

Geological Association of Canada

ABSTRACTS

Newfoundland Section 2013 Spring Technical Meeting

JOHNSON GEO CENTRE, SIGNAL HILL, ST. JOHN'S, NEWFOUNDLAND

After a year's absence, the 2013 Spring Technical Meeting was once again held in the depths of the Newfoundland winter in the Johnson GEO CENTRE on scenic Signal Hill in St. John's.

The meeting featured a special session entitled "Geoheritage in Newfoundland and Labrador" which provided an introduction to the geoheritage potential of Newfoundland and Labrador, as well as updates on projects from throughout the province. In addition, a general session included papers on an eclectic range of topics, as is normally the case at these meetings.

Due to stormy conditions and flight cancellations the fifth "Topical Geoscience Lecture" series, sponsored by the Professional Engineers and Geoscientists of Newfoundland and Labrador (PEG-NL), was postponed to a later date. The speaker would have been Dr. John Calder from the Nova Scotia Department of Natural Resources with a talk entitled "Coal Age Galápagos: The Joggins Fossil Cliffs World Heritage Site and its Place in Earth's Incredible Story"

The Newfoundland and Labrador Section of the Geological Association of Canada is pleased to have once again hosted an interesting and diverse meeting, and we are equally pleased to see the abstracts published in *Atlantic Geology*. Our thanks are extended to all of the speakers and the editorial staff of the journal.

JAMES CONLIFFE
TECHNICAL PROGRAM CHAIR
GAC NEWFOUNDLAND AND LABRADOR SECTION

Identification of local maxima in regional geochemical datasets

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Strong regional or 'global' geochemical features tend to set the regional threshold too high for the detection of more subtle anomalies. For example, background levels of fluoride in lake water are much lower in southern Labrador than farther north, which results in the non-appearance of an anomalous response to the REE mineralization at Pope's Hill if regional threshold values, derived for the whole of Labrador, are applied to the data. A filtering method has been devised which highlights local maxima in regional datasets, whether local background is high or low. Processing the fluoride data in this way shows that Pope's Hill is indeed associated with a local maximum. Where background is particularly high, for example in the Flowers River region, filtering the data has the equally desirable effect of drawing attention to local hotspots, in both fluoride and REE, in what is essentially a large regional anomaly.

Elsewhere in Labrador, filtering the data has revealed the presence of an As dispersion train down-ice from Strange Lake. Dispersion from the Voisey's Bay Ni-Cu-Co deposits is also more clearly indicated in filtered data, although a subtle Ni response in lake sediment had been noted previously. The filtering of Br data in the lake sediments from Newfoundland results in the appearance of a number of local maxima in the interior of the island, which are masked in unfiltered data by the dominant effect of coastal lakes and the probable effects of marine incursion.

It is believed that a number of anomalies of potential economic interest may have been overlooked because of the masking effects of variable local background. It is proposed to re-evaluate the regional geochemical datasets from both Labrador and Newfoundland and release the results in 2013.

Torngat Mountain National Park: an ancient land, an Inuit homeland

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The Torngat Mountains National Park is Canada's 42nd national park established on December 1, 2005, with the consent of Inuit of Labrador and Inuit of Nunavik. It was established to protect the natural region of the Northern Labrador Mountains, and to showcase the natural and cultural resources and the 7,000 years of human history in this region.

The mountain peaks along the border with Quebec are the highest in mainland Canada east of the Rockies and are dotted with remnant glaciers. Rocks 3.9 billion years old, some of the planet's oldest geological units, are found here. The age of the Torngat Mountains encompasses eighty percent of the earth's geologic history. There are few places on earth where such an array of geological features and processes can be observed in a single landscape. The limited vegetation cover, high mountains, coastal cliffs, deeply incised fjords, and sheer cliffs that cut perpendicular to the rock fabric, provide some of the best exposures of the earth's geologic history.

Inuit today continue to use this area in ways that have been influenced and inspired by this geology. Everywhere there is evidence of stones marking tent rings, stone graves, food caches, stone traps, stones used to erect inuksuit and cairns for way finding, stones used for tools, to make carvings and amulets. And these mountains which bear the name of one of the most powerful of the Inuit spirits – Torngait – hold many stories and legends keeping it a place of spirits and mystery.

Parks Canada wants to weave the geological story of this ancient land through a cultural context in ways that will capture the minds and imagination of visitors. This journey is just beginning.

**Petrography, geochemistry, age and tectonic significance
of the Paul's Lake dyke swarm in north-central Dunnage
Zone**

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Geological mapping, petrography, and major- and trace-element geochemistry, along with new U-Pb age determinations, of the Paul's Lake dyke swarm and associated host rocks have provided more insight into post-subduction Silurian magmatic processes that occurred in the north-central Dunnage Zone of the Newfoundland Appalachians. The magma-mingled Hodges Hill granite-diorite host rocks, as well as the dyke swarm, were emplaced into locally metamorphosed, Ordovician volcanic and sedimentary sequences of the Notre Dame Subzone, located immediately west of the Red Indian Line.

The dykes exhibit a full compositional range from basalt through rhyolite and are associated with diorite and gabbro-norite intrusions, most of which show well-developed chilled margins. Igneous textures observed during petrographic analysis include granophyric, myrmekitic and spherulitic and suggest variations in the cooling rate and depth of crystallization. Locally intense saussuritization and chloritization indicate low-grade metamorphism and deformation. Numerous petrographic similarities between dykes of contrasting trace-element geochemistry give insight into magmatic differentiation processes such as magma mixing, fractional crystallization and partial melting. Six geochemical groups were defined from the thesis outcrop, based on trace-element geochemistry, and consist of: (1) LFSE-enriched mingled granite-diorite Hodges Hill host rock exhibiting negative Nb anomalies and local prominent positive U anomalies; (2) a group of dykes ranging from depleted basalt – lacking a negative Nb anomaly and LFSE enrichment - to LFSE-enriched basalt and basaltic andesite; these latter all show similar geochemical trends and negative Nb arc-signatures; (3) a group of andesite dykes, showing prominent negative Nb anomalies and LFSE enrichment, and identical trace element geochemistry; (4) a group of intermediate to felsic dykes with granophyric texture that exhibit high degrees of LFSE enrichment and prominent negative Nb and Ti anomalies; this group is further subdivided based on similarities in trace element geochemistry with select basaltic andesite and andesite dykes; (5) LFSE-enriched rhyolite dykes, showing prominent positive U anomalies, along with negative Nb, Eu, and Ti; and (6) a group of medium- to coarse-grained diorite dykes, that share geochemical similarities with basalt and basaltic andesite dykes, and in comparison, LFSE-depleted gabbro-norite intrusions with less prominent Nb arc anomalies.

