solid-liquid phase relations of complex fluids containing high concentrations of several salts (e.g., NaCl+KCl+$CaCl_2$+$FeCl_2$) remain poorly known, hindering the interpretation of thermometric data. Effects of additional anions are virtually unexplored.

Here, we describe approaches to overcome some of the challenges in deciphering complex, multicomponent fluid compositions. Microthermometric measurements including the dissolution temperatures of both the last and second-to-last solid phases are interpreted simultaneously with cation ratios derived from microanalytical data. Thermodynamic formalisms for electrolyte solutions are adapted to link microthermometric and microanalytical observations according to the activity of water, ion activity relations and solubility products of relevant solid phases. These methods allow us to uniquely and rigorously pinpoint the concentrations of multiple salts simultaneously, providing a basis for quantifying minor and trace element (e.g., ore metal) concentrations. We describe applications of these methods to interpreting FI from hydrothermal mineral deposits.

Abstract ID: 35355

Final Number: VGP43A-06

Title: Estimating Ore-fluid Conditions in the Cortaderas Ag-Zn-Sn-In Deposit, NW Argentina: Integrated Fluid Inclusion Thermometry, Sulfosalt Assemblages, and Tetrahedrite Chemistry

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Co-authors: Daniel Kontak, Mineral Exploration Research Centre, Sudbury, ON, Canada; Andy McDonald, Mineral Exploration Research Centre, Sudbury, ON, Canada

Abstract Body: The nature of ore-forming processes is preserved in the mineralogy and textures of ore samples. In this study of the Cortaderas Ag-Zn-Sn-In-rich deposit, which is part of the larger Miocene epithermal system at the Pirquitas Mine of NW Argentina, such information is integrated with fluid inclusion (FI) thermometry to provide a record of the PTX conditions of ore formation. Colloform sphalerite in high-grade ore samples contains two populations of aqueous FIs: Type I are equant-shaped and L-rich with consistent V:L ratios of 0.1-0.2, whereas Type II are irregular-shaped and V-rich. Fluid inclusion assemblages (FIAs) of Type I inclusions, which cross-cut primary growth zones and are thus secondary or pseudosecondary in origin, have salinities of 0.18-4.80 wt. % eq. NaCl and T_h values of 207°-227°C. These data are consistent with dilution of a magmatic fluid with heated meteoric water. The FIAs of Type II inclusions may be primary and record the instantaneous boiling of the ore-fluid during transient fluctuations from lithostatic to hydrostatic conditions (i.e., flashing). The Ag-mineralization occurs as a variety of sulfosalts with Sb, As, Pb, Cu, Sn, Zn, Fe, and Bi that are intergrown with the colloform sphalerite. Sulfosalts with cuspate interfaces are interpreted to have unmixed from a heterogeneous phase, as minerals equilibrated with cooler thermal conditions after initial deposition. For example, kesterite exsolution lamellae are common in the stannite-like mineral pirquitasite; the two phases were deposited as a solid solution and exsolution resulted from structural differences at lower temperature. Re-heating of these sulfosalts, using a calibrated thermometric stage, until they have homogenized provides minimum temperature estimates for their initial deposition, which is inferred to be at least 300°C. These conditions are consistent with temperatures estimated from Ag-rich tetrahedrite used as a mineral thermometer to constrain formation to ~250°-300°C.

Abstract ID: 35903

Final Number: VGP43A-07

Title: Dependence of the Calculated CO_2 Content of Silicate Melt Inclusions on the Choice of Raman Densimeter Used to Estimate CO_2 Density

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Abstract Body: When a melt inclusion (MI) cools, the melt inside contracts, depressurizes and forms a bubble. Sometimes, CO_2 contained in the vapor bubble was originally dissolved in the melt, and exsolved from the melt as the bubble formed. In recent years, Raman spectroscopy has been used to estimate the density of CO_2 contained in vapor bubbles in silicate melt inclusions and mass balance calculations indicate that 50 to 90 percent of the CO_2 in the MI is often contained in the bubble. If the CO_2 contained in vapor bubbles is not taken into account when estimating the total CO_2 content of the melt inclusion, the pre-eruptive CO_2 concentration may be under-estimated by 1000s of ppm CO_2, corresponding to under-estimates in trapping pressures of hundreds to thousands of bars. The implications affect not only our understanding of the volcanic “plumbing” system, but also our understanding of the Earth’s global carbon cycle as related to volcanic degassing. Several different Raman densimeters have been proposed in recent years to estimate the CO_2 density based on splitting of the Fermi diad in the Raman spectrum. These various densimeters often predict significantly different densities for the same measured Fermi diad splitting, resulting in different calculated CO_2 concentrations in the reconstructed melt. To emphasize this point, we have compared the results of Raman analyses of MI vapor bubbles collected at two different labs on MI from several tectonic settings (Central America, Alaska, Hawaii, and Iceland). Raman spectral data were used to determine CO_2 densities of the vapor bubbles using the various densimeters, and these densities were then used to estimate pre-eruptive CO_2 contents of the melts and pressures of trapping. For the same measured Fermi diad splitting, the CO_2 densities can vary by as much as a factor of 2 depending on which densimeter is used. As a result, the choice of densimeter can result in differences in estimated trapping pressures ranging from 0-2 kbar.

Abstract ID: 36030

Final Number: VGP43A-08

Title: Sulfide Melt Inclusions in Magmatic-Hydrothermal Ore-Forming Systems

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Published Material: The results presented here constitute a review of studies conducted by my group over the past 7 years. Specific aspects of the presentation have been delivered at other conferences when those studies were in their preliminary stages. This presentation, intended as a keynote contribution, concludes those studies and importantly, links the findings from each study together into a general classification and interpretive scheme for sulfide melts as they occur in the inclusion record of magmatic-hydrothermal ore systems.

