GEOLOG

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GEOLOGICAL ASSOCIATION OF CANADA
ASSOCIATION GÉOLOGIQUE DU CANADA

President's Preamble

I hope you all had a great field season and a wonderful summer with family and friends. Now that the fall months are upon us, we turn back to meeting our challenges and following up on a number of initiatives at GAC®. My last *GEOLOG* article summarized our priorities this year including the following:

- Improving the profile of Geoscience across Canada;
- Enhancing communications across the GAC® organization;
- Review and improve GAC®'s business model;
- Increase GAC®'s revenue stream; and,
- Active participation and organization of the Resources for Future Generations (RFG 2018) conference in Vancouver.

Tackling these priorities will require a team effort using largely a volunteer base. GAC® Headquarters staff does an excellent job of supporting the organization but our resources are limited. The GAC® Fall Council meeting was held in Vancouver to discuss these priorities and other business issues for the organization. Please let me know if you would like to get involved in helping with these priorities. We need your support!

RFG 2018 is shaping up to be an exceptional conference with 44 technical partners and a full slate of Technical Sessions, Short Courses and Field Trips. Registration is now open and work continues to finalize the details for this exciting event. Please remember that RFG 2018 is our annual conference and your participation is important for GAC®.

GAC®'s annual fall membership drive has started and I encourage you to renew your membership in support of Canada's oldest national geoscience organization.

Finally, membership engagement is crucial for the future of our Association. If you any ideas or wish to pass along your thoughts in regards to any of the above, please contact me at gac@mun.ca. All the best for the remainder of 2017 and stay tuned for progress on our initiatives and challenges.

Stephen Morison
President, Geological Association of Canada

On the Ocean and the Road

Introduction

In our everyday rush of activity, it is easy to lose sight of how the geological history of Canada has shaped our remarkable country and how it influences our daily lives.

In preparing our thoughts around this issue of *GEOLOG*, the three of us took some time to reflect on how our recent travels in different parts of the country over the summer months highlight the diversity and beauty of Canada and the pivotal role that geoscience has on our daily lives.

Cont'd on p. 4

GEOLOGICAL ASSOCIATION OF CANADA

The MISSION of the Geological Association of Canada is to facilitate the scientific well-being and professional development of its members, the learned discussion of geoscience in Canada, and the advancement, dissemination and wise use of geoscience in public, professional and academic life. The VISION of the GAC® is to be a multidisciplinary scientific society supportive of the entire scope of the geosciences in Canada. The GAC® aims to be a geoscience community that is knowledgeable, professionally competent and respected, whose input and advice is relevant, widely sought and utilized, and whose vital contribution to the economic prosperity and social well-being of the nation is widely acknowledged.

La MISSION de l'Association géologique du Canada est d'aider au développement scientifique et professionnel de ses membres, de favoriser les échanges géoscientifiques au Canada ainsi que de promouvoir et de diffuser l'utilisation éclairée des géosciences dans un contexte public, professionnel et académique. La VISION de l'AGC® est de faire connaître une communauté géoscientifique de grand savoir, dont les compétences professionnelles sont respectées, dont les suggestions et les avis sont pertinents, recherchés et utiles, et dont la contribution largement reconnue est considérée comme vitale pour la prospérité économique et le bien-être de la nation.

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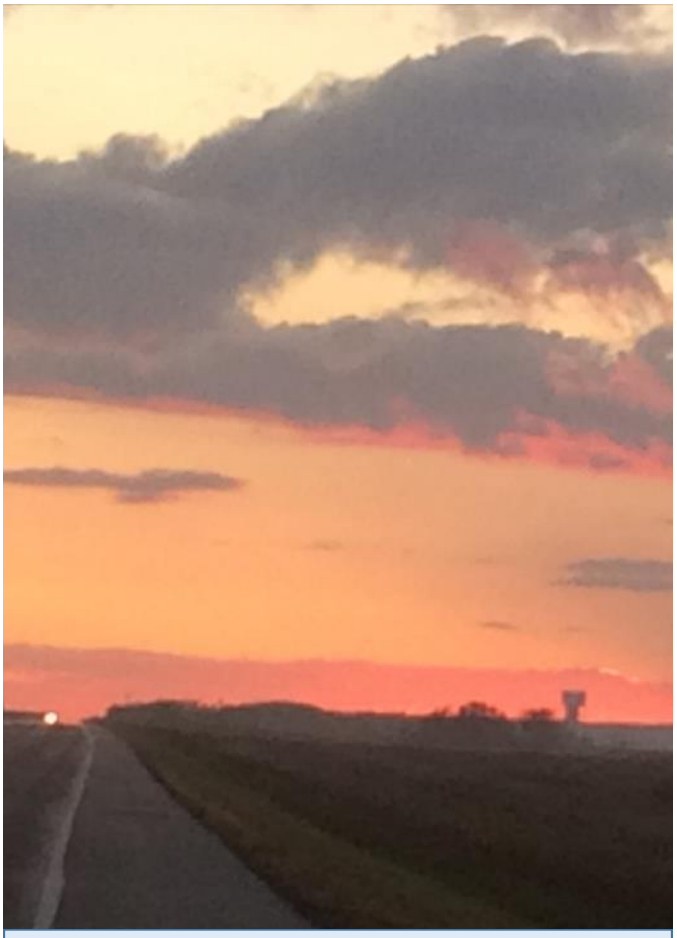

Potash sunset. Mosaic potash mine headframe near Esterhazy, southeast Saskatchewan. See p. 7.
Photo: Dène Tarkyth

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Acknowledgements and Thanks

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Contributions for next issue

Please send items for the next issue of *GEOLOG* by e-mail to Alwynne.Beaudoin@gov.ab.ca on or before **December 1 2017**.

Nodding donkey (otherwise known as a pump jack), petroleum well, beside Whitewater Lake, southwest Manitoba. See p. 7.
Photo: Graham Young

Cont'd from p. 1

Coastal British Columbia, Desolation Sound Marine Provincial Park.
Photo: Stephen Morison

On the Ocean

As I cruise along the coast of British Columbia marvelling at the spectacular coastal fjords carved by the last glacial advance and admiring the pristine marine waters, I feel incredibly lucky to be experiencing this environment with friends. The landforms and terrain, marine ecology and coastal features are directly linked to the tectonic history as well as recent glaciation and deglaciation along the coast of British Columbia. The long and over-steepened slopes that characterize the fjords are truly amazing, exhibiting some of most productive biodiversity in the world as well as providing world class boat cruising.