A minimum time frame of 6 million years, spanning the Middle (Wenlock) to Late (Ludlow) Silurian, has been determined for large scale bimodal magmatism occurring within the thesis outcrop and is bracketed by the 429.4 ± 1.3 Ma Hodges Hill granite host, and a cross-cutting rhyolite dyke, previously dated at 423 ± 2 Ma. These ages correspond in time with within-plate Silurian magmatism throughout the Central Mobile Belt that has been previously suggested to be linked to lithospheric delamination at depth, or a slab-break off event that occurred upon closure of the Exploits back-arc-basin. Emplacement of the dyke swarm, and host rocks of the Hodges Hill suite, may have been initiated and localized during simultaneous sinistral transpressional-transensional movement along regional arcuate faults that were active in central Newfoundland throughout the Silurian.

**Paleontological geoheritage of Newfoundland and
Labrador**

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Newfoundland and Labrador contains a wealth of paleontology-related geoheritage sites. Eastern Newfoundland has some of the oldest and richest localities of a unique deep-water Ediacaran biota on the planet, typified by the fossils of the Mistaken Point Ecological Reserve, Spaniard's Bay, and the eastern Bonavista Peninsula. Furthermore, the type locality of the first described Ediacaran fossil *Aspidella terranovica* Billings, 1872 is in downtown St. John's. The Global Stratotype-Section and Point (GSSP) for the base of the Cambrian Period occur within the Fortune Head Ecological Reserve on the Burin Peninsula, where they are defined by the First Appearance Datum (FAD) of the trace fossil *Treptichnus pedum*. Manuels River is world-famous for its Middle Cambrian "Paradoxides Beds" studied by Dr. B.F. Howell of Princeton University, though his original collections now are lost. It was in the Manuels River area where G.F. Matthew's and C.D. Walcott's earlier debate about the relative stratigraphic positions of *Callavia* and *Paradoxides* was settled. In addition, Bell Island is world-renowned for its abundant Ordovician trace fossils.

With respect to western Newfoundland, in the 1860s a substantial number of fossil genera were described for the first time by E. Billings (the Geological Survey of Canada's first paleontologist); the fossils were collected by J. Richardson during the field mapping for W.E. Logan's historic Geology of Canada report. Gros Morne National Park is a UNESCO World Heritage Site. A large complete Early Cambrian olenellid trilobite has been visited and

photographed during many field trips over the years. The GSSP for the base of the Ordovician Period is defined at Green Point, based on the FAD of the conodont microfossil *Iapetognathus fluctivagus*. The Table Point Ecological Reserve contains unusual Early Ordovician graptolites preserved in dolostone, as well as one of the most diverse and well preserved assemblages of Middle Ordovician fossils in the world. Complete paleoniscid fish occur in Early Carboniferous (Mississippian) rocks in the Codroy Valley and the Pasadena area. Blanche Brook, Stephenville has well-preserved Late Carboniferous (Pennsylvanian) petrified tree trunks and other plant fossils.

Labrador has both the oldest and youngest fossils in the province. The oldest fossils are approximately two billion years old (Palaeoproterozoic) and have been found in several different areas. In western Labrador, microbial mounds (stromatolites) are extensively developed in the Denault Formation at Marion Lake. The youngest fossils are Cretaceous-age insect and plant fossils recovered from the Redmond iron ore deposit of the Knob Lake District of western Labrador. Globally, archeocyathid fossils and reefs were first recognized and described in the Forteau Formation at Point Amour in southeastern Labrador. Some of the best exposed Early Cambrian bioherms anywhere occur along the southeastern Labrador coast.

The Rooms Provincial Museum contains the province's Paleontology Reference Collection, obtained by officers of the Department of Natural Resources, Geological Survey, from 1976 to the present day.

Geoheritage, education and tourism: the Fortune Head Interpretation Centre

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Fortune Head ECO Friends, a not-for-profit organization, became incorporated in May of 2007 to provide advice and direction pertaining to the ongoing operations of the Fortune Head Interpretation Centre located in the town of Fortune, NL. The Board's mandate is to educate and preserve the significance of the Fortune Head Ecological Reserve (located 1.6 km west of the town), which contains the Global Stratotype Section and Point from the Precambrian Era and the Cambrian period. Professionals have referred this fossil find as the golden spike - making it unique to the entire world because it's accessible, easy to relate to other similar sedimentary rock formations elsewhere in the world, and shows a thick, unbroken sequence of trace fossil types.

The aim of the organization is to develop and implement

a strategy to ensure sustainability of the Interpretation Centre that will also provide economic benefit to the region by utilizing the Reserve as a resource - an anchor! We have come to the realization in a small area of our small, yet beautiful, Province that our unique and geological history can reap benefits! Its preservation and promotion through educating our youth through programs and activities, and of course engaging the general public/tourists, creates an interest to visit - extending facts in the field of geology, extending a stay in the area!

Fortune's proximity to the French Islands of Saint Pierre and Miquelon is a competitive advantage for us - with a steady stream of tourism traffic waiting to board a ferry. Many of these tourists explore the area, and acquire points of interest from the Visitor Information Desk housed in the Centre.

We are encouraging visitation to these sites and are eager to capitalize on lengthening stays in the area and our Province, increasing economic development for many small businesses. To do this, we need to be creative in providing information and development-quality educational programs.

The use of integrated fluid-inclusion studies in constraining the petroleum charge history at Parson's Pond, western Newfoundland

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Hydrocarbon exploration in western Newfoundland has been ongoing for nearly 200 years, with small quantities of oil being produced in the 19th and 20th century from the Port au Port Peninsula and the Parson's Pond area. However, relatively little is known about the relative timing of petroleum migration and potential migration pathways. Further understanding of syn- and post-diagenetic petroleum and aqueous fluid flow has important implications for new exploration strategies, particularly at Parson's Pond where oil and gas shows have been recorded in allochthonous sandstones and underlying carbonate reservoirs in the autochthon.

This project integrates fluid-inclusion petrography and microthermometry of petroleum, gas-bearing and aqueous inclusions with fluorescence microspectroscopy of inclusion oils, in order to determine nature and relative timing of oil and gas migration events at Parson's Pond.