Abstract Body: Inclusions containing crystallized sulfide liquids are infrequently reported in magmatic-hydrothermal ore deposit settings. Some key conclusions are presented from recent studies of intrusion-related Au-Sn-W-Mo, porphyry Cu-Au-Pd, and mafic-ultramafic Ni-Cu-PGE deposits. Textural and compositional criteria for discriminating sulfide melt inclusions from sulfide mineral inclusions, and best approaches for microanalysis (LA-ICPMS, SEM, EMP, microthermometry) are also discussed.

Three classifications of sulfide melt inclusions are presented: (i) inclusions trapped in phenocrysts synchronous to magma mixing that resulted in a transient stage of sulfide saturation; (ii) inclusions trapped in intercumulus minerals synchronous to magma differentiation as sulfide liquids were migrating through crystal mush; and (iii) inclusions trapped in xenocryst phases that, on the basis of thermobarometry, were entrained during magma emplacement from mid-lower crustal cumulates or staging chambers. Type (ii) and (iii) sulfide melt populations are commonly observed coentrapped with immiscible silicate melt in non-cotectic proportions and show widely variable compositions ranging from relatively undifferentiated Fe-Ni-Cu-S to highly fractionated Cu-rich liquids enriched in Au and PGE, whereas type (i) inclusions typically show homogeneous compositions throughout large magma volumes. In several examples, sulfide melt inclusions preserve metal ratios consistent with bulk ore ratios. This is surprising as it demonstrates negligible fractionation of ore metals during any processes subsequent to sulfide melt resorption/destabilization.

Recognition of sulfide melts included in mineral phases and subsequent study of the timing of their entrapment and their compositional features can be shown to have great potential to address key first order problems in ore genesis. They aid in constraining the original metal budget and differentiation systematics of sulfide liquids, in particular in systems that have undergone extensive post-crystallization deformation and alteration, compromising bulk rock geochemical analysis of ore metals. They may also be used to predict metal tenor and metal ratios in undiscovered deposits if dispersed through magmatic host rocks in robust mineral host phases.

Abstract ID: 33797

Final Number: VGP44A-0427

Title: Gas chromatographic investigation of the light hydrocarbon compositions of fluids associated with various geological environments and regimes: A first comparison

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Abstract Body: The light, saturated hydrocarbon signatures (C1-C4 saturated species) of volatile fluids hosted in a variety of distinct geological environments (trapped in fluid inclusions and/or as occluded gas) have been analyzed. Fluid composition data was acquired directly by in-line gas chromatographic (GC) analysis, and from a number of published literature sources. The geological environments investigated include a variety of sedimentary, metamorphic and igneous terranes, both ore-bearing and non-ore-bearing. Although studies using bulk GC analysis to investigate the hydrocarbon signatures of trapped fluids from certain environments have been performed previously, a study comparing the hydrocarbon signatures from a diversity of geological environments has yet to be compiled and may offer insight into the influence of non-aqueous fluid constituents in these systems. Hydrocarbon-bearing fluids of known biogenic/thermogenic origin (i.e., from oil and gas fields and gas hydrates) are markedly richer in C3-C4 hydrocarbons and possess elevated C4/C3 and C3/C2 hydrocarbon ratios relative to hydrocarbon-bearing fluids of suspected abiogenic origin. Fluids from various igneous environments (e.g., mantle, porphyry-epithermal, alkali-agpaitic, mafic-ultramafic-associated Ni-Cu-PGE sulfide deposits, and rare metal pegmatitic environments) share very similar hydrocarbon signatures and consistently display a log linear decrease in hydrocarbon abundance with increasing carbon number (Shultz-Flory distribution). This suggests that light hydrocarbons hosted in these igneous terranes may share similar origins and genetic controls, likely abiogenic in nature, due to their magmatic, organic-poor setting of entrapment. These processes may include, but are not limited to, catalytic Fischer-Tropsch synthesis and reductive coupling reactions, which generate higher order hydrocarbon via step-wise homologation reactions. Understanding the non-aqueous fluid chemistry associated with various geological environments will help elucidate the complex physicochemical controls responsible for hydrocarbon generation under geologically relevant conditions (T, P, fO_2, pH, etc.) and the potential for ore metal remobilization by these non-aqueous compounds.

Abstract ID: 34536

Final Number: VGP44A-0428

Title: Deep Degassing of CO_2-rich Basanite Magma at El Hierro, Canary Islands: Insights from Melt and Fluid Inclusions

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Abstract Body: Basaltic magmas erupted at mid-ocean ridges, subduction zones and intraplate hotspots transfer matter from the mantle to the surface of the Earth. In recent years, increasing research efforts have focused on constraining CO_2 degassing from the mantle, which is a critical, yet poorly resolved input into the carbon cycle. Such estimates of carbon flux rely partly on knowledge of the CO_2 content of primary magmas, the best archive of which is provided by melt inclusions. Here we report on detailed analyses of quenched basanite lava balloon samples from the recent submarine eruption at El Hierro (Canaries), an intraplate ocean island. Laser ablation ICP-MS and ion microprobe analyses of matrix glasses and melt inclusions reveal high concentrations of incompatible trace elements and dissolved volatiles in this magma, with 100 ppm Nb and up to 1.2 wt% CO_2, 3.0 wt% H_2O and 0.5 wt% S. Recent models (e.g., Shishkina et al., 2014) accounting for the effect of alkalinity on CO_2 solubility predict saturation pressures in excess of 200 MPa for most melt inclusions extending up to 1300 MPa. As most melt inclusions contain bubbles, which may have sequestered part of the originally dissolved CO_2 (e.g., Hartley et al., 2014), measured CO_2 concentrations, and hence calculated pressures, are considered minima. In addition, microthermometry on CO_2-rich fluid inclusions from the same basanite samples yield fluid densities between 590 and 860 kg/m^3, corresponding to equilibration pressures of 280-580 MPa at 1150 **°**C. The El Hierro basanite thus had a particularly high volatile-carrying capacity, began exsolving a CO_2-rich fluid at a depth of at least 20 km (but likely as deep as 40 km) in the upper mantle and may have released 4-6 Tg CO_2. These results have further implications for understanding the eruptive behavior at El Hierro and similar volcanoes elsewhere and the volumetrically small but potentially significant contribution of alkaline magmas to volatile fluxes from the mantle.