I also had the good fortune during the summer of travelling to the Yukon both for business and personal time. As a former Yukon resident for more than 20 years, this was a particularly personal journey for me and felt like I was back home. The drive from White-horse to Dawson City is a remarkable trip that transects a variety of glacially derived terrains, from the late Wisconsinan McConnell glaciation to progressively older terrain including Reid and pre-Reid glaciations, and finally to unglaciated terrain in central Yukon near Dawson City. The Klondike Highway to Dawson City crosses these vastly different terrain types that show features such as broad glaciolacustrine and glaciofluvial

Overview of the Five Finer Rapids, Yukon River, central Yukon
Photo: Stephen Morison

plains and terraces, broad mountains that are mantled with morainal and colluvial cover to valley bottom alluvial deposits and tributary river systems that feed into the Yukon River. The road also has to contend with wetlands, and organic landforms with permafrost features such as palsas, thermokarst and many frozen areas with high ice content. You can always detect sensitive terrain areas with high ice content when the road becomes highly irregular and bumpy and is constantly being repaired. The vantage points from the Tintina Trench north to the Ogilvie Mountains are always awe-inspiring.

Finally, as you approach Dawson City, the unglaciated terrain becomes characteristically subdued with V-shaped valleys and smaller stream systems that have been mined for placer gold since the 1890s. In particular the distinct dredge tailings from the Yukon Consolidated Gold Corporation (YCGC) are seen across the Klondike River valley bottom up into Hunker and Bonanza Creeks. These document a time in Canada's history when the Yukon experienced the world's largest gold rush as a result of the bedrock geology and the region's unique Quaternary history. Placer gold mining remains one of the Yukon's key industrial activities that is important for the Territory's overall economy.

Stephen Morison, GAC® President

On the Road

Driving north-east from Vancouver, I am in awe at the majesty of the mountains. This feeling underscores a sense of respect and admiration for those who designed and built the Sea to Sky Highway that we are driving on, along with a fervent hope that they correctly carried out geotechnical work to assess rock strength and stability. Road signs warning of rock fall areas provide intermittent reminders that we are in a geologically active area. Running alongside the highway for much of the journey across the country is the track of the Canadian Pacific Railway, built in the 1870s and 1880s to unite the country, transport new settlers to the West, bring British Columbia into Confederation, and prevent the northward expansion of the United States.

In addition to the challenges of crossing the Rocky Mountains and the Canadian Shield, the railway needed fuel to power its locomotives. In the early twentieth century, the government actually encouraged coal mining in Banff National Park. Just as the world's first geological map was created to help locate the coal to power England's Industrial Revolution, so one of the aims of early geological expeditions was to locate coal reserves in the sedimentary formations of the mountains and prairies.

Train tracks running beside the river, North Thompson River Provincial Park, north of Kamloops, British Columbia
Photo: Dène Tarkyth

Atlas Coal Mine, near Drumheller, Alberta
Photo: Dène Tarkyth

In the Badlands and dinosaur country of southern Alberta the line between industrial natural resources and tourism blurs. The Atlas Coal Mine near Drumheller, Alberta, is preserved as a museum. The dinosaur fossils preserved with such abundance in the Cretaceous strata motivated fossil hunters who would sell their finds to collectors and museums. The fossils serve as economic drivers for tourism, not to mention sources of scientific knowledge. The decision to protect fossils under Alberta's *Historical Resources Act* is a reflection of societal values and the importance of this geological legacy.

At the Horseshoe Canyon overlook west of Drumheller, the majestic landscape carved in Cretaceous sedimentary rocks by glacial meltwater after the last ice age supports a business that offers helicopter tours over the canyons. A "No Drone Area" sign highlights that above the geological foundation technologies and societies continue to evolve.

Out on the flat lands, a profusion of pump jacks proclaim the bounty of the underlying oil fields. Related policy issues of royalties, energy policies, and pipelines are passionately debated across the country. Just as the farmland of the West led to mass migration in the late nineteenth and early twentieth century, Alberta's oil has had a tremendous effect on the movement of people from the Maritimes and other communities across Canada.

In Saskatchewan, amid the old-fashioned grain elevators and modern concrete inland grain terminals along the railway, an occasional headframe testifies to

Horseshoe Canyon overlook, near Drumheller, Alberta.
Photo: Dène Tarkyth

the presence of rich Devonian evaporites below, now mined for potash fertilizer that is sold globally to help feed the world. Initial attempts to reach the potash horizon were stymied until the 1960s, because the rush of groundwater through the Blairmore aquifer would flood and collapse the shafts. The eventual solution was development of the Blairmore Ring. Groundwater was temporarily frozen long enough to allow the shaft to be sealed with the interlocking steel plates that constitute the Ring. The Potash Interpretive Centre in Esterhazy provides a simulated potash mine shaft and Blairmore Ring for those who do not have the chance to go underground.

Dène Tarkyth, GAC® Vice-President

On the Road

Shortly after this spring's excellent GAC-MAC meeting in Kingston, I was involved in museum research in western Manitoba. There, I visited localities with other curators as we considered landscapes, organisms, and historic sites for new exhibits that are being planned for the Manitoba Museum. It was fascinating to consider many examples showing how past peoples made use of landscapes and geological features. A deep understanding of stone was evident in the materials selected for tools at a prehistoric bison kill site, and in the choice of hard gneiss and granite for the walls of a 19th century fieldstone house, even though the people carrying out these tasks had no formal geological knowledge. It is clear that the success of past human endeavours has always depended on some sort of understanding of geology. Although there is little bedrock to be seen in that region, there is plenty of evidence of recent activity by geoscientists. Most notably, in the abundant "nodding donkeys" and other elements of petroleum infrastructure that have sprung up in the past few years near the US border, where recent research has allowed Canadian companies to successfully exploit resources of the Bakken Formation.