Fluid-inclusion studies were undertaken on 58

core and cuttings samples in three wells in the Parson's Pond area. Petroleum, gas, wet gas and aqueous bearing fluid inclusions were identified in all three wells, which revealed a complex hydrocarbon charge history at Parson's Pond, with multiple petroleum charge events of multiple compositions. Petroleum and gas bearing fluid inclusions in the allochthonous cover rocks are restricted to calcite and quartz vein material. This indicates that petroleum and gas migration at Parson's Pond is fracture-controlled, and no hydrocarbons were present during the cementation of the essentially tight sandstones of the Lower Head Formation and Cow Head Group. In addition, these data indicate that hydrocarbons were generated at multiple times during progressive burial and heating, and the distribution of petroleum and gas-bearing inclusions with depth suggests that deeper levels are gas-prone, with petroleum confined to relatively shallow depths. The scarcity of hydrocarbon inclusions in autochthonous carbonates indicates that no hydrocarbons were present during hydrothermal dolomitization, and any potential hydrocarbon charge events must have postdated dolomitization (and associated porosity enhancement).

Geology At The Edge: a geologist residency program for Fogo Island and area, northeast Newfoundland

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Geology At The Edge is a community-based, geologist-in-residence program, initiated by Shorefast Foundation and based on Fogo Island, Newfoundland. It was initiated in 2012 and formally announced at the GAC/MAC meeting in St. John's in May. Applications for potential candidates started in October, 2012. The Residency Program will be fully operational in 2013.

The bedrock geology of Fogo Island and the adjacent Change Islands exhibits many features of a Silurian magmatic complex and related volcanic sequences as well as two distinct sedimentary basins, one of Silurian age and the other an older Ordovician sequence. The bedrock geology is superbly exposed in the coastal regions and this provides for easy access and ideal conditions for study, research, interpretation and public education. These superb exposures are literally "at the edge" of the Appalachian Mountain Belt, North America, the Atlantic Ocean and the Island of Newfoundland.

Geologists in Residence will lead public outreach and education programs designed to provide geological interpretation of the bedrock and glacial history of the Islands for residents of Fogo and Change Islands as well as visitors to the islands, in particular, guests of the new Fogo Island Inn. The key programs are: Geological Excursions

on the twelve Geological Trails already established; Public Lectures; School Class Initiatives; and Engagement of Public Interest Groups. Geologists will also conduct research on a chosen or assigned topic during the term of their residency to help enhance the geoscientific database for the Islands.

The term of a Residency may vary up to three months and second periods of residency are also possible. Accommodations, transportation and logistical support are provided as well as a living allowance. Applicants should have a degree in Earth Sciences as well as relevant experience in engaging the public on some aspects of the Geosciences. Applications may be received at any time and are subject to screening by a Selection Committee using established criteria.

The Residency Program should be of interest to retired professionals, graduate students, research fellows, scientists on sabbatical leave, and other scientists who have some flexibility in the work environment. Family members and students under supervision are also welcome. The success of the Geology At The Edge Residency Program depends on the support of the local and national Geoscience community. All applications, inquiries and offers of support are most welcome. Further information is available at <http://facebook.com/GeologyAtTheEdge> and also at info@GeologyAtTheEdge.org.

The Far East – Canada's Atlantic Provinces – opportunities and challenges

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Mining opportunities in the Atlantic Provinces are driven primarily by their location, on the coast or accessible to the sea with good infrastructure, power, and roads and a generally mining-friendly and knowledgeable population. Recent exploration and development have been driven primarily by the rush for iron ore in Labrador's Labrador Trough where resources/reserves in the order of billions of tonnes have been defined and are under advanced production and advanced exploration/development, generally in concert with users in China, India, and Korea.

Other mineral production includes nickel/copper at Voisey's Bay in Labrador, base metals in the Bathurst camp of New Brunswick, potash in New Brunswick, gold, copper/gold and antimony on the island of Newfoundland, and industrial minerals, mainly gypsum, in Nova Scotia. Significant advanced exploration/development projects include uranium and REE in Labrador, and base metals and gold/silver in all the Atlantic Provinces.

Challenges for development include the ongoing demand nationally for skilled workers for all projects, and

an increased recognition of limited infrastructure such as rail and power availability and other infrastructure, which may affect the development of iron ore deposits in western Labrador and a REE deposit in northern Labrador.

Battle Harbour, southern Labrador: from merely geologically interesting to geoheritage status

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Battle Harbour, situated on Battle Island (1 km by 0.4 km) in eastern Labrador, was established in the 1770s as a fishing station. Throughout the 19th century, it was the site of a thriving saltfish, salmon and seal-processing complex, and was the economic and social centre of southern Labrador. The once-abandoned settlement has recently been given a new lease on life as a result of a 7-year restoration project undertaken by the Battle Harbour Historic Trust, and is now a major tourist destination in southern Labrador. In 2007, C.F. Gower was invited by the Battle Harbour Historic Trust to spend a week at Battle Harbour as part of its Expert-in-Residence program, a program that has included the scientific disciplines of geology, botany, orthithology, mycology and cetology, and various craft skills. From reconnaissance geological mapping in 1987, it was known that the bedrock on Battle Island was more varied than seen elsewhere in the Grenville Province in eastern Labrador and included rock types that could capture the interest of non-geologists. The island is made up of metamorphosed supracrustal sequence of psammite, semi-pelite, and calc-silicate rocks, intruded by a metamorphosed mafic sill, voluminous pegmatite, and a Phanerozoic mafic dyke.

During the week spent on the island in 2007, a detailed geological map was prepared and numerous samples were collected. C.F. Gower was accompanied at times by visitors to the island and also conducted tours for groups on a request basis. Large samples of interesting minerals and rocks were collected for inclusion in a small rock garden. The results of the mapping were initially written up in the form of a Geological Survey of Newfoundland and Labrador (GSNL) Current Research article, and, later, when petrographic and whole-rock geochemical data were available, as a more comprehensive GSNL Open File publication. Neither of these was intended for the layman, although to make the Open File publication more accessible (e.g., junior undergraduate field camps), it included illustrated text boxes explaining some technical points, as well as an appendix providing a glossary of geological terms and a list of minerals with their chemical compositions. For the layman, a fold-out brochure was prepared that outlined a geological walking tour and explanations of some geological processes evident at various

places along the route. From feedback received, the brochure has been well received.

The final product of this project was a journal article on Battle Island that included U-Pb ages for various units. The samples were submitted for analysis more with the thought that it would be helpful if some quantitative basis could be provided to visitors regarding the age of the geological units, rather than having much expectation of obtaining scientifically exciting new data. Geochronology for tourists is perhaps an indulgence, but in any case, the reverse proved to be the case. The ages obtained indicate that the supracrustal rocks are the youngest pre-Grenvillian supracrustal rocks in the eastern Grenville Province and the only known example of their kind. Thus, from humble beginnings as a merely geological appealing locality, Battle Harbour has emerged as a site having genuine geoheritage status.