Hartley et al. (2014), Reconstructing the deep CO_2 degassing behaviour of large basaltic fissure eruptions, *Earth and Planetary Science Letters*, *393*, 120-131.

Shishkina et al. (2014), Compositional and pressure effects on the solubility of H_2O and CO_2 in mafic melts, *Chemical Geology*, *388*, 112-129.

Abstract ID: 36629

Final Number: VGP44A-0429

Title: Secondary Gold Precipitation Involving Immiscible Methane-Nitrogen-Carbon Dioxide and Aqueous Fluids, Lupin Gold Deposit, Nunavut

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Co-authors: Steven Crowell, Saint Mary's University, Halifax, NS, Canada; Daniel Kontak, Mineral Exploration Research Centre, Sudbury, ON, Canada

Published Material: The results of this study were recently presented as a poster contribution at the NWT Geoscience Forum in November of 2014

Abstract Body: Fluid inclusions in gold-rich, late-stage “ladder” quartz veins in sulfidic BIF of the Lupin Deposit, Nunavut, preserve CH_4-N_2-CO_2-H_2O fluids responsible for secondary gold transport and deposition.

Three inclusion types are identified in the mineralized vein quartz: (i) gas-rich inclusions containing single phase (at room T) CH_4-N_2-CO_2 homogenizing to liquid between -113º and -19^{o}C (but exhibiting similar T_h in inclusion assemblages), consistent with a wide inter-assemblage range in CH_4:N_2:CO_2 ratios and/or variable $P_{trapping}$; (ii) liquid-rich inclusions containing a vapour bubble and a saline aqueous fluid that exhibit clathrate melting (Tm_{clath}) between -0.3º and 1.8^{o}C (2s range; mean of 0.6 ^{o}C; n=64), corresponding to salinities of 15.9-13.6 wt.% eq. NaCl, and homogenize ($Th_{L-V>L}$) between 254º and 308^{o}C; and (iii) mixed CH_4-N_2-CO_2-H_2O inclusions that decrepitate on heating above ~300^{o}C rather than homogenize and which occur in groups with type (i) and (ii) inclusions. Petrographic and microthermometric characteristics of type (iii) trails are consistent with entrapment of only locally immiscible (coeval) CH_4-N_2-CO_2-rich and aqueous-rich fluid “end-members”. These end-member fluids were derived from separate sources and later interacted at the point of type iii inclusion entrapment. Entrapment conditions for end-member

fluids are estimated between 1-3 kbar and 350-550°C, with localized immiscibility occurring at <2 kbar and 400°C, well below conditions of peak metamorphism and late pluton emplacement associated with primary gold deposition in the Lupin BIF.

The results of this study introduce possible mechanisms for localized gold enrichment at Lupin and may explain the lack of gold enrichment associated with quartz veining in shallow parts of the deposit where immiscible fluids entering structures from depth had already precipitated gold. Importantly, cumulative gold deposition at Lupin was protracted and continued to much lower conditions than previously thought, requiring structural ponding of residual Au-bearing metamorphic fluids prior to secondary gold deposition.

Abstract ID: 35005

Final Number: VGP44A-0430

Title: Sulphur Isotope Fractionation During Degassing of Canary Island Magmas

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Abstract Body: Isotopic fractionation of sulphur in volcanic systems is controlled by the speciation of sulphur in the silicate melt, degassing of sulphur-rich volatiles, and saturation with sulphur-rich melts or minerals. These factors are in turn tightly linked to the oxidation state of the melt, as well as temperature and pressure. The complexity of such multi parameter systems results in a wide array of sulphur behaviours in magmas, the understanding of which is still limited. In this work, we present triple S-isotope ion microprobe measurements of crystal-hosted melt and sulphide inclusions as well as matrix glasses from the 2011-2012 submarine eruption at El Hierro, Canary Islands, which involved volatile-rich basanite magma. Comparison of $\delta^{34}S$ measurements on matrix glasses (457 ± 80 ppm S) and S-rich melt inclusions (up to 5000 ppm S) indicate that degassing results in the preferential loss of heavy sulphur isotopes (up to 10 permil relative). This can only occur in a narrow oxygen fugacity range. Isotopic and compositional differences among olivine-, pyroxene- and magnetite-hosted inclusions appear to describe the evolution of the oxidation state of the magmatic system, with consideration to the order of appearance of phenocryst phases. The isotopic characteristics of El Hierro products are consistent with bulk rock multiple S isotope compositions from nearly all other historical eruptions of the Canary Archipelago, measured in both sulphide and sulphate fractions by gas-source isotope-ratio mass spectrometry. Variations between and within islands are highlighted in view of their other compositional particularities and lateral configuration. This analysis further provides insight into the degassing history of the notable 1730-36 basaltic fissure eruption of Lanzarote. Our work implies that volatile-rich magmas in the Canary Islands are subject to open-system degassing processes that effectively fractionate sulphur isotopes.