Later in the summer, my family drove east for some vacation time in the Maritimes. Every year road crews are working to improve the highways across northern Ontario, and this meant that we frequently had to stop to wait our turn at temporary traffic lights. The number of bridges and roadcuts in that part of the country is truly remarkable; each of them has a different geological setting, and of course someone has had to consider the geology for every single one. From the time of the voyageurs onward, connecting this great country has required us to figure out how to traverse those landscapes that are so often both physically challenging and geologically complicated.

Crossing northern Ontario, I always enjoy the section east of Marathon, where the road passes very close to the Hemlo mining camp. The discovery of Hemlo was a huge story back when I was a student, and I was always

Brockinton House, near Melita. This old fieldstone house in southwestern Manitoba demonstrates the care with which people selected geological materials.
Photo: Graham Young

fascinated how a very significant gold deposit could have remained "hidden in plain sight" right next to the Trans-Canada Highway. If major deposits can be discovered in such accessible locations, then there is surely tremendous opportunity remaining in Canada's immense hinterland!

Farther east, our drive along the highway down the Ottawa valley and into the St. Lawrence valley crossed large areas of sensitive Leda Clay which forms unstable terrain that is prone to landslides due to its clay mineral composition. Leda Clay has been the subject of considerable geological and geotechnical work, because it underlies a vast and populous area with many of the nation's most important buildings. As a paleontologist, I am also fond of that stratigraphic unit because it hosts some beautiful little fish fossils, such as capelin preserved in carbonate nodules.

I always look forward to going "home" to New Brunswick, and it was a great pleasure to spend the height of summer beside the Bay of Fundy. The shore of that great bay is one of the best places to sit and consider how essential geology is to our understanding of the landscapes beloved by both Canadians and visitors. Many of the basalts along and under the bay date from right around the Triassic-Jurassic boundary, 200 million years ago. During the breakup of Pangaea, Fundy was one of the rift valleys where North America began to separate from Africa and Europe. As Canadians we are perhaps fortunate that the Fundy rifting was to eventually fail, with the ocean basin forming some distance to the southeast. Geology tells us about those alternate Earths we could just as easily have had – in this case, a planet where Nova Scotia would be somewhere on the other side of the Atlantic Ocean!

Beachcombing on the shore each day, we watched those powerful tides rising and falling. We could also observe geological evidence for phenomena from the past few centuries, showing processes that might well affect us in the coming years. Around Grand Manan Island and at various other places at the lower end of the Bay of Fundy, one can see substantial remnants of 3000-year-old "drowned forests", where tree stumps and peat horizons are now at or below sea level. This evidence of local or regional sea level change in the recent past shows what a dynamic geological environment this place has been. Like so many other parts of the world, future development plans for this region depend on the predictive work of geologists and other scientists, as we try to understand ongoing changes to our environment. Our work has never been as critical or as timely as it is today.

Graham Young, GAC® Past President

From the Fundy Trail Parkway in southern New Brunswick, it is possible to view both the New Brunswick (left) and Nova Scotia (on right horizon) sides of that ancient failed rift.
Photo: Graham Young

Milestones, Memories, and Tributes

Sunil S. Gandhi, Ph.D.
April 28, 1935 – April 17, 2017

Sunil departed his family and the geological community peacefully at The Ottawa Hospital while revising his final scientific manuscript. He is survived by Marlene (née Douglas, his wife of 55 years), sons Viren and Tarun, daughter-in-law Mythili Rajiva and her family, and grandchildren Arjun and Dhilan, his mother-in-law Odette, his sisters in law and his extended family in India, United States, and Canada. Sunil arrived in Montreal from Mumbai, India in 1958 where he met and married Marlene, and quickly became a member of Canada's burgeoning community of research and exploration geologists. He was a genial social collaborator, enthusiastically participating in the various events by the local geological community, such as curling and cottage parties, both as a host and an attendee, always with camera in action. He will be missed by his many colleagues and friends.

Sunil began his geological career in India, earning B.Sc. and M.Sc. degrees at Bombay (Mumbai) and Karnatak Universities, respectively, and undertaking his first field work with the Bombay Mining Syndicate. He completed his M.Sc. Applied in mineral exploration (1960) and Ph.D. in igneous petrology (1967) at McGill University, both topics prominent themes throughout his career. He worked summers for the Québec Department of Natural Resources (1959, 1960), Saskatchewan Department of Natural Resources (1961), Consolidated Zinc Corp. of Canada Ltd. (1962), and Iron Ore Company of Canada Ltd. (1963). He joined British Newfoundland Exploration Ltd. in 1964 as a project geologist, and led exploration in central mineral belt in Labrador for volcanogenic uranium deposits, stratiform copper, and granite-related deposits. He was also involved in gold and base metal exploration in other parts of Canada, as well as global metallogenic studies.

In 1977, Sunil was hired as a Research Scientist in the Mineral Resources Division, Geological Survey of Canada (GSC), and moved to Ottawa. His work included annual assessments of uranium resources of Canada as a member of the Uranium Resource Assessment Group, regional metallogenic studies in the District of Mackenzie, Northwest Territories (NWT) and Nunavut, assessment of mineral resources in areas of proposed National Park and native land claims, and research on the genesis of a variety of mineral deposits. His research led him to world-wide conferences and field excursions, notably in Europe, China and Australia. During his mineral resource investigations, he became intensely interested in the magmatic evolution and tectonic history of the Great Bear magmatic zone, NWT, and studied the area's uranium deposits and its prolific polymetallic deposits characterized by intense brecciation, alkali alteration, and iron oxide flooding (known broadly as iron oxide-copper-gold or IOCG mineralization). One such deposit, the NICO cobalt-gold -bismuth-copper deposit owned by Fortune Minerals Ltd., is now poised to become a new mine and major local employer.

