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Atlantic Universities Geoscience Conference 2015

ABSTRACTS

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65TH ANNUAL CONFERENCE HOSTED BY:
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Abstracts from the Atlantic Universities Geoscience Conference (AUGC) are published annually in Atlantic Geology. Such publication provides a permanent record of the abstracts, and also focuses attention on the excellent quality of the oral presentations and posters at the conference and the interesting and varied geoscience topics that they cover.

THE EDITORS

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Geochemical analysis of uranium mobilization from geologic formations in Nova Scotia, Canada

Oliver Blume

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

Many rock formations, particularly granitic rocks and sandstones of Devonian to Carboniferous age, may have an impact on the water quality of surrounding areas. Weathering and geochemical processes can mobilize uranium, which allows uranium to accumulate in ground water systems in concentrations above recommended guidelines established by Health Canada. It may also be possible that anthropogenic modifications can mobilize uranium from soil or rock. This study is focused on discovering the chemical agent or agents responsible for mobilizing uranium from uranium-bearing rocks in Nova Scotia. It is believed that both natural and anthropogenic causes may be behind uranium mobilization in some Nova Scotian locations. Road salt and sea water introduce ions into geologic formations that have a potential impact on uranium. Gypsum, either in the form of gyprock in construction waste or as naturally occurring geologic formations, introduces sulfate into bedrock and soil, which adds another variable to analyze. Ions such as chloride, calcium, sulphate, and bicarbonate will be analyzed in an attempt to isolate the variable (or variables) that mobilize uranium. A leaching experiment using ground rock samples and controlled extraction fluids will aim to isolate the geochemical process or processes responsible for the accumulation of uranium in Nova Scotia ground water. [Poster]

Fine-grained sediment distribution, stratigraphy, and ichnology in closely spaced cores from the Lower Clearwater Formation, Athabasca oil sands, Alberta, Canada

Celine Chow

Department of Earth Sciences, St. Francis Xavier University, Antigonish, Nova Scotia, B2G 2W5

Detailed stratigraphic descriptions and sedimentology of 14 vertical wells were used to correlate lithofacies within the Lower Clearwater Formation. Located in the Mobile Water V pattern in the southeast part of the Firebag Project in northern Alberta, these wells were drilled between 25 and 50 m apart from each other. The close spacing of these wells allows for detailed lithofacies, structural, and lithological analysis. Vertical heterogeneity and lateral continuity were mapped within the Lower Clearwater Formation. Trace fossil assemblages and sedimentary structures were used to correlate 14 different lithofacies packages from well to well and were used to define 7 lithologies. It was determined that these lithofacies were part of nearshore to offshore marine environments which underwent several sea level changes. Detailed correlation shows variation in structure and lithological packages over less than 300 m. Expanding this study to a more regional area outside of the Mobile Water V pattern and into a larger portion of the Firebag Project area has shown that the detailed correlations continue in the Lower Clearwater Formation. The goal of this study is to expand the correlations to encompass the whole of the Firebag Project area and to see how far the correlations continue. From the results of this study, a solid base of information was collected that can be used to examine variations in rock integrity and the relationship between the reservoir and non-reservoir. Determining the detailed sedimentology of the Lower Clearwater Formation in the Firebag Project area will be significant for future SAGD oil and gas exploration and production.

Constraints on the geochemical provenance of refined copper and brass artifacts from Nova Scotia, Canada: insights into the metallurgical and trace element systematics of European contact-era trade alloys brought to Atlantic Canada

Paige Fleet[1], Glen Hodge[1], Jacob Hanley[1], Katie Cottreau-Robins[2], Brandon Boucher[3], Chris Mcfarlane[3], Graham Layne[4], Bruce Stewart[5], and Mike Sanders[5]

1. Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3 ¶ 2. Nova Scotia Museum of Natural History, Halifax, Nova Scotia, B3H 3A6 ¶ 3. Department of Earth Sciences, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3 ¶ 4. Department of Earth Sciences, Memorial University, St. John's, Newfoundland and Labrador, A1C 5S7 ¶ 5. Cultural Resource Management Group Ltd, Halifax, Nova Scotia, B3K 1T8