Abstract ID: 35351

Final Number: VGP44A-0431

Title: Using Petrographic Observations and Evaporate Mound Chemistry of Fluid Inclusions to Assess Metal Fertility and Fluid:Rock Interaction in a Large Peraluminous Batholith: A Case Study of the Mineralized (Sn-W-U-Cu-Zn-Ag) South Mountain Batholith, Nova Scotia, Canada .

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Abstract Body: The Devonian South Mountain Batholith of Nova Scotia is a large (~7300 km^2), contiguous granitoid intrusion that consists of 13 coalesced plutons of granodiorite to leucomonzogranitic composition which host a variety of mineralized zones (e.g., Sn-Zn-Cu-Ag, Mo, Mn-Fe-P, U, Cu-Ag). Given the hydrothermal nature of this mineralization, it is expected that the mineralizing fluids might manifest itself both petrographically, as alteration assemblages, and by the chemistry of secondary fluid inclusions in the granites on a scale equal to or larger than the mineralized centres. This study assesses the potential of using such information as a vector for mineral exploration. The research protocol includes: (1) detailed petrography of hundreds of archived samples that focuses on: (i) abundance and type of perthite, (ii) degree of chloritization of biotite, (iii) abundance of sericite, (iv) degree of saussuritization of plagioclase, (v) abundance of white mica, and (vi) abundance of secondary fluid inclusions in quartz; and (2) the chemistry of quartz-hosted fluid inclusions, based on SEM/EDS mound analysis from a sample suite representative of the entire batholith. The petrographic data and fluid chemistry was used to map the extent of alteration across the batholith, which indicates that fluid:rock interaction was batholith-wide and that its interaction generated Na-K-Ca-Cl-F rich fluids in addition to primary enrichment of Fe, Zn and Cu. Specifically, two distinct fluid types are present, one Na-K-Cl and the other Na-Cl-F; this enrichment of F in one of the fluid populations is the first recognition of this phenomenon in granitic bodies on such a large scale. The occurrence of this F-rich fluid across the SMB, including its most primitive rocks (i.e., granodiorites), suggests its generation is part of the natural evolution of the system and consistent with the presence of topaz in both the most evolved phases and as an integral part mineralized greisens.

Abstract ID: 33644

Final Number: VGP44B-0432

Title: Arc Magmatic Evolution: The Central American Example

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Abstract Body: Geochemical and isotopic data compiled for >1000 samples of lavas and intrusives from the ~1000 km long segment of the Central American Volcanic Arc system (oceanic CAVAS: Panama, Costa Rica, and Nicaragua) allow us to demonstrate how it evolved chemically and isotopically over its 75 Ma lifespan. We used available age constraints to subdivide the data into six magmatic phases: 75-39 Ma (Phase I or PI); 35-16 Ma (PII); 16-6 Ma (PIII); 6 -3 Ma (PIV); 5.9-0.01 Ma (PVa arc alkaline and PVb adakitic); and 2.6-0 Ma (PVI, Quaternary to modern magmatism, mostly much younger than 1 Ma). To correct for magmatic fractionation, selected element abundances were linearly regressed to 55 wt. % SiO_2. The most striking observation is the collective chemotemporal evolution from early low-K tholeiitic to late high-K calc-alkaline and shoshonitic magmatism. Similarly, all $LILE_{55}$, $LREE_{55}$ ΣREE_{55} and $LREE_{55}$ fractionations systematically increase from either PI to PIII or to PIV. Compositions are collectively similar to bulk continental crust (BCC) by PIII in Panama and Costa Rica, however compositional trends between Costa Rica and

Nicaragua diverge after 6 Ma, with the former and latter evolving to more enriched and more depleted sources, respectively. Galapagos Plume contributions initially accelerated enrichment by providing an anomalously thick arc substrate which aided ultimately in the shrinking of melt columns after PI. We conclude that progressive crustal thickening and concomitant melt column shortening resulted in decreasing degrees of partial melting over time which allowed for collective enrichment of the CAVAS. This evolution was interrupted only when subduction ended, allowing adakite and alkali basalt formation or upper plate extension and melt column lengthening and production of more depleted magmas. Seamount-subduction interaction after 10 Ma as posited in recent models, accentuated enrichment processes which peaked during PIV and PV in Costa Rica and Panama.

Abstract ID: 36397

Final Number: VGP44B-0433

Title: Mesozoic and Cenozoic reconstruction of magmatism and basin development within the South China Sea and their implications to regional tectonic evolution

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Abstract Body: The South China Sea (SCS) is one of the most active exploration regions for oil and gas over the past decades. This marginal sea is situated within three major tectonic plates of the Eurasian, Indo-Australian and Philippine plates that exhibited various types of plate boundaries and complex tectonic evolutions. In order to decipher the evolution and their tectonic framework, correlation between the temporal and geographical distribution of Mesozoic and Cenozoic magmatisms, and the development histories of major basins within and surrounding the SCS were conducted. Firstly, three main collision processes formed the present shape of SE Asia are determined: The age of collision between South China and Indochina, is documented by age of the Song Ma ophiolite (230.5 Ma). Timing of collision of Sibumasu and East Malaysia (Indochina) (210 Ma) is based on the new U-Pb dating results of three main granite provinces of Malaysia. And when India collided with Asia, it only occurred the soft collision around 55 Ma and changed to the hard collision in 34 Ma because the age of metamorphic rocks in the region (<35Ma). And then, four major tectonic episodes, affecting the evolution of SCS, can be recognized. (1) The southeastward younging trend of A type granite and high-K calc-alkaline magmatic rock in SE Asia during Paleogen indicated the initiation of continent extension by eastward retreating of subduction of the Pacific plate to Asia. (2) The SCS began its spreading in the N-S direction (C11-7) around 30-25 Ma possibly response to southward slab pull during the subduction of proto-South China Sea oceanic crust, which is also marked by the break up unconformity within surrounding basins. (3) The left lateral shearing activity of the Red River Shear zone (23~16 Ma) due to collision of India into Eurasia trigger a southward ridge jump event (C6b~5c). (4) The SCS seized spreading around 15.5 Ma as the Pacific sea plate continued subducted westward.