After leaving the GSC in 1997, Sunil became a geological consultant, specializing in exploration concepts and target selection, mainly for uranium, gold, and IOCG-type deposits in Canada and India. He returned to the GSC in 2001 to compile a digital database of world class IOCG deposits for the World Minerals Geoscience

Database Project, subsequently enhancing a database of Canadian uranium deposits within and around the Athabasca, Thelon, and Otish basins. Meanwhile, he continued his work on the geology of the southern Great Bear magmatic zone, which resulted in publication with co-authors of two papers in the *Canadian Journal of Earth Sciences* (2001, 2005), and presentations in Boston (GSA-SEG 2001) and Santiago, Chile (IAVCEI 2004). He continued to represent Canada in the activities of the International Atomic Energy Agency, Vienna, and participated in its international symposiums and field trips. Furthermore, he took the opportunity to enhance his knowledge of IOCG and uranium mineralization by participating in field excursions in North and South America.

Sunil was a classic gentleman geologist who inspired many who worked with him. His enthusiasm for geology was infectious. Sunil flew often with the late Stu Roscoe, the legendary pilot/geologist, covering much of Canada's north and bringing back key samples and concepts from those remote areas. Time was not important: he would often work outside until darkness or snow obscured the rocks, and was known to engage in long geological and philosophical conversations. He was a consummate collaborator, freely sharing his ideas, data, and photographs with academic and industry colleagues. Above all, Sunil insisted on making sure that all of the meaningful results of his work were published so that the fruits of the job he loved could be shared with those who could eventually make use of them either for exploration or for further scientific advancement. At 80 years old, he was proud to bring his just-released synthesis map of the southern Great Bear magmatic zone to a former colleague.

He was a great mentor before and after his retirement, and was generous with his time. While helping his GSC colleagues organize the GSC's radioactive materials vault, Sunil opened up a treasure trove of samples and underground charts from the famous, but completely closed, Port Radium Eldorado uranium-silver mine, the surface geology of which he had already sampled. Excited, he dug out his old data and worked with colleagues to constrain the timing and nature of the uranium mineralization with respect to other orogenic events in the region. The paper will be published posthumously in *Ore Geology Reviews*.

Sunil pioneered research on settings prospective for IOCG and affiliated uranium deposits across Canada. He envisioned the importance of these ore systems well before they became widely accepted worldwide. Through his work and that of his colleagues, the Great Bear magmatic zone became, with the giant Olympic Dam deposit in Australia, a type area for defining this deposit type.

Thanks Sunil for your creativity, vision, kindness, research and enthusiasm.

Charlie Jefferson and Lesley Chorlton
Geological Survey of Canada

J. D. (Jack) Mollard
1924—2017

Jack Mollard has made a difference to our country and has certainly enriched the lives of his fellow Canadians.

Jack was a bright young man, obtaining his B.E. (Civil) from the University of Saskatchewan in 1945 at age 21, his M.Sc.E. from Purdue University in 1947, and his Ph.D. from Cornell University in 1952. The skills and knowledge that he was learning were the somewhat rare and unique skills of the interpretation of airborne remote sensing, specifically air photo interpretation, and later satellite imagery.

During the Second World War, these techniques were applied by the Allies in their victories over the Axis, and Jack was astute enough to see the applications to the peace time development of Canada. Jack developed into one of the world's leading experts in interpretation of airborne remote sensing for 65 years.

The difference Jack has made to Canada has been to apply air photo interpretation as an aid to developing Canada's resources and engineering structures with minimal upset to the environment. And this was long before regulatory agencies even recognized the significance of environmental degradation.

In the 1950s, Canada was developing hydroelectric potential, and Jack worked on over 60 dam sites, saving millions by detecting natural hazards. He helped Newfoundland Agriculture in mapping the soils and terrain and early in his career helped the Canadian Colombo Plan Project map resources.

These examples illustrated how Dr. Jack Mollard made a difference to Canada by helping in the early days and continuing in his 90s with the continued development of the infrastructure of our country.

How has he enriched the live of others? Here's how.

Most consultants sold their knowledge. Jack shared his.

During his career Jack gave almost 100 short courses to more than 3000 participants and published more than 100 papers and articles.

From the 1960s to 2017 he has taught map makers how to use air photos to map Canada's landscape. "I always said I took away more from my courses than those taking them," said Jack..

On a personal level, Jack Mollard inspired me to take up my career as an engineering geologist and has continued to inspire me in my professional career. I have attended many of Jack's lectures over the years, and his enthusiasm for his craft energized the audience, whether they be professionals or members of the Rotary.

Jack Mollard has enriched my life as a scientist and as a person.

Well done, Jack!

John F. Gartner, D.Sc., P.Eng., P.Geo.
Consultant Engineering Geologist
Former President Gartner Lee Limited
Adjunct Professor, University of Waterloo

T. Kurt Kyser
1951 - 2017

GAC® President Stephen Morison regrets to inform our membership that Dr. Kurt Kyser of Queen's University has suddenly passed away. As the Chair of the Local Organizing Committee for GAC-MAC Kingston 2017 in May, Dr. Kyser demonstrated his strong leadership skills by ensuring a highly successful conference. Dr. Kyser also won the Duncan Derry Medal from GAC's Mineral Deposits Division at the Kingston conference. His scientific contributions distinguished him as a leading national geoscientific researcher, and he took great pleasure in mentoring students.

A tribute to his memory has been posted to the Queen's University website at www.queensu.ca/geol/remembering-dr-kurt-kyser

We are in his debt, and extend our sincerest condolences to his family and friends.

View of the badlands along the Red Deer River valley from the overlook, Dinosaur Provincial Park, central Alberta. See p. 6.
Photo: Dène Tarkyth

Events and Happenings

Coming soon to a lecture theatre near you...

As announced in the last issue of *GEOLOG*, two distinguished Canadian geoscientists are embarking on Canada-wide lecture tours this fall: Dr. Christie Rowe (Department of Earth and Planetary Sciences, McGill University) and Dr. Peter Hollings (Department of Geology, Lakehead University). Please check departmental websites for details of the dates and times of their presentations.