Trace element concentration data for copper artifacts of suspected European origin were analyzed using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). The raw data for 21 trace elements was organized into Excel spreadsheets, where raw data values below the limit of detection were replaced with the limit of detection value. Average trace element concentrations in parts per million were calculated from 5–15 analyses of the same object. Standard deviation values for each average were used to identify significant outliers outside the range of 2 sigma values, which were removed from subsequent plots. Average and standard deviation values were used to plot comparisons of first to last 9 seconds of data collection for all elements in a given object, series of direct ratios of elements, and series of two-element ratio comparisons as well. In particular, ratios of Au/Ag against As/Sb were used to distinguish groups of European copper objects that differed in the quantities of these diagnostic trace elements. Despite originating from the same archeological sites, many objects plot in close proximity to one another, as expected. For instance, spread in the range of two orders

of magnitude with respect to the As/Sb ratio and one order of magnitude for the Au/Ag ratio was observed between 15 objects found in Pictou, NS. Trace element data for copper coinage of various years from French, Swedish, Spanish, Netherlands, English, and Hungarian origins were also analyzed via laser ablation. The concentration data of 17 elements for the copper coinage was compared to that of copper objects in order to start dating, determining provenance, and grouping objects based on similarities between their compositions. Preliminary results suggest that the diversity of alloy trace element compositions show affinities to French, English, and Swedish coinage from the 17th Century. [Poster]

A unique paragneiss-hosted monazite-xenotime mineralized zone in Highland Falls, New York: a petrogenetic analysis

Eric A. Garcelon and David R. Lentz

Department of Earth Sciences, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3

In southeastern New York State within the Mesoproterozoic Grenville Orogen, the Hudson Highlands is metamorphosed to granulite facies, consisting primarily of locally migmatitic paragneiss, and intruded by late tectonic granite and pegmatite. The study area is a 200 m-long road cut outcrop in which the dominant lithology changes from granite/pegmatite, to migmatite, and then to paragneiss. At the contact between the migmatite and paragneiss (apparently conformable), a narrow zone is composed almost entirely of monazite and xenotime (mz-xn zone) with an average grain size of ~1 mm and enveloped by coarse biotite. This mz-xn zone is approximately 0.25–1 m wide and 4 m in extent in the outcrop. It is a weakly deformed, steeply dipping (80°), and striking NNE. Based on previous research and confirmed in this study, the mineralized zone contains 1.0% U, 3.8% Th, 35% total REE (enriched HREE), 19% Y, 0.2% Zr, and has a large negative Eu anomaly. A previous study identified cores and rims in the zircon, monazite, and xenotime, which were analyzed to develop a U-Pb geochronologic history. Detrital and xenocrystic zircon cores in the mz-xn zone have ages of 2065–1270 Ma. The proximal granite intrusion has an age of 1058 ± 14 Ma. Zircon, monazite, and xenotime cores in the mineralized zone formed between 1004–1034 Ma, as well as homogeneous rims on the paragneiss zircons. Over the next 130 Myr, three separate dissolution-reprecipitation rim populations were identified in each mineral. The petrogenetic process has been interpreted as metasomatic replacement of the paragneiss, based on the geochronologic constraints and intracrystalline zoning textures; the main objective of this study is to determine the source and nature of those metasomatic fluids. Mineral trace element analysis, including W zoning in molybdenite, shows high T characteristics typical of hydrothermal and magmatic systems, making the involvement of a late tectonic A-type, NYF-type pegmatite typical of the Ottawan phase of the Grenville Orogeny probable. A high temperature hydrothermal fluid or an immiscible hydrous phosphate melt, derived from a pegmatite at depth, are possibilities. This will be examined based on textural interpretation at multiple scales, microprobe analyses of biotite and other accessory phases, geothermometry, tracer isotope systematics, and compositional dynamics.

Preliminary interpretation of the geological history and characterization of a Paleoproterozoic metasedimentary cover sequence near Daly Bay Complex, Nunavut, Canada

Billy Garrison and Mike Young

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

The nature and timing of collision between the Archean Rae and Hearne cratons of the Western Churchill Province remain uncertain. The Snowbird Tectonic Zone (STZ) is a 2800 km-long belt separating units with highly contrasting geological and geophysical properties and is thought to represent the suture between these two cratons. Paleoproterozoic (2.2–2.0 Ga) sedimentary cover sequences on the Rae and Hearne cratons are generally distinct from each other and thought to have formed independently prior to collision. More recent studies on the tectonometamorphic history of the STZ dispute the assertion of a 1.9 Ga STZ suturing event and instead suggest a much earlier (ca. 2.5–2.3 Ga) collision. The study area is in eastern mainland Nunavut near the northern boundary of the Daly Bay Complex and may contain the closest known cover sequence relative to the STZ. As part of the Geological Survey of Canada's Geo-mapping for Energy and Minerals program, a suite of samples was collected along with field observations and structural data. The main purpose of the study will be to characterize the different units within the cover sequence and to define a relative geological history. This will be done using field observations as well as microscopic analysis and subsequent comparison of the units to other cover sequences overlying the Rae, Hearne, and Daly Bay Complex. In addition to the characterization and comparison of the cover sequence, five samples were collected within a gossanous zone for geochemistry/assay to assess any economic potential. The Western Churchill Province is one of the largest fragments of Archean crust, although it is still poorly known overall. The characterization of the stratigraphic units and detrital zircon geochronology will help us discern the provenance of the cover sequence, and in doing so will help us to better understand the timing of the collision of the Rae and Hearne cratons.