Manuels River Hibernia Interpretation Centre: opening this spring!

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A 7 km-long section of Manuels River provides access to Late Proterozoic volcanic rocks, Cambrian sedimentary rocks, including a world-famous trilobite fauna, and modern geological processes along the river and at its outlet into the sea in Conception Bay. The Manuels River Natural Heritage Society (MRNHS) has created a linear park along the river and has provided tours of the river to the public, school classes and visiting community groups for 16 years or so. In collaboration with the Rotary Club of Avalon Northeast (RANE), a new 1200 m² interpretation centre is under construction to facilitate access to the river. The new centre will have exhibits focussing on the river's geology, its flora and fauna, and its human history. Of particular interest will be a re-creation of the river's bedrock geology, with interpretation, and exhibits on the trilobite fauna, honouring the work of Dr. Riccardo Levi-Setti, who has donated to MRNHS his collections from many years spent on the river. The centre will also provide rentable audio-guides to the river. Funding for the centre and for further development of the trail system is coming from founding partners—the Town of Conception Bay South, the Hibernia Management and Development Corporation, the Atlantic Canada Opportunities Agency, the Government of Newfoundland and Labrador, RANE, and MRNHS—and a raft of corporate and individual sponsors. The centre will open in Spring of this year, and will be offering educational programmes for schools, summer camps, and tours for various community groups. A gift shop and café, together with a function suite and mini-theatre will offer a wide variety of opportunities for visitors and for community activities.

Writing for tourists: one woman's perspective

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In connection with a book project, I visited about 150 sites of geological interest in Newfoundland during the summer and autumn of 2011. This talk is an informal reflection on some insights gained into the world of geotourism and its need for user-friendly literature.

I learned that many tourists feel time-pressed as they try to optimize their brief escape from routine, so they get frustrated with literature that is impractical or presents other difficulties of use. Due to the vagaries of weather, transport, or wellness they often need flexibility, so modular activities (e.g., flexible combinations of related sites) or alternative activities (e.g., hike- vs car-accessible sites) are welcome. They plan and navigate using multiple resources and appreciate when it is easy to cross-reference among them. They may be negotiating with travelling companions about what to do, so they seek multi-faceted activities (e.g., combining geology and history) that can satisfy various interests. Above all, every tourist is seeking a memorable experience, one that provides a good story worth sharing with others. Content that is lively and colorful—without condescension—rather than relentlessly instructive can frame such a story and highlight its appeal.

Geoscientists naturally gravitate in their writing toward helping people understand geologic features and concepts, but the geotourist first needs help selecting destinations they will enjoy, successfully arriving at the outcrop without confusion, and locating and observing the features of interest. Literature that does not support the full range of issues geotourists face will not deliver the “good story” they seek to capture. Indeed, careful selection of sites is an important first step in successful geotourism writing. While the province's geoheritage includes a wide variety of sites worthy of documentation and protection, only a subset of those are capable of delivering experiences of high quality that will meet tourists' expectations and perpetuate the province's reputation as a geotourism destination.

The geoheritage community in Newfoundland and Labrador could adopt a scoring rubric and use it to define an inventory of provincial geoheritage sites as well as a prioritized subset of geotourism sites. Then the adoption of a set of expertly developed content templates and guidelines would enable a variety of authors to generate useful geotourism pamphlets, booklets, phone apps, etc., having a consistent look and feel. Use of fixed-length or modular, pre-designed templates would be preferable. Populating them with content requires editorial decision-making that fosters clarity, impact, and consistency. Open-ended document formats would rarely be suitable for use in geotourism.

**Geotourism potential of Newfoundland and Labrador:
“the good, the bad and the ugly”**

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The term “geotourism” is relatively new, becoming mainstream after the 2002 release of an in-depth Geotourism Study commissioned by National Geographic Traveler magazine and conducted by the Travel Industry Association of America (TIA). Based on this study, geotourism was defined as tourism that sustains or enhances the geographical character of place - its environment, culture, aesthetics, heritage, and the wellbeing of its residents. While this definition emphasizes the “geographic” character of place, tourism researchers like Australians Newsome and Dowling (2010) prefer to highlight the “geological and geomorphological” aspects and define geotourism as a form of natural area tourism specifically focused on geology and landscape viewing. This geology-centred view for geotourism is ideally suited for the province of Newfoundland and Labrador, a case in point being the island portion of the province. The island of Newfoundland forms the northeast terminus of the Appalachian Mountains; a mountain system which developed in part due to closing of the Iapetus Ocean around mid-Ordovician time. This ocean-closing event and subsequent formation of a mountain system, however, is certainly not unique only to our province and numerous examples of mountain systems formed through plate tectonic processes may be viewed around the globe. What is unique, and therefore has the potential to offer a world class ‘geotourism’ experience, is the realization that global plate-tectonic processes are responsible for the formation of Newfoundland and Labrador and that the effects of these processes are easily observed in the rocks. From a tourism perspective, this is very powerful when one considers the thousands of kilometres of rocky coastline accessible by boat, and the province-wide road network linking urban areas and outlying coastal communities, thus providing access to an unlimited number of coastal sections, barren hillsides and roadside rock exposures.

Every single rock in the region tells a story and this story can be linked to the global plate-tectonic “Big Picture”. If done correctly this sets the stage for a new realm of tourism or “geology-based” geotourism in this province. The province of Newfoundland and Labrador is an outdoor geolearning classroom on a par with the best and it is no accident that earth scientists worldwide have come to our shores over the past forty years to view the rocks and test their theories and/or develop new concepts on plate-tectonic processes. Not every place in the world can lay claim to being called “the Galapagos of Plate Tectonics” and in local geological circles as “the Eighth Wonder of the World”.

Geotourism resource development, at least in the

initial stages, should require minimal development effort and expense. The resource is already in place and with provincial, regional and local consultation to develop a go-forward plan in combination with new government regulations or better policing of existing regulations, systematic development initiatives like site selection, access and interpretive materials can get underway. The key will be to enhance and promote the “GOOD”, minimize the “BAD” and eliminate the “UGLY” in order to ensure world-class geotourism development.

Not just for the birds: geological heritage and geotourism possibilities in the Cape Shore region

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The Cape Shore region, encompassing several communities between Placentia and Branch, along Route 100, is one of the most scenic regions of eastern Newfoundland, and maintains strong cultural links to its Irish roots. The huge seabird colony at Cape St. Mary's forms its premier attraction, and many visitors pass through the area from late June to mid-August. The region is also blessed with some spectacular geology, and wonderful coastal exposures, including some of the highest sea cliffs on the island. Its geographic location means that it is one of the foggiest places in the Province, especially during the summer months. However, unlike the birds, the rocks can (usually) be seen in such conditions!