Dr. Christie Rowe is the Hutchison Lecturer for 2017-2018. This tour is undertaken by the recipient of the W. W. Hutchison Medal and is funded through the Canadian Geological Foundation (CGF). The award is given to an outstanding young geoscientist for exceptional advances in Canadian earth science. Dr. Rowe has prepared two lectures for her tour: *How earthquakes are preserved in the rock record, and what the rock record can teach us about earthquakes*, and *The 2011 M9.0 Tohoku (Japan) Earthquake: Insights from Drilling the Megathrust.* Abstracts for these talks are given below. Dr. Rowe will be travelling to eastern Canada in October, with other venues to be added later.

How earthquakes are preserved in the rock record, and what the rock record can teach us about earthquakes

Ancient faults preserve evidence of past earthquake cycles, including rupture, aseismic creep, and interseismic healing, but our ability to read that record is incomplete. There are two key features that distinguish earthquake slip from other fault motion that have the potential to be preserved in rocks. First: the slip velocity is high enough that that frictional heat can be produced faster than heat can diffuse away, resulting in temperature rise. This temperature rise can cause clay dehydration, rapid maturation of organic compounds, and even melt rock to produce pseudotachylyte. By recognizing and analyzing these and other seismic rocks, we can estimate coseismic peak temperatures between ~ 250° up to >1400°C. Second: seismic slip is *dynamic*, that is, the slipping area grows quickly (~ 3 km/s) and its growth is driven by inertia from the rapid slip. This dynamic propagation results in extreme stress gradients in the wall rock, which forms distinctive patterns of closely spaced fractures and sometimes wall rock pulverization.

Once we understand the range and variety of earthquake 'fingerprints' we can find in the rock record, we can use these to understand the mechanics of earthquakes. I will show an example of a research project executed by an undergrad-grad advanced structure class studying pseudotachylytes in Norumbega Shear Zone in Maine. The class made extremely detailed maps of pseudotachylyte networks and developed criteria to determine whether pseudotachylyte veins formed singly during individual earthquakes or formed at the same time representing networks of faults that slipped simultaneously. Spoiler alert: We found networks of faults for each (paleo-) earthquake. Outcrop studies like ours help to understand how slip is distributed across connected networks of faults, and the geometry of networks that are likely to be triggered in simultaneous slip. These observations might be scaled up to elucidate the behaviors of plate boundary fault networks.

The 2011 M9.0 Tohoku (Japan) Earthquake: Insights from Drilling the Megathrust

On March 11, 2011, the subduction plate boundary under northern Japan ruptured in a M9.0 megathrust earthquake. The earthquake rupture displayed some very unusual characteristics. The offset between the overriding and subducting plates was measured as ~60 m at the seafloor, more than twice the previous record for displacement in a single event! This great displacement, along with slowing of the rupture as the earthquake grew toward the surface, contributed to the production of a very large tsunami.

One year after the earthquake, the drilling vessel Chikyu sailed to the Japan Trench with 27 scientists from 14 countries to drill through the seafloor to sample the plate boundary fault (International Ocean Discovery Program Expedition 343). We recovered geophysical logs, thermal measurements, and core samples of the accretionary wedge, the downgoing Pacific Plate sediments, and the amazingly thin and slippery megathrust clays. My role on the expedition was "XCT Watchdog", examining X-ray CT scans of the core as it came on board the ship to identify important deformation structures and distribute samples to the other specialist teams.

In this talk I will describe the M9.0 earthquake and explain how it was different than most of the M9 earthquakes of the 20th and 21st centuries. I will show some of the laboratories on D/V Chikyu and explain how science is done at sea on a big drilling vessel. Finally, I will show the data collected on the expedition and present our explanation for the unusual Tohoku Earthquake.

Dr. Peter Hollings is the Howard Street Robinson Lecturer for 2017-2018 as selected by the Mineral Deposits Division of GAC®. His tour is funded through the Howard Street Robinson Fund and is intended "for furtherance of scientific study of Precambrian Geology and Metal Mining". Dr. Hollings has prepared two lectures for his tour: *Using igneous petrology to unravel the tectonic triggers for porphyry mineralization*, and *Metallogeny and magmatism of the 1.1 Ga Midcontinent Rift*. See below for the lecture abstracts. Dr. Hollings will be travelling to western Canada in October. Other venues will be added.

Using igneous petrology to unravel the tectonic triggers for porphyry mineralization

Recent studies of the magmatic rocks associated with porphyry systems in both continental and island arc environments has shown that the geochemistry of the pre-and syn-mineralization rocks shows systematic variations that can be attributed in some cases to the subduction of aseismic ridges. The role of ridge subduction, either as a source of metals or simply as a cause of flattening and compression, remains to be determined but the fact that ridge subduction is linked to the majority of recent giant porphyry Cu-Mo-Au systems suggests they play a critical role. This talk will examine the evidence for the effects and impact of ridge subduction in Chile and the Philippines.

The Cretaceous to middle Miocene volcanic rocks of Central Chile, host to some of the world's largest Cu-porphyry deposits, are characterized by enriched LREE and negative Nb anomalies, consistent with an arc setting. The geochemical signature of these rocks remains more or less constant until the Late Miocene when a rapid change in the geochemical signature between the end of the eruption of the Farellones Formation and the eruption of the high La/Yb La Copa Rhyolite Complex implies a more abrupt change in the tectonic environment. The subduction of the Juan Fernández Ridge may have been the key geodynamic process responsible for the genesis of the three middle Miocene to lower Pliocene giant porphyry copper deposits in central Chile, possibly by promoting crustal-scale faulting and even acting as a source of metals**.**

The Baguio district of the Philippines is one of the world's premier mineral provinces, containing >35 million ounces (Moz) of gold and 2.7 million metric tons (Mt) of copper in epithermal, porphyry, and skarn deposits that formed in the last 3.5 m.y. The geochemical and isotopic characteristics of the Pliocene and Pleistocene magmatic rocks of the Baguio district are characteristic of primitive mantle-derived melts that underwent minimal crustal contamination prior to emplacement. In contrast, the intermediate to felsic suite has been contaminated by young arc crust, suggesting ponding and fractionation within shallow-crustal magma chambers. The early mafic suite is broadly coeval with the onset of subduction of the Scarborough Ridge and slab flattening. The young aseismic ridge would have been more susceptible to melting than the downgoing plate and those melts may explain the isotopic recharge of the Pliocene subarc mantle as well as the generation of the primitive melts and adakitic rocks found within the Baguio district. The interaction between primitive mafic melts and the more felsic calc-alkaline rocks has generated fertile melts that were highly productive for porphyry copper and epithermal gold mineralization. Evidence for this interaction is preserved in hornblendes from the Black Mountain Southeast Cu-Au-(Mo) porphyry deposit. The hornblendes can be divided into two groups: one formed at depth in a mafic magma and the other at shallower levels in a felsic magma. The presence of both groups within a single sample suggests mixing of mafic and felsic magma, consistent with the recharge

indicated by the district scale whole rock geochemistry. Porphyry mineralization in the Black Mountain area is interpreted to have formed as a result of underplating of a felsic magma chamber by a mafic magma that formed as a result of mantle recharge related to the subduction of the aseismic Scarborough Ridge.