A preliminary look at the field and petrographic relationships of intrusions of the Tilting Harbour area, Fogo Island, Newfoundland, Canada

Emily Gorner and Greg Dunning

Department of Earth Sciences, Memorial University Newfoundland, St. John's, Newfoundland and Labrador, A1B 3X5

The geology of Fogo Island shows a complex history of magmatic intrusions intruding volcanic and sedimentary rocks. Field work between Tilting Harbour and Oliver's Cove on the northeastern coast of Fogo Island included mapping this area to determine relative age relationships, describe the rock units, and sample for petrography and geochemical and geochronological analyses. Mapping determined that there are intrusions of granite, biotite- and hornblende-quartz diorite and mafic layered rocks within approximately 1 km of coastline. These are cut by late bimodal mafic-felsic dykes. The layered rocks are represented in two different areas: the first area extends across the mapped peninsula from Tilting Harbour to the east side of the peninsula and has been intruded by a differentiated diorite sill. The other is a mafic sill that shows differentiated cumulate layers that have been sampled for geochemical analysis and is intruded at one end by a bimodal dyke. Polished thin sections were made of the various units and across the layering of the mafic sill. Petrographic work has so far shown cumulate layering of olivine/pyroxene/plagioclase with oikocrystic amphibole within the first layered mafic unit, and different generations of amphibole with relict pyroxene within the diorite sill among other interesting relationships and textures. The electron microprobe will be used to analyze cumulate phases and any other samples of interest to document the change in mineral composition with differentiation, and the SEM-MLA will be used as a complement to the petrography to look at textures on a finer scale. U-Pb zircon ages of 2 key rocks will be determined by thermal ionization mass spectrometry in order to correlate magmatic events on Fogo with those elsewhere in Newfoundland.

Petrological and geochemical examination into the Fe-oxide-bearing hydrothermal breccias at the Moran Lake Upper C-Zone deposit, and the Poz Pond, Trout Pond and Armstrong Lake occurrences

Mark Grant

Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, A1C 5S7

The Central Mineral Belt (CMB) of Labrador is a 260 km-long easterly to northeasterly linear trend of supracrustal sedimentary and volcanic rocks and associated granite extending from the eastern coast of Labrador to the Smallwood reservoir and known for multiple base metal and uranium occurrences. The occurrences seen at Moran Lake C-Zone area are the basis for this project. Bedrock mapping in this area by Ryan in 1984 showed 3 main lithology groups including the Moran Lake Group, Bruce River Group, and the Kanairiktok Intrusive Suite. Mineralization at the Upper C-Zone deposit is recognized by fracturing/shearing, hematitization with chalcopyrite-, pyrite-, and bornite-bearing quartz-carbonate veining of Joe Pond Basalt (Moran Lake Group). Geochemical signatures of mineralized areas include enrichments in K, Nb, and LREE with depletions in HREE and Ti. The goal of this project is to provide a better overall understanding of mineralization relationships at the above occurrences and with the presence of Fe-oxide-bearing breccias, a relation to IOCG-type deposits is plausible.

Fe-oxide altered breccias are diagnostic features of Iron Oxide-Copper-Gold (so-called IOCG) or Olympic Dam-type mineral deposits. They are low-grade, high-tonnage deposits rich in a variety of commodities including iron, copper, gold, and silver with by-product uranium and REEs, and as such they are highly prized exploration targets. A number of Fe-rich breccias have been identified in the Central Mineral Belt (CMB) of Labrador. Detailed information on these CMB occurrences is lacking, this study will characterize mineralogy and geochemistry in particular, of the iron-oxide-rich breccias at the Moran Lake Upper C-Zone deposit. Data will be documented, and then compared with other breccia occurrences along strike including the Poz Pond, Trout Pond and Armstrong Lake occurrences. Emphasis will be focused put on defining the alteration assemblages and the particular assemblage(s) and associated geochemical signatures directly linked with uranium mineralization.

Techniques to be used include: (1) autoradiographs of samples to determine the distribution of radioactive uraniferous phases in the breccias, (2) major and trace element geochemical analyses to determine the signature of the alteration and host rocks, (3) petrographic examination of polished thin sections made from selected samples to examine the mineralogy of the breccias and natures of cross-cutting relationships, and (4) MLA-SEM mapping to determine more detailed mineralogy of the breccias.