Abstract ID: 36664

Final Number: VGP44B-0434

Title: Trace element variation in plagioclase phenocrysts from ignimbrites from the Mogollon-Datil volcanic field, southern New Mexico, USA: Insights into the processes and timescales of magmatism

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Published Material: The ages of the volcanic units were published in the Fall 2012 New Mexico Geological Society Field guide. Citation below:Michelfelder, G.S.; and McMillan, N.J.; 2012, Geochemistry, origin, and U-Pb zircon ages of the Sierra Cuchillo laccolith, Sierra County, New Mexico. New Mexico Geological Society Fall Field Conference Guidebook vol. 63 Geology of the Warm Springs Region, Lucas, S. G., McLemore, V. T., Lueth, V. W., Spielmann, J. A., and Krainer, K. [eds], 249-260.

Abstract Body: The Mogollon-Datil volcanic field in southern New Mexico represents the last volcanism associated with continental arc magmatism in the southwest United States. In the 13 m.y. history of the volcanic field as few as 15 calderas erupted homogeneous andesite to rhyolite ignimbrites and lava flows between 38 Ma and 25 Ma. Here we present bulk-rock major- and trace- element compositions, Sr isotopic ratios and single crystal major- and trace- element data from phenocrysts for two volcanic sequences near the Sierra Cuchillo Mountains in Sierra County.

The Dacite-Rhyolite sequence (36.5 Ma) is a crystal-rich, high-K, calc-alkaline rhyolite consisting of six tuffs and tuff-breccias. The basal member is a densely welded, tuff-breccia and the remaining members are vitric-crystal tuffs. Mineralogically, this sequence contains plagioclase>quartz>biotite>>hornblende and trace orthopyroxene. The youngest member also contains abundant sanidine.

The Latite-Andesite sequence (36.2 Ma) is a crystal-rich, high-K, calc-alkaline suite of four volcanic units. The basal member consists of a crystal-rich, trachy-andesite lava. The remaining members of the sequence contain blocks of the underlying lava and lithics from the Paleozoic sedimentary rocks. Mineralogically, the tuff-breccia's contains plagioclase>alkali feldspar>quartz> biotite>hornblende>orthopyroxene. The lava flow contains plagioclase>alkali feldspar> hornblende>biotite>>quartz.

Geochemically, the two volcanic sequences are distinct. Bulk-rock trace elements compositions for the Dacite-Rhyolite sequence exhibit large negative Eu anomalies (Eu/Eu*~0.538) and high HREE concentrations (Lu=0.91 ppm, Yb=5.84 ppm). The Latite-Andesite sequence exhibits only a small Eu anomaly (Eu/Eu*=0.998) and comparatively lower HREE concentrations (Lu=0.24-0.27 ppm, Yb=1.5-1.7 ppm) that are similar to intrusive granitites outcropping in the area.

Abstract ID: 34873

Final Number: VGP44B-0435

Title: Overview of Appinites and their relationships with other enigmatic igneous rock suites

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Published Material: About 25% at a symposium in memory of Ben Kennedy in Dublin in February 2014. The start of the talk may provide an overview that I published in Earth Science Reviews in January 2014

Abstract Body: The appinite suite of rocks offers a unique opportunity to study the effect of water on the generation, emplacement and crystallization history of mafic to felsic magma. The suite consists of a group of coeval plutonic and/or hypabyssal rocks, ranging from ultramafic to felsic in composition in which hornblende is the dominant mafic mineral, and typically occurs both as large prismatic phenocrysts and in the finer grained matrix. The suite is also characterized by abundant evidence for mixing and mingling between diverse magma types and variable degrees of contamination by host rock. Textures characteristic of appinites are consistent with rapid growth and with experimental evidence for the reduced viscosity of depolymerized melts allowing efficient migration of ions to the sites of mineral growth.

Appinite suites apparently range in age from Neo-Archean to Recent, and occur at all crustal levels, at depths of up to 40 km. Appinite suites share some similar geochemical features with shoshonites, lamprophyres, high-Mg andesites, sanukitoids and adakites and genetic relationships with voluminous granitoid bodies have been proposed. Melting may be triggered by asthenospheric upwelling caused either by slab breakoff (e.g. after terrane or continental collision) or by the generation of a slab window (e.g. where a ridge collides with a subduction zone). Some common tectonic traits include a tendency to form soon after the cessation of subduction, and the important role of deep crustal faults as conduits for magmas of various compositions to rise towards the surface. These conduits provide the setting for magmas of diverse composition to mix and mingle. Neo-Archean appinites, and their genetic relationship with abundant coeval sanukitoids, have been interpreted as evidence for the existence of some form of plate tectonics at that time.

Abstract ID: 36785

Final Number: VGP44B-0436

Title: Building Continents and Keels: Implications from the Hf Isotopic Compositions of Archean-Hadean Zircons

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Published Material: The data are a combination of new data and data from the literature (ours and others) as the basis for a model of intial continent formation. The model itself has not been presented previously.