Metallogeny and magmatism of the 1.1 Ga Midcontinent Rift

The ~1.1 Ga Midcontinent Rift (MCR) is widely accepted to have formed above an upwelling mantle plume. Recent geochemical and geochronological studies have revealed a previously unrecognized complexity that has implications for the petrogenesis, metallogeny and origin of the rift.

The MCR is host to a wide range of mineralization styles, including both hydrothermal and magmatic systems (Miller and Nicholson, 2013). MCR-related hydrothermal deposits include: 1) native copper and silver deposits in basalts and interflow sedimentary rocks (e.g., Keweenaw Peninsula, Michigan; 2) stratabound copper sulfide and native copper in clastic sedimentary rocks (e.g., White Pine Mine, Michigan); 3) copper sulfide veins and lodes hosted by volcanic rocks (e.g., Coppercorp Mine, Ontario; and 4) polymetallic, silver-bearing veins around Thunder Bay (e.g., Silver Islet, Ontario). MCR-related hydrothermal activity is also thought to have remobilized pre-existing metals in older rocks, generating lead-zinc-barite veins and uranium-bearing veins and breccias northeast of Thunder Bay. Magmatic deposits in MCR igneous rocks include: 1) low-grade Cu-Ni-PGE sulfide deposits hosted by predominantly gabbroic rocks of the Duluth and Coldwell complexes (e.g., Mesaba, Nokomis, Minnesota; Marathon, Ontario); 2) stratiform, PGE-enriched "reef" intervals in layered mafic intrusions (e.g., Seagull, Ontario; Tamarack, Minnesota), 3) high-grade, Ni-Cu-PGE-bearing sulfide deposits in ultramafic intrusions (Eagle Mine, Michigan; Current Lake, Ontario); 4) Ti-Fe(-V) oxide-rich ultramafic intrusions in the Duluth Complex (e.g., Longnose and TiTac deposits, Minnesota); 5) U-REE in diatremes and carbonatites (e.g., Dead Horse Creek and Prairie Lake complexes, Ontario); and 6) Cu-(Mo)-bearing breccia pipes (e.g., Tribag deposits, Ontario).

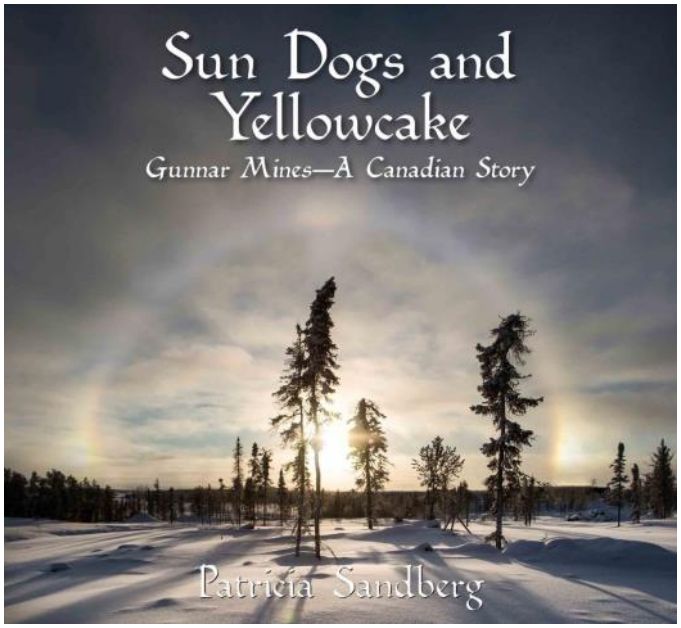
Geochronologic data, published in the past 10 years, have yielded significantly older ages than previously recognized (*ca.* 1120 Ma; Heaman *et al.*, 2007, Hollings *et al.*, 2010 and Dunlop, 2013). This implies that MCR magmatism spans at least 30 million years (i.e., *ca.* 1120 to 1090 Ma) and possibly longer, considerably longer than is typical for the Large Igneous Provinces (LIPs) which are characterized by short-duration magmatism (less than 1–5 My; Ernst *et al.*, 2013). Recent, detailed geochemical studies have shown that the intrusive and extrusive rocks of the MCR north of Lake Superior comprise a complex suite of rocks derived from a heterogeneous mantle source. Early, PGE-mineralized ultramafic intrusions are among the most geochemically and isotopically primitive rocks in the MCR, although the olivine chemistry of those rocks suggests a parental magma with 8-10 wt% MgO (e.g., Goldner, 2011); younger mafic intrusions are less commonly mineralized. The geochemical evolution of magmatism in the northern MCR suggests that source of magmatism for the rift became more depleted through time.

The long duration of MCR magmatism, the absence of primary ultramafic magmas and the lack of a radiating dike swarm collectively suggest that a passive rifting model may be more appropriate for the rift. According to this model, rifting of the Superior Craton, possibly in response to a newly recognized global LIP event, enabled upwelling of material underplated by earlier plume events thought to have been centered in the vicinity of the present-day Lake Superior (e.g. the Marathon LIP, Halls *et al.*, 2008). Ongoing research seeks to elucidate the timing, nature and tectonic setting of MCR magmatism and its associated mineral deposits.