Assets of geological interest include stratified sedimentary rocks of late Precambrian and Cambrian age exposed in towering cliffs, some folds that you can actually walk around on, more mafic dykes than most people can count, and a fossil locality that might be significant on a global scale. It also contains some of the finest sand beaches in Newfoundland. This presentation gives a general overview of possible sites that might have geotourism potential in the region, but these need linking in some way to other facets of this environment. The idea of a multi-stage hiking trail along the coast from St. Bride's to Branch is perhaps a concept that should be considered. Much of this coastline is scenically spectacular and barren, and such trails already exist in some areas; although the interior is boggy and damp, the coastal strip is generally well-drained and good for hiking. Such a trail would also traverse a wide range of environments within the southern hyperoceanic barrens ecoregion. Cape St. Mary's is a special place in many ways, and justly renowned for its close encounters with seabirds, but it is but one of many attractions along 70 km of spectacular coastline.

Facies variability from an Early Ordovician mud-rich deltaic deposit: Redmans Formation, Bell Island Group, Newfoundland, Canada

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Marginal marine mudstone systems are poorly known from the Palaeozoic. It is important to have a better understanding of these systems to more accurately assess the interplay of marginal marine environments, at the facies level, on geochemical signatures that are used for stratigraphic correlation. The interaction of bioturbation, sedimentation style, and organic carbon are directly linked to geochemical signatures and represent the control marginal marine environments have on these signatures.

We present a combined sedimentological-ichnological facies model for mud-dominated shoreface and shelf facies members in the Early Ordovician (477.7 Ma) Redmans Formation (Bell Island Group, Newfoundland). Over seventy metres of core from the Bell Island Group, Redmans Formation, have been described at centimetre-resolution. Twelve sedimentological facies have been recognized, comprising proximal, central, and distal distributary mouth bars, prodelta, bay fills, and possible channel deposits. The Redmans Formation is composed of thick quartz arenites interbedded (up to 3.25 m thick) with intervals of intensely bioturbated mudstone (up to 1 m thick). Sandstone ichnofabrics are dominated by *Diplocraterion* isp. and *Planolites* isp., whereas mudstone traces are more diverse and include *Cruziana* isp., *Planolites* isp., *Trichophycus* isp., *Diplocraterion* isp., other unidentifiable vertical and subvertical traces that range in size from 30 µm to 20 cm.

An array of ichnological and physical sedimentological textural information was used at a range of scales from outcrop to thin section to characterize facies. Sedimentological descriptions allow consideration of the relationship between organic matter abundance, distribution, and biogeochemistry with respect to palaeoenvironment in the Early Ordovician Redmans Formation. In addition the relationship between bioturbation and preserved organic matter quality is assessed.

**Volcanic stratigraphy and setting of the Hood
volcanogenic massive sulphide (VMS) deposit, Nunavut,
Canada**

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The Slave Province, Nunavut, contains numerous undeveloped and underexplored volcanogenic massive sulphide (VMS) deposits. The Hood deposit of the Hanikahimajuk Lake area, Nunavut (total resource of all lenses - 3.8 Mt @ 2.6% Cu and 3.8% Zn), located 425 km north of Yellowknife, NWT, remains poorly understood, in spite of intermittent exploration for the past 40 years. The Hood deposit consists of a cluster of lenses over a ~10 km² area hosted by the late Archean Amooga Booga volcanic belt. Re-logging of drill core has resulted in new stratigraphic reconstructions for the different lenses of the deposit, including the H10, H41 and H41A lenses. Mineralization is hosted in a bimodal volcanic sequence composed of basaltic and rhyolitic tuffs and flows. Basaltic and diorite dykes cross-cut the volcanic rocks. The volcanic and intrusive rocks are regionally metamorphosed to greenschist-grade. Younger (~2.58 Ga) pink granitoids have intruded all the above rocks and are associated with quartz-K-feldspar alteration. There are variations in the lithofacies, host rocks, and structural setting in each lens. The H10 lens is hosted in a steeply-dipping isoclinally folded sequence dominated by felsic volcanic flows. Stratigraphy of the H41 deposits lies at a near vertical angle and mineralized horizons occur near the contact of mafic and felsic volcanic flows. The H41A deposit is dominated by steeply-dipping mafic volcanic rocks including abundant mafic to intermediate tuffs. Volcanogenic massive sulphide-related alteration includes chlorite-quartz and sericite-quartz alteration that is strong in the immediate footwall of the various lenses and extends into the hanging wall. Mineralization in the lenses consists of massive and semi-massive pyrite-pyrrhotite-sphalerite-chalcopyrite and minor zones of stringer sulphides. Abundant clasts within the ore and abundant hanging-wall alteration are consistent with formation via sub-seafloor replacement.

**The development of an aspiring geopark on the Bonavista
Peninsula of Newfoundland and Labrador**

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As stated in the Guidelines and Criteria for National Geoparks seeking UNESCO's assistance to join the Global Geoparks Network (GGN), National Geopark initiatives, which seek UNESCO's assistance, should integrate the preservation of significant examples of geological heritage in a strategy for regional sustainable socio-economic and cultural development, safeguarding the environment. A group of local citizens on the Bonavista Peninsula in the province of Newfoundland and Labrador are aspiring to create a geological park that will one day be able to join the Global Geoparks Network (GGN).

Providing 500 years of fishing history and creating a resilient people who made their living off the cold harsh North Atlantic Ocean, Newfoundland is not only known for its unique culture, but also its geology. The island itself contains parts of the ancient continent "Laurentia" on the west coast, fragments of "Gondwana" on the east coast, and the seafloor of the "Iapetus Ocean" in between.

The rocks of the Bonavista Peninsula are part of the Iapetus Ocean's seafloor that created the micro-continent "Avalonia" approximately 480 million years ago in the early Ordovician period, which also resulted in the formation of the Rheic Ocean between it and Gondwana. With the collision of Laurentia and Gondwana in the formation of the continent "Pangaea" approximately 420 million years ago, Avalonia and the two seafloors were merged together with the two continents. After Pangaea broke apart, the Atlantic Ocean was created as the modern continents began to form. The Bonavista Peninsula, being left with pieces of Avalonia, is now a part of the present day "Avalonian Belt."