Abstract Body: A major, unresolved problem in terrestrial geochemistry is: When did the first crust form with sufficient volume and density to nucleate a modern continent? Although model dependent, "ages" calculated for separation of crust from mantle in the Sm-Nd, U-Pb, and Lu-Hf systems consistently point to the Eoarchean-Hadean (>3.6 Ga) as the time of separation for many continental nuclei. Older nuclei may have formed, but were likely destroyed (e.g., by large impacts). Consequently, the most robust data repository for the >3.6 Ga Earth is dominated by zircons, both detrital and igneous, and their chemical and isotopic compositions. Focusing on Hf, data are typically interpreted in two ways: 1) calculation of model ages to estimate the time of formation of the original source rock and 2) plotting of initial εHf vs. age in order to outline an evolutionary path for a specific locale. Here we focus on the pattern of Hf isotopic compositions over time because it reveals more about crustal evolution and does not require assumptions about model reservoir compositions. Most data-sets describe one of two distinct evolutionary paths, both of which are diachronous. In the more common Type-PR paths the oldest Hf isotopic compositions fall near BSE (bulk silicate earth) and DM (depleted mantle) models (i.e., initial εHf values within error of 0). Subsequently, εHf values show a sequence of progressively more negative values interspersed with less negative, but not positive, values for several hundred million years. This pattern is seen in data from the Jack Hills, Wyoming Province, Slave Province, and Minnesota River Valley. In Type-SR patterns, the evolution paths suggest less recycling with continua of values over a given age-span that may be negative or positive and may or may not show significant age-concentration (e.g., Rae Province, SW Greenland). We suggest that Type-PR patterns correspond to dominantly plume-driven growth and Type-SR to subduction driven growth.

Abstract ID: 36384

Final Number: VGP44B-0437

Title: The tectonic implication of temporal-spatial distribution of magmatism in northwestern Sibumasu terrane, the western Yunnan, China

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Abstract Body: The closure of Neo-Tethys Ocean between India and Eurasia since the Cretaceous, resulted in multiple episodes of magmatism in Lhasa and Sibumasu terranes. Tengchong block, the northwestern Sibumasu, displays wedge geometry with its narrower part in the north linking to the eastern Himalaya syntaxis and its wider part in the south extending into Burma. Thus, Tengchong block might be the only part of Sibumasu that recorded the magmatic events induced by the Neo-Tethyan subduction. In this district, the S-type granitoids are dominated by biotite granites with metaluminous to peraluminous compositions (A/CNK = 0.98-1.11), high SiO_2 contents (65.2-79.2 wt.%), and subalkaline contents (K_2O + Na_2O = 5.00-8.28 wt.%). LA-ICP-MS zircon U-Pb age results indicate that the emplacement of these granitoids occurred during the early Cretaceous (~118 Ma), late Cretaceous (~78 Ma) and early Paleocene (~63 Ma) periods. The temporal-spatial distribution of granitoids in Tengchong block shows that the ages of the plutons decreased progressively from east to west since the late Cretaceous, which fits the hypothesis of rollback of the subducted Neo-Tethyan slab. Combining the structural reconstruction, the slab retreated southward beneath Sibumasu after the late Cretaceous as in southern Tibet, then was bended along with the rotation of Tengchong block due to the formation of eastern Himalaya syntaxis.

Abstract ID: 34890

Final Number: VGP44B-0438

Title: Petrogenesis and Tectonic Implications of Neoproterozoic Na-rich Adakites and High-
K Granites on the Western Margin of the Yangtze Block

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Abstract Body: The Gongcai and Qinganlin plutonic complexes in the Danba Domal Terrane, eastern Tibetan plateau, consists of the ca. 860 Ma adakitic tonalite and the 828±2 Ma high-K granite, respectively. Rocks of the Gongcai complex have variable SiO_2 (66-72 wt%), high Al_2O_3 (14.3-17.6 wt%), low alkalis (5.71-6.61 wt%), and high Sr (576-1309 ppm) and low Yb (2.2-10.4 ppm), similar to typical adakites. The Qinganlin pluton possesses higher SiO_2 (71-73 wt%) and lower Al_2O_3 (13.5-14.2 wt%), and variably higher K_2O contents (1.2-3.8 wt%) than the Gongcai complex. On the chondrite-normalized REE diagram, both plutons are enriched in LREEs, but the Gongcai complex display strongly fractionated patterns or concave patterns ($(La/Yb)_N$ =7-33; $(Gd/Yb)_N$ =1.5-4.4) with weak negative to slightly positive Eu-anomalies (δEu=0.89-1.25), while the rocks of the Gongcai complex exhibit relatively flat HREE fractionation patterns ($(La/Yb)_N$ =6-10; $(Gd/Yb)_N$ =1.3-1.6), with apparent negative Eu-anomaly (δEu=0.56-0.67). Their primitive-mantle normalized spidergrams are all characterized by negative Nb-Ta and Ti anomalies but positive Pb spikes. Both rocks of Gongcai and Qinganlin plutons have high positive zircon εHf(t) values (+3.2 to +8.5 and +5.5 to +12.2, respectively) with two-stage Hf-isotope modeal ages of 1.08 and 1.33 Ga and 0.89 to 1.07 Ga, respectively, which imply different petrogenesis and magma source. We suggest that the Gongcai adakites are indicative of partial melting of basaltic rocks modified by minor slab melt, and their relatively lower Mg# (37-53), Cr (3.9-5.4 ppm) and Ni (1.5-2.7 ppm) compared to the Cenozoic adakites indicate an distinctive source region where allows the subducting slab to be abnormally heated, melted and rapidly ascent through the thin lithospheric mantle. The parental magma of high-K Qinganlin granites is considered to be produced by low-degree partial melting of newly underplated basaltic rocks.