Reading on the Rocks

Sun Dogs and Yellowcake: Gunnar Mines – A Canadian Story

Patricia Sandberg. Crackingstone Press, 2016. 258 pages.



When burnished by memory the events and locations in our past can become shining places. This can be particularly true when we think back to specific parts of our childhood that can be bracketed with a clear definition, such as arrival and departure. This is how it was for Patricia Sandberg.

This burnishing can be even brighter when the remembered place occupied a part in one of the great dramas in human history. In this case, the race for atomic weapons and the unstable conditions of the Cold War provide the sharpened backdrop to Sandberg's story. From when she was three until she was eleven Sandberg lived in Gunnar Mines, a town perched on the rock bordering Lake Athabasca, Saskatchewan, and home to uranium mines and processing plants. The mine operated from 1955 until the end of December, 1963, producing almost 18 million pounds of uranium.

In July 2014 Sandberg decided to collect stories of Gunnar and began contacting residents and collecting their memories. These memories, related in snippets arranged in thematic chapters such as Tug Tales and Other Watery adventures, School Days, and A Cold War Legacy Mine, form the bulk of the book. She begins, however, by placing Gunnar Mines within the history of uranium exploration and extraction in Canada. We learn of the explorations and mines developed Gilbert and Charles Labine, of the adventures of bush pilots flying prospectors over kilometres and kilometres of the Canadian Shield, and of towns and mines that preceded Gunnar, such as Eldorado Mines at Port Radium in Manitoba.

The sun dogs (rings that can flank the sun on a cold winter day), and yellowcake (the yellow powder of partially refined uranium) of the title neatly foretell the dual purpose of this book, for Sandberg not only includes the personal experience of living in Gunnar, but the technical aspects of opening, running, and finally abandoning the town and mine. Patricia's father and grandfather worked for the mine, and her mother, Barbara, provides revealing tales of life at the site. "Our new home was a ten-by-twelve-foot plywood shack with a tarp roof…One door, one window, one light bulb, one table, one washstand, one bed, one crib, one counter with cupboards, one tin stove, one wood box, and two chairs." Stories of the winter's cold, mice in the bread box, and movies and makeshift haircuts take us right into the daily life of a new town and the varied people who came to live there.

We meet many of those men and women, and see in their stories the excitement and unpredictability of life in a resource town. "I had no idea what a mine was," Stewart Spencer says, "had never been outside Manitoba or flown in an airplane, but the money sounded good, so I bought a bus ticket to Edmonton and away I went…I had to be eighteen to work in the mill, so I said I was." His first job was shovelling up ore spillage behind the grinding mills. Joan Lang Buck recalls "I was working in Winnipeg in 1959, and a girlfriend and I were saving money to go to Europe…My

parents were at Gunnar and I went there to help my mother, who was unwell. Shortly after I arrived, a woman who worked at the bank fell ill, so the bank manager asked me to come and work for him. I had never worked in a bank in my life." Joan, and one of the bank's customers, a charming Englishman who loved riding his motorcycle, soon fell for each other, and Gunnar became home.

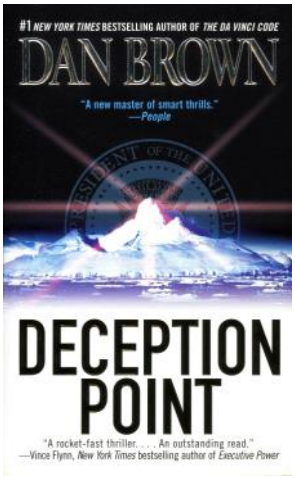
The personal remembrances are just one part of the book. Sandberg has amassed an astonishing collection of photographs of almost every part of the town, the mine, and the surrounding landscape. A hockey game, the tug boats, Mary Marcelet's garden that fed bachelors living in the bunkhouse who longed for a home-cooked meal, the Marion shovel in the pit, a plaid-shirted and helmeted man working the mucker machine gathering up the broken rock after a blast. In page after page of aerial shots of the settlement, lamps made of drill core, children at parties, Barbara Sandberg preparing for her radio program, and Gunnar's headframe atop silver gravel behind blue Athabasca Lake life at Gunnar unfolds for the reader.

While Sandberg does tackle difficult topics, such as whether the uranium at Gunnar had an effect on the people who lived there, she cannot offer data to answer her question. She also discusses remediation of the site. But these areas are not the main reason for the book, nor are they the book's strength. The experiences of living in a resource town, the comprehensive photographs and maps, the glossary and footnotes, these are what bring Gunnar to life, and provide evidence of life in a resource community that is of tremendous value to the historical record. Ensuring those photographs and her research materials are deposited in a public archive would make sure this rich resource would always be available for future research.

Patricia Myers
Royal Alberta Museum, Edmonton

GeoFact: Dec 11 1847: John Murray publishes his memories of Mary Anning, from his visits to Lyme Regis in the 1830s, as a memorial notice entitled 'The late Miss Mary Anning' in the Mining Journal.

Deception Point



Dan Brown. Pocket Books, New York. 2001. 558 pages.

I picked up this techno-thriller in a moment of desperation some years ago. Perhaps you can relate. It was winter and I was out with a crew doing lake coring. We spent the short daylight hours on the ice surface, winds exacerbating the cold, grappling with frozen gear and struggling to recover intact sediment cores. Tired by evening, we stayed in a small remote prairie town. I'd read all the books I'd brought with me—this was the days before e-readers—and I was desperate for something—anything!—to read. I found myself foraging through the pot-boilers in a wire display stand at the local gas station, trying to decide which paper-back sounded the least awful. I eventually settled on *Deception Point*, mainly because at 558 pages it promised to last at least a couple of evenings. In the event, it turned out to be surprisingly entertaining, perhaps because it too is set mainly in a dark, cold, and icy landscape. It does, however, require overlooking some decidedly inappropriate workplace banter as well as a creatively improbable mishmash of geoscience notions.

As the story starts, NASA is on the verge of being eliminated and is seeking a new project that will secure its continuing existence. Then comes word that a satellite has detected the presence of a huge meteorite buried in the Arctic. Initial investigation suggests the specimen contains fossils. Electrifying news! Some scientists tout this as providing evidence of life elsewhere in the Universe and hence validation of the Panspermia hypothesis. Others are more sceptical. Rachel Sexton, government intelligence analyst, is sent to the Arctic site to investigate and verify the find.