The earth history recorded on the Bonavista Peninsula spans from the late Precambrian to the Devonian (600 – 400 million years ago), and the rocks themselves range in age from the Ediacaran Period to the Cambrian Period. The area holds Precambrian fossils that provide evidence of the earliest multicellular life after "Snowball Earth" during the Ediacaran Period, approximately 580 million years ago. Among them are excellent examples of the "sun-like" *hiemalora*, "disc shaped" *aspidella*, "spindle-like" *fractofusus*, and *charniodiscus*, which are fern-like with disc shaped holdfasts. In an effort of protection, and with lobbying from local groups, the provincial government recently passed legislation prohibiting the removal or vandalism of these unique fossils.

With a unique geology, a distinct culture, and the desire to protect and conserve the geological heritage, the steering committee of the Discovery Geopark Project are well on their way to establishing North America's second Geopark.

Evaluation of uranium accumulation in black spruce trees

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This study evaluated the metal accumulation capacity of black spruce seedlings (*Picea mariana*) with a special focus on uranium, and compared uptake from peat and podzol soil treated with various concentrations of uranyl nitrate hexahydrate. Bioavailable indices for uranium in the substrates, accumulation factors, and transfer factors for translocation of U between different plant organs were estimated. The results showed higher concentration of U in shoots, with accumulation factors up to seven times greater than values determined in roots. Uranium accumulation in stems was several orders of magnitude higher than the metal content in roots and needles. Transfer from substrate to the plants was influenced by substrate-specific properties, resulting in higher uptake of U from soil than from peat. The pattern of U accumulation was consistent with that previously reported in field studies. Metal accumulation values also showed linear progression with bioavailable metal concentrations in the substrate suggesting that black spruce trees are best classified as bioindicators of uranium content in underlying substrates, rather than hyperaccumulators of the metal.

Magma mingling in the Avalonian Holyrood Granite, Newfoundland

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The purpose of this study is to examine the geometry and possible chemical interaction where intermediate magma intruded into felsic magma in the Holyrood Intrusive suite. The mapped outcrop is located in Holyrood, Newfoundland, at the end of Duff's Road, which is off the Conception Bay Highway (Route 60). The outcrop is approximately 30 m in length and 10 m wide. The host rock contains varying sizes of "blobs" of the intruded rock. Analytical techniques involved small-scale digital mapping of the outcrop, petrological examination and rock descriptions, and geochemical data analysis.

Mapping was performed by taking pictures over a grid laid out on the outcrop and then using a DGPS to assign each picture a coordinate. The coordinates were entered into Arc GIS where the map was assembled. The map is used

to characterize the geometries and size distribution of the "blobs", and their relationships to each other.

From the major-element composition of the rock types, relevant physical properties of the magmas such as density, viscosity, and liquidus-solidus temperatures were calculated using the software K-Ware Magma. The physical properties were needed to work out the dynamics of magma interaction.

Petrology and geochemistry have classified the host as granite, and the blobs as quartz-rich diorite to tonalite. The contact between the two rock types appears sharp in the outcrop but in thin sections it is more of a gradual boundary, with crystals of both rocks included in one another. Both the host and the blobs have undergone later alteration, shown by the alteration of biotite to chlorite, and the deposition of carbonate in some veinlets.

Sm-Nd and U-Pb isotope geochemistry of the Sweetwater Wash Pluton, Mojave Desert, California

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In-situ analyses of the isotopic and trace-element composition of minerals at the sub-grain scale have proven to be effective tools for understanding the origins and evolution of magmatic systems. The ability to simultaneously measure Sm-Nd and U-Pb isotopes by the Laser Ablation Split Stream (LASS) method allows a high-resolution spatial and temporal snapshot of crystallisation history.

The late Cretaceous Sweetwater Wash Pluton (SWP) in the Mojave Desert, California, provides an excellent opportunity to utilise these techniques in order to understand the petrogenesis of continental arc granites. This peraluminous granite is well understood in terms of field relations and geochemistry, allowing for detailed mineral-scale analysis. A preliminary study of monazite in the SWP suggests that the ϵ Nd signature of the source region is retained (~1700 Ma) yet U-Pb ages show an isotopic resetting during emplacement at ~75 Ma. Mineral-scale heterogeneity also demonstrates extreme isotopic disequilibrium in monazite and titanite.

The current study aims to further constrain the petrogenesis of the SWP and place it in its regional context. Recent fieldwork involved systematic sampling through a transect of the pluton to examine the spatial changes from the edge to the centre of the pluton as recorded in monazite.

Geological setting, geochronological constraints and the nature of mineralization at the Mosquito Hill (Huxter Lane) gold deposit, central Newfoundland

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The Mosquito Hill gold deposit in NTS map area 2D/5 of central Newfoundland was discovered in 1998, through prospecting and sampling of arsenopyrite-bearing quartz-feldspar porphyry float, in extensive till cover, immediately south of the Northwest Gander River. This geologically complex area contains, from NW-SE: Precambrian to Cambrian rocks of the Spruce Brook Formation of the Ganderian Mount Cormack Complex; the Cambrian ophiolitic Coy Pond Complex, and the Cambrian to Ordovician marine sedimentary and volcanic rocks of the Baie D'Espoir Group. Exploration work and ongoing geoscientific investigations indicate that Mosquito Hill mineralization is mainly hosted in non-foliated, quartz-veined and sericite-arsenopyrite-pyrite altered quartz-feldspar ± biotite ± hornblende-bearing, subvolcanic andesite-dacite porphyry (Mosquito Hill porphyry: MHP). The MHP ranges from fine- to coarse-grained and exhibits transitional contacts with compositionally similar crystalline lapilli tuff. The MHP is interleaved with affiliated volcanoclastic tuff, epiclastic sandstone, and grey and black graphitic shale and mudstone of the North Steady Pond Formation of the Baie d'Espoir Group, as well as a number of discrete mélange intervals. Mineralization consists of ≤ 15 % disseminated euhedral arsenopyrite spatially associated with pyrite, and abundant subhedral sericite grains and variable Fe-carbonate. Quartz veining appears to be slightly younger than alteration and highly anomalous gold is associated with abundant arsenopyrite rather than veining. Free gold has not been observed. Industry data have provided an NI 43-101 compliant resource of 11.18 million tonnes averaging 0.546 g/t gold for 196,257 ounces gold and an inferred resource of 38.76 million tonnes averaging 0.457 g/t gold for 569,496 ounces gold (0.3 g/t Au cutoff).