Therefore, the nature and petrogenesis of the closely associated Na-rich adakites and high-K granites provide effective perspective into the initial flat subduction system of the western Yangtze Block at ~860 Ma, and a later intracontinental extension occurred at ~830 Ma immediately after the assembly of the Yangtze and Cathaysia Blocks during the Neoproterozoic.

Abstract ID: 35479

Final Number: VGP44C-0439

Title: Tourmaline in the Maw Zone, the Gryphon Uranium Deposit, and Sandstones above the Phoenix Uranium Deposits, Athabasca Basin, Saskatchewan, Canada

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Abstract Body: Various species of tourmaline have been reported from the Athabasca Basin, northern Saskatchewan. We examined the occurrence and mineral chemistry of tourmaline from three areas of the Denison Mine's Wheeler River property: the Gryphon zone, the Maw zone, and the Phoenix deposits. The newly discovered Gryphon zone is high-grade basement-hosted uranium deposit and samples for tourmaline analysis are collected from a graphitic pelite 17 m above the mineralization of the discovery hole, WR-556. The Maw zone is a REE-rich breccia pipe in highly hematitized sandstones with no significant uranium (mostly less than 8 ppm). Samples were collected from sandstones of MFd, MFc, MFb, and RD. The Phoenix uranium deposits (confirmed resources of 70.2 M lb U_3O_8; Roscoe, 2014) occur primarily along the unconformity between the Athabasca sandstones and the crystalline basement rocks. Samples were collected from upper most part of RD and MFb; both over 100 m above the deposits. Tourmaline in all three study areas occurs as fan-shaped aggregates of needles (up to 0.2 mm in length) together with illite, kaolin and sudoite in grain boundaries of quartz grains that have already been coated with overgrowth. Similar compositions of tourmaline and its mineral assemblages in three sites suggest that they are all contemporaneous.

EPMA analysis shows that all tourmaline grains belong to vacancy group and are identified as magnesiofoitite following the classification method of Hawthorne and Henry (1997). Tourmaline from the Gryphon zone show a higher X-site vacancy (0.7-0.8) and Mg-rich with Mg/Fe atomic ratios ranging from 0.98-0.99. The composition plots in the field of tourmaline associated with the McArthur River uranium deposit (Adlakha et al., 2014). Tourmaline in sandstones far from the uranium ore, such as those from the Maw Zone and MFb/RD sandstones above the Phoenix uranium deposits, shows lower vacancy < 72% in the X-site and a large range in Mg/Fe (0.88-0.96). The difference in H+/Na+ in the X-site and Mg/Fe in the Y-site likely reflect the composition of hydrothermal fluids.

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Title: Fluid Evolution Recorded in the Composition of Tourmaline and Aluminum Sulfate-Phosphate Minerals along the P2 Fault and McArthur River Uranium Deposit, Saskatchewan

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Published Material: American Mineralogist- currently under reviewCanadian Mineralogist- currently under reviewGACMAC2014 meetin

Abstract Body: The P2 fault is a 13 km long, reverse displacement basement structure along graphitic metapelite in the eastern Athabasca Basin and hosts the world-class McArthur River uranium deposit. An assemblage of magnesiofoitite (alkali-deficient tourmaline) and LREE-rich aluminum sulfate-phosphate minerals (APS) occur along the entire P2 fault. These minerals are found in highest abundance in proximity to the McArthur River deposit. In the basement, magnesiofoitite was found only along the P2 fault. Magnesiofoitite forms aggregates of fine-grained (typically < 0.2 µm) needles that are intergrown with sudoite and/or illite, or form veinlets (< 2 mm). Magnesiofoitite is similar in composition along the entire P2 fault, independent of mineralization, and contains a high vacancy in its alkali site (0.70 – 0.85 apfu), suggesting low Na^+/H^+ in the fluids. Magnesio-foitite has an average chemical formulae of $(◊_{0.77}Na_{0.20}Ca_{0.02}K_{0.01})(Mg_{1.95}Fe^{3+}_{0.09}Al_{0.94})Al_6(Si_{6.02}O_{18})(BO_3)_3OH_3(F_{0.04}OH_{0.66}O_{0.30})$, where ◊ = vacancy. Proximal to mineralization, magnesiofoitite is slightly enriched in HREE relative to LREE ($[LREE]_N/[HREE]_N \approx 0.7$), and displays slightly greater variability in LREE distal to mineralization. APS occur within and outside the P2 fault, but the compositions vary depending on the locations. Along the fault, APS form zoned pseudo-cubes (> 20 µm), with Sr- Ca- and SO_4^{2-}-rich cores (svanbergite composition) and LREE- and P-rich rims (florencite composition). These APS contain up to 16 ppm U, suggesting that the fluids were uraniferous. Outside the fault, APS occur along the unconformity with kaolin and are svanbergitic in composition. Magnesiofoitite and florencite show complementary REE patterns implying that the two minerals are contemporaneous. APS cores contain high SO_4^{2-}, suggesting an earlier oxidized fluid, whereas SO_4^{2-}-poor rims, especially near the ore, indicate that the fluid became relatively reduced. Reducing conditions are further supported by the presence of sulfides associated with florencite. The data suggests that the uraniferous fluids passed along the entire P2 fault, but the mineralization took place only when the fluids were reduced.