From here, the tale comprises relentless fast-paced mayhem, involving conspiracy theories, a presidential election, geologists, corruption, murder, and wild chases across Arctic terrain and ice. Sexton's foreboding, it turns out, is well-founded. The meteorite is a magnet for groups with hostile agendas. It all made my fieldwork seem refreshingly tame by comparison!

Alwynne B. Beaudoin
Edmonton, Alberta

Announcements

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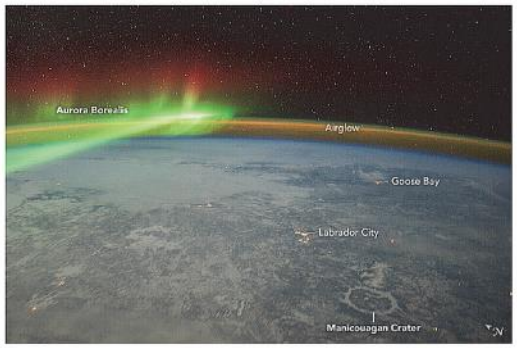

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The Robinson Fund was established in 1977 by the Geological Association of Canada, using a bequest from the estate of Howard Street Robinson. The fund is dedicated to the furtherance of scientific study of Precambrian Geology and Metal Mining by:

- sponsoring an annual Distinguished Lecturer Tour whose focus alternates between Precambrian research and economic geology (lecturer alternately chosen by the GAC®'s Precambrian and Mineral Deposits divisions)
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For further information and proposal submissions, please contact: Dr. Stephen Piercey, Chair, Robinson Fund, c/o Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NL A1B 3X5 Canada, E-mail: spiercey@mun.ca

The Last Word In mid-October, I unexpectedly had the opportunity to do some fieldwork in southwest Alberta. The weather is always dicey at this time of year but we were greeted at our field site by clear crisp windy days. The chill added extra zest to field survey and walking. In the distance, the Rockies stood out clearly against the brilliant blue sky, peaks sparkling with fresh snow, the distinctive outline of Chief Mountain on the far horizon. It was wonderful to be away from my desk and e-mail for a few days, reconnecting with the subject-matter that brought me into earth sciences in the first place. I returned to the office re-energized, with samples, notes, and pictures. Much e-mail to catch up on and, ah yes, this issue of *GEOLOG* to finish! Alwynne B. Beaudoin, *GEOLOG* Editor

Information for Contributors

Contributions should be submitted by e-mail to Alwynne.Beaudoin@gov.ab.ca, with GEOLOG in the subject line. Contributions are welcome in either of Canada's two official languages. MS Word (.doc or .docx) is the preferred format for contribution but generic word processing (.rtf or .txt) files are also fine. Please do not submit PDF files. Up to four hi-res images may be submitted per contribution: preferred format is .jpg, RGB colour, with a minimum 300 dpi resolution at 5" x 3" size. Please ensure that images are cropped and colour-corrected, and provide a caption for each image, and an image credit line if needed. Contributors are responsible for securing permission to publish for any third-party images or images of living recognizable people. Diagrams (vector graphics) may also be submitted. Preferred format for graphics is Adobe Illustrator (.ai); make sure that the file is saved with "save text as lines" option enabled to ensure no font substitutions. Additional information on other file formats can be obtained from the Editor. Please do not embed images or graphics in your text document; images or graphics should be submitted as separate files. In your text, use a call-out in parentheses to indicate the approximate placement of each image and graphic. If files are larger than 10 mb, please contact the Editor for alternate delivery arrangements. Your contribution will be copy-edited to ensure consistent spelling and orthography and to correct any obvious typos or errors. Contributions may also be edited for clarity and length. If the Editor has questions about specific information in the text, she will contact contributors for clarification. Contribution deadlines are March 1, June 1, September 1 and December 1.

Consignes aux auteurs

Les contributions d'auteur doivent être soumises par courriel à Alwynne.Beaudoin@gov.ab.ca, en indiquant GEOLOG à la rubrique Objet. Les articles seront acceptés dans l'une des deux langues officielles du Canada. Les fichiers de format MS Word (.doc ou .docx) sont préférables, mais les formats génériques (.rtf ou .txt) sont aussi acceptables. Veillez ne pas soumettre de fichiers au format PDF. Par article, jusqu'à quatre images haute résolution peuvent être soumises; format préféré est .jpg, couleurs RVB, avec un minimum de 300 PPP en taille 5 po x 3 po. Veillez vous assurez que les images sont recadrées et leurs couleurs corrigées, qu'elles sont accompagnées d'une légende ainsi que des informations de référence le cas échéant. Il est de la responsabilité des auteurs d'obtenir la permission de publier toute image de tiers ou de personne reconnaissable. Des diagrammes (graphiques vectoriels) peuvent également être soumis. Le format préféré pour les diagrammes est celui d'Adobe Illustrator (.ai); assurez-vous que le fichier est sauvegardé avec l'option « Sauvegarder le texte comme ligne » activée pour éviter toute substitution de police de caractère. On peut obtenir des informations sur d'autres formats de fichiers en communicant avec l'éditrice. S'il vous plaît ne pas incorporer d'images ou de graphiques dans votre texte; ces images ou graphiques doivent être soumis sous forme de fichiers distincts. Dans votre texte, veillez utiliser des notes numérotées entre parenthèses pour indiquer l'emplacement approximatif de chaque image et graphique. Dans le cas de fichiers dépassant 10 Mo, veuillez contacter l'éditrice pour convenir des modalités de téléchargement. Vos articles seront révisés afin d'en assurer la cohérence orthographique et corriger les fautes de frappe ou erreurs évidentes. Les articles pourront aussi être corrigés pour plus de clarté et éviter des longueurs. Dans les cas où l'éditrice aurait besoin d'informations particulières concernant le texte, elle communiquera avec les auteurs. Les dates limites pour soumettre des articles sont le 1 mars, le 1 juin, le 1 septembre et le 1 décembre.