The LAM-ICP-MS U-Pb zircon geochronology for two samples indicates that the MHP crystallized during the interval ca. 508–469 Ma (494 ± 14 and 477 ± 8 Ma); the younger date overlaps, within error, the only other dated felsic volcanogenic rock (Twillick Brook Member, 468 ± 2 Ma), exposed in the easternmost Exploits Subzone. An

intermediate dyke that cross-cuts a portion of the mélange below mylonitized MHP yielded an age of 464 ± 7 Ma, placing a lower limit on the age of the volcanic rocks of the North Steady Pond Formation and demonstrating that some of the mélange must have formed in the Ordovician. Randomly oriented sericite, forming part of the alteration assemblage in the MHP, yielded two identical Devonian $^{40}\text{Ar}/^{39}\text{Ar}$ plateau ages of 406 ± 2 Ma. As these rocks preserve sub-greenschist facies metamorphic-mineral assemblages, the hydrothermal fluids generating the mineralization at Mosquito Hill must have immediately postdated regional widespread Silurian emplacement of bimodal granitoid intrusions and metamorphism and deformation in the Hermitage flexure to the southwest.

Gros Morne National Park – celebrating 500 million years as a geotourism destination

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Part of Canada's family of 44 national parks, Gros Morne National Park was established in 1973, and designated a UNESCO World Heritage Site in 1987. The rocks of Gros Morne National Park are world-renowned for the stories they tell of the formation of ancient mountains and ancient seas. The geology illustrates the theory of plate tectonics, one of the most important ideas in modern science, and every year we share this big idea with tens of thousands of visitors from all over the world: Gros Morne Geology ROCKS! This presentation highlights how we use technology, interpretive theatre, Artists in Residence, and new and old media to connect with audiences, both real and virtual, to expose the geological wonders found in the rocks, fossils, and layers of Gros Morne National Park. 2013 marks our 40th anniversary as a national park so we'll have some special geologically-themed programs. We'll be making personal connections and sharing stories about the rocks beneath our feet, helping us preserve and celebrate the spectacular geological heritage found in Gros Morne National Park.

Mistaken Point and the world heritage project – an update

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Being inscribed on UNESCO's World Heritage (WH) List is the most prestigious, formal, international recognition a fossil site can attain. Currently, the WH List comprises 962 properties of which only 13 are 'primary' Fossil Sites. To date, there are no Precambrian WH Fossil Sites.

Mistaken Point Ecological Reserve (MPER) is a globally significant Ediacaran fossil site located on the southeast coast of Newfoundland's Avalon Peninsula. Renowned as "the place where life first got big", the Reserve contains fossils of the world's oldest (579 Ma) and largest, architecturally-complex, multi-cellular organisms. In 2004, MPER was added to Canada's official Tentative List of World Heritage properties. The province's Parks and Natural Areas Division (PNAD) manage the Reserve and are tasked with producing MPER's WH-nomination dossier.

Attaining WH Site status is a protracted, complex, demanding (and expensive) process. Work on Mistaken Point's WH application began in earnest in 2010 with the hiring of a Project Lead. Much essential preparatory work remains to be done, but writing the WH dossier will commence later this year. The provisional date for submitting the dossier to the WH Centre is February 1, 2015.

A critical component of any successful WH nomination is the involvement and support of the local communities associated with the site. Considerable progress has been made in addressing MPER's perceived community engagement 'deficit'. In March 2012, a WH Public Advisory Committee was established and has since met seven times and held two strategic planning workshops. A WH Community Liaison has been hired (August, 2012) and Dr. Alistair Bath (Memorial University of Newfoundland) has conducted 'human dimensions' research and facilitated workshops in support of the nomination process.

Late in 2012, Dr. Alex Liu and Prof. Martin Brasier completed a detailed Global Comparative Analysis (commissioned by PNAD) of the world's 109 Ediacaran fossil sites. MPER performed extremely well in this Analysis—a result which demonstrates its possession of Outstanding Universal Value and provides a major boost to its chances of success.

The Ediacaran biota remains a "hot" research topic. A recently-published claim that some Ediacaran organisms were terrestrial is proving highly controversial. Palaeontological research at MPER continues apace with significant new discoveries being made. Coastal erosion in the Reserve is the subject of a M.Sc. thesis and is presently being monitored (using RTK GPS) by NL Geological Survey

staff. A geotechnical assessment of how best to stabilize the gravel slopes and rock walls above the main "D" and "E" surfaces has also just been completed.

Since 2007 there has been a dramatic increase in media coverage of MPER. In 2012, the Reserve was featured in NL Tourism's iconic "Find Yourself" advertising campaign. The total number of guided tour participants in 2012 increased by 118% versus 2011. Concerns over fossil wear on "D" and "E" due to foot traffic has prompted PNAD to investigate alternative public tour destinations.

Coastal erosion along the southeastern coastline of the Avalon Peninsula, Newfoundland

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In March 2009 a coastal-erosion project for the Mistaken Point Ecological Reserve (MPER) was undertaken with the purpose of understanding dominant erosional and depositional processes affecting the integrity of the coastline of the Mistaken Point Ecological Reserve. The 5.7 km² coastline within MPER is internationally known for its 565 Ma Ediacaran fossil-bearing horizons. The stratigraphic section contained within MPER is ~2.5 km thick, exposed as rock platforms and cliffs along an indented and morphologically variable coastline. The primary catalyst for the project was the reserve's entrance into Canada's official Tentative List as a potential UNESCO World Heritage Site. As a result, the importance of conservation management has been emphasized, with effectiveness that can only be assured once dominant processes, and rates of those processes, are identified along specifically chosen sites within the reserve. The four sites chosen for assessment include: two sites within Pigeon Cove (Western MPER) and two sites within Mistaken Point (central MPER). Observations have indicated erosional processes including: increased storm intensity and frequency, geological structure, angle of cove, as well as protective headlands that contribute to wave power and angle of hit. Sites with fossils present are also under threat of illegal casting (leaving behind erosive chemicals), and removal of fossils by diamond saw, creating weak points within the rocks' structure. Foot traffic due to visitation is also a concern at Mistaken Point. Further quantitative analysis is being undertaken to understand the rates of erosion that might be present at each of the above sites.

Geophysical investigations at Phillip's Garden, Newfoundland

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This paper presents the 2011–2012 geophysical investigations, including ground-penetrating radar and magnetometry, at the prehistoric site of Phillip's Garden, northwestern Newfoundland. The site was occupied from 1990 to 1180 BP (years before present). Phillip's Garden is the largest Dorset Palaeoeskimo settlement in the Canadian North, with the remains of at least 67 identified dwellings spread out over 2 ha; our 2012 research shows that there may be close to 150 dwellings at the site. Most dwellings at Phillip's Garden are large (ranging between 75 m² and 100 m²) and they are associated with many artefacts and animal bones. This makes the excavation of a dwelling time consuming and expensive.