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Title: Petrographic study of albitization associated with uranium mineralization in the Beaverlodge district of northern Saskatchewan

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Abstract Body: The Beaverlodge district is located in the southwest Rae craton of the Churchill province in northern Saskatchewan and is well known for its vein-type U mineralization. The mineralization is structurally controlled by major faults (e.g. Black Bay and St. Louis faults), many of which have an early ductile mylonitic history, although U tends to be concentrated in brittle secondary structures such as breccias, veins and fractures. Mineralization is found in variably deformed granites of differing ages, and Murmac Bay group supracrustal rocks, particularly amphibolites. The Martin group redbeds unconformably overlie the Murmac Bay group and are spatially associated with several deposits, but host only minor occurrences. Albitization occurs extensively as a replacement alteration of granitic rocks spanning several tens of meters in width and as millimeter-scale veins in albitites, partially altered granitic rocks and supracrustal rocks. Albitization has long been noted as having a spatial association with U mineralization in this area and in districts worldwide; however, a genetic relationship between the two is unclear.

Replacement albitites commonly form by the alteration of granitic rocks where dissolution of quartz and replacement of primary feldspars by albite has occurred. Voids believed to be the result of quartz dissolution, are filled with rutile, specular hematite, carbonate and minor albite. Rutile and specular hematite, often associated with carbonate, are also found interstitially and in veinlets. A range of carbonate and quartz veins, including at least one generation of U-mineralized veinlets with hematized albite margins and calcite ± dolomite cores, are found in many rock types. Relating the many generations of albite, carbonate, and U mineralization is an ongoing challenge. Although, the replacement albitization predates the main mineralizing event, mineralized albite-carbonate veins appear younger and coeval with at least one stage of U mineralization.

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Title: Geochemistry and Geochronology of the Andrew Lake Deposit, Thelon Basin, Nunavut, Canada

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Abstract Body: The Thelon Basin is an intracratonic Paleoproterozoic basin that shares many similarities with the U producing Athabasca Basin, Canada. However, there are striking geological differences that highlight the need to better characterize the Thelon U systems. The Kiggavik project area, located near the northeastern edge of the basin, comprises a series of deposits and showings along an ~18km long NE-SW structural trend. At present, the basement-hosted Andrew Lake deposit is the southernmost end-member along this trend, located near the intersection with the Scissons North fault. Mineralization is hosted within Neoarchean metasedimentary rocks informally termed the Woodburn Lake group. The objectives of this study are to: (a) characterize the deposit mineralogy, (b) determine the ages of U and alteration minerals, and (c) develop a genetic model for the Andrew Lake deposit for comparison to other deposits along the trend. Three generations of U minerals have been identified: (1) uraninite, (2) coffinite, and (3) boltwoodite. Stage 1 uraninite occurs as nodules, veins and fracture-filling grains interstitial to quartz, and as colloform uraninite. Stage 1 uraninite has relatively high and variable SiO_2 and CaO contents, ranging from 0.63 to 7.23 wt.% and 1.94 to 8.14 wt.%, respectively. Alteration of nodular and colloform uraninite formed stage 2 coffinite, which is characterized by elevated and variable SiO_2 contents ranging from 9.35 to 20.97 wt.%. Stage 3 boltwoodite occurs clusters and disseminated halos around coffinite. Apatite occurs in several units, but is not associated with U minerals. Based on major element chemistry and U-Pb isotopic analysis of U minerals, both U and Pb were remobilized by numerous hydrothermal fluid events. Therefore, the oldest age obtained for U minerals, 578 Ma, is clearly not primary. Further work is required to establish how these stages of U correlate with hydrothermal fluid events recorded in other deposits in the Kiggavik area.

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Title: Long term geochemical evolution of U mine tailings from the Denison TMA-1 tailings management area, Elliot Lake, ON, Canada.

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Abstract Body: Unexpected remobilization of ^{226}Ra within uranium mine tailings disposal facilities after extended periods of stability is a complex phenomenon currently occurring within historic tailings sites. There are 11 legacy uranium mine tailings sites in the Elliot Lake mining camp in Ontario, Canada. At some sites ^{226}Ra remobilization appears to have resulted from biogeochemical cycles during sulphate reduction, whereas at others, such as the Denison tailings management area, remobilization of ^{226}Ra appears to have been caused by the dissolution of iron-oxy-hydroxides. We seek a better understanding of the long-term evolution of U-mine tailings through geochemical analysis and reactive transport modeling based on field sampling of the water-covered Denison tailings management area (TMA-1) in October 2014. We performed reconnaissance sonde probing of bottom water throughout the tailings pond and selected several areas with anomalous values of redox potential, pH and conductivity for sediment coring and pore water extraction. We will characterize core samples by SEM, XRD, XRF, MLA and solution ICP-MS analysis. Analytical results and observations will be used in conjunction with sequential extraction experiments performed by the CNSC, enabling a more thorough understanding of ^{226}Ra behaviour within the tailings pond.

Pore waters showed conductivity values ranging from ~250 uS/cm to extreme values of 3100 uS/cm within areas having both neutral and low pH

values with some areas having high redox potential. There is a distinct difference in pH and redox conditions between exposed and deeply submerged tailings environments. A pH of 2 was obtained from an area of exposed tailings whereas pH values of 7-8 were obtained where tailings are fully submerged. Redox potential ranged from 95 mV in neutral pH areas to ~530 mV closer to the location of the exposed tailings. Dissolved ferric and ferrous iron concentrations in tailings porewaters range from ~-2.0 and 0.5 mg/L respectively in reduced, water-covered tailings, reaching a high of 2300 mg/L and 6000 mg/L respectively in the exposed areas. Sediment cores display a zone of intense bleaching under a layer of thick, black organic material, thought to result from the dissolution of iron oxy-hydroxide phases and perhaps responsible for the remobilization of ^{226}Ra.