The purpose of this study is to test the efficacy of geophysical methods at Phillip's Garden, which could non-intrusively identify the presence of dwellings at the site as well as their associated architectural features. This research builds on Eastaugh and Taylor's 2001 magnetometry survey of Phillip's Garden, who used the method to identify possible buried dwellings at the site. Based on data collection from two consecutive seasons, we concluded that geophysical methods are useful in identifying the presence of dwellings structures, including interior layout and some interior features.

While geophysical methods have been previously used in North American prehistoric archaeology, these studies have been focused on the establishing the presence/absence of sites using large intervals (1 m) between surveying transects. Our research operates at a much higher resolution with smaller sampling intervals (10 cm and 25 cm) between transects. This is significant for Phillip's Garden as it provides us with a non-invasive and fast way of investigating the dwellings at the site. Additionally, our research shows that geophysical methods can be used on more ephemeral hunter-gatherer sites in Newfoundland and elsewhere.

New U-Pb and Nd data for the Kiruna iron oxide apatite ores and their host rocks in the Norrbotten region of northern Sweden

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About 40 iron deposits near Kiruna in the Norrbotten region of northern Sweden are of the iron oxide-apatite (IOA) type, also referred to as Kiruna-type deposits. They are commonly considered a subgroup or end-member of iron oxide-copper-gold (IOCG) deposits, containing no economic grades of copper or gold. Both IOCG and IOA deposits are characterized by abundant low-Ti Fe oxides, enrichment in rare-earth elements (REE), and intense sodium and potassium wall-rock alteration adjacent to the ores. Deposits of these types are of a great economic importance, not only for iron, but also for other elements such as REE or uranium.

Kiruna, the type locality of the IOA type of mineral deposits, is the focus of this study, including the giant underground mine Kiirunavaara. Despite a century-long mining history and 2500 Mt of iron ore produced in the region to date (with grades of 30 to 70 wt % Fe), the genesis of these deposits is poorly understood: theories of a magmatic vs. a hydrothermal or metasomatic origin have been proposed, and the iron mineralization in the Norrbotten region has never been directly dated. The results anticipated from this study will provide a better understanding of the nature of the IOA type of mineral deposits and their relation to IOCG deposits such as Olympic Dam in Australia. An array of geochemical methods is used in order to gain insights into the emplacement history of the host rocks, their subsequent alteration, and the ore genesis of these deposits. This includes in-situ U-Pb geochronology of zircon, monazite, and titanite to constrain the timing between host-rock emplacement, alteration and mineralization. The combination of U-Th-Pb ages, tracer isotopes and trace element abundances at mineral scale (e.g., Lu-Hf in zircon, and Sm-Nd in monazite, apatite, titanite), along with the O-isotopic composition of zircon, will be used to decipher whether the Kiruna iron ore deposits are of metasomatic or igneous origin.

First Sm-Nd isotopic data point to distinct source differences between host rocks ($\epsilon_{Nd} \sim -6$), ore and heavily altered ($\epsilon_{Nd} \sim -3$ to -4) samples. Preliminary in situ U-Pb dating of zircon from both host rock and ore samples confirms a previously documented event around 1880 - 1900 Ma in the Norrbotten region. However, U-Pb in monazite from an ore sample suggests a further event at ca. 1624 Ma, a period of known activity in Fennoscandia.

Further investigation and more U-Pb data are needed to confirm those dates and how the iron mineralization is related to those two events. Overall, the study also intends to develop a predictive model for exploration of similar iron oxide-apatite deposits worldwide.

The Voisey's Bay footprint – tracking the geochemical signal of magmatic Ni-Cu-Co sulphide mineralization in northern Labrador

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The Voisey's Bay (VB) deposits constitute a significant new (discovered 1993) style of orthomagmatic Ni-Cu-Co sulphide mineralization. The sulphides are hosted by the Voisey's Bay Troctolites (VBT) in a feeder and magma chamber system which constitutes only a minute component of the aerially extensive (19,000 km²) Nain Plutonic Suite (NPS); the VBT is one of the oldest assemblages (ca. 1330 Ma) in the NPS and is essentially swamped by younger anorthosite and granite suites. The VBT is intrusive into Archean Nain Province orthogneiss and Paleoproterozoic Churchill Province enderbite and paragneiss. Notwithstanding intensive exploration of the NPS and host gneisses, no other examples of this type of mineralization have been found.

We report the preliminary results of three research projects funded by the Research and Development Corporation (RDC), Government of Newfoundland and

Labrador, through the GeoExplore program to detect and track geochemical footprints of the VB mineralization. Project 1 is examining the massive-sulphide mineralization from two perspectives, viz.; (1) mechanisms of sulphide-mineral breakdown due to oxidation by the atmosphere and ground waters, and the nature of mineral residues in till cover, and (2) conversely, explaining why upper surfaces of the Ovoid deposit were not oxidized. Variably oxidized sulphide minerals (pyrrhotite, chalcopyrite, and pentlandite) have been identified in till surrounding the Ovoid deposit. In pyrrhotite, oxidation appears to develop first along troilite-exsolution lamellae. The surface of the Ovoid massive-sulphide mineralization exhibits glacial striae and thus was essentially sealed from oxidation; the "seal" was determined to be a calcite-cemented clay layer. Project 2 is investigating three temporally distinct geochemical haloes that might be associated with the VB mineralization, viz.; (1) an Emplacement Halo in the contact aureole of the gneissic country rock associated with the VBT intrusion, (2) a Late Aqueous-Emplacement Halo formed as the VB sulphides were cooling, and (3) a Post-Emplacement Halo in younger NPS granitoids. Early analyses of primary fluid inclusions in quartz veins, seemingly derived during the late cooling of sulphides, suggest the presence of two-phase (liquid + vapour), low salinity (< 7 eq. wt% NaCl) H₂O + NaCl inclusions with a wide range of homogenization temperatures and phase ratios that precipitated from a boiling fluid at relatively low temperatures (<250 °C) and depths (< 300 m). Project 3 is evaluating whether a biogeochemical halo is present in black spruce trees and Labrador Tea shrubs surrounding the VB deposits. Preliminary results indicate Ni concentrations of up to ca. 40 ppm Ni in spruce bark from south of the Ovoid deposit compared with levels below detection limits in tree bark from control areas near Voisey's Bay and Anaktalak Bay. Factor analyses of the data indicate a sulphide loaded with Ni, Cu, Co, and Ag.