Mid-Canada Corridor: sustainable mining development for the future

Fiona Henderson

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

The Mid-Canada Corridor holds 50 to 70 % of the wealth in Canada and is the driving force for economies in our major cities. It is a resource rich region, particularly in lumber, minerals, oil, and gas) stretching from west to east, slightly north of the metropolises. Although it has a fairly habitable climate, Canada's corridor lacks sustainable

long-term infrastructure, population, and the stability of local economies. Mining development and the presence of infrastructure is well associated and dependent on each other. The growth of most cities and towns, (mining towns) within the corridor can be strictly based off the success of the mining industry's prospects. The lack of a stable economy within these communities often arise after the resource within a given area is fully exploited, which eventually leads to the degradation of infrastructure. In turn, as the extractive industry continues to evolve within this belt, lack of infrastructure will begin to pose more issues and increase costs towards mining development. Development within the Mid-Canada Corridor will continue to become more important (to Canadians and geologists) as access to the North's natural resources increases and becomes more economic with climate change. [Poster]

Fluid inclusion and stable isotope study of gold formation in the Lavoie-Maisie Gold District, northwestern New Brunswick, Canada

Glen Hodge[1]*, Jacob Hanley[1], and Jim Walker[2]

1. Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3 ¶ 2. Geological Surveys Branch, Energy and Mines, Bathurst, New Brunswick, E2A 3Z1

Hosted in the late Ordovician sediments of the Grog Brook Group, the Menneval gold occurrence in the Lavoie-Maisie Gold district is a gold-bearing quartz vein striking northeast with a strike length of ~600 m (with gold grades ranging from trace to >10g/t). The first discovery at Maisie was in 2011 by M. Taylor, which led to more detailed exploration in the region to further understand the conditions of formation of the gold occurrences, as well as the full expanse of the gold occurrence. Minimum conditions of entrapment and fluid isochores for the system are being determined through fluid inclusion studies of two phase quartz-hosted fluid inclusions (L+V). The average minimum trapping temperatures resulting from these measurements is 177.58 ± 31.10°C for 55 single inclusions measured, with the average salinity being 2.77 ± 0.03 wt% NaCl. Additional constraints on vein formation temperature are being constrained by the chemistry of quartz (Ti-in-quartz thermometry) and rutile (Zr-in-rutile thermometry) in the mineralized veins by means of LA-ICPMS (University of New Brunswick). The timing of rutile formation is unclear at present but initial data suggest that the hydrothermal system locally reached much higher temperatures than suggested by regional metamorphic assemblages. Trace element chemistry of the rutiles in the veins, wall-rocks and associated Ti-bearing oxides in the porphyry intrusion are being compared in order to determine whether the rutile in the veins are wall-rock derived, or crystallized from the same fluids that sourced the gold (possibly from the intrusion). Cathodo-luminescence has been used to examine growth textures and brittle structures in the vein quartz in order to determine whether different generations of fluids can be linked to specific growth periods in the veins. SIMS oxygen isotope results (University of Manitoba) showed very little variation in isotope ratios suggesting that either the quartz vein underwent a number of opening-closing cycles which would restore the initial isotope values of the parental fluid reservoir (i.e., open system), or that there was mixing of fluids, with sources being close in isotope values. The more likely of the two scenarios with the data thus far would be mixing of fluids, involving hydrothermal and metamorphic sources similar salinities and temperatures. Further data are being collected to better constrain the temperatures of the quartz veining, which will then allow fluid sources to be clarified. [Poster]

Winner of the Imperial Oil Award for the best poster presentation

Petrographic analysis of major and trace element partitioning during assimilation of quartz xenoliths into the lava of the 2013-2014 New Southeast Crater eruption, Mt. Etna, Sicily

Rilea N. Kynock

Department of Earth Sciences, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3

Mt. Etna is a continental volcano with multiple cinder cones on its flanks and several craters in its summit area (approx. 3000 m high, with an area of 190 km^2 around). The powerful eruptions that began at the end of 2013 developed into strombolian lava fountains that blanketed the area around the new southeast crater with fresh volcanic rock. Twenty-one samples of volcanic rocks in contact with quartz xenoliths from the siliceous metasedimentary basement were collected from the December 2013–January 2014 eruption at the new southeast crater. The goal of this study is to examine the petrography and mineral/glass chemistry of both the lavas and the xenoliths to decipher the patterns of element partitioning during assimilation of the xenoliths. The xenoliths comprise subrounded and embayed quartz and interstitial glass as well as rare poikilitic clinopyroxene crystals. The host lava comprises phenocrysts of complexly zoned, plagioclase and clinopyroxene, as well as forsteritic olivine, and Fe-rich oxides all of which are in a glass- and microlite-rich groundmass. Between the lava and the quartz-rich xenoliths there is commonly a zone of mixing in which melts from the lava and xenolith are co-mingled. Preliminary analyses show that glass in the quartz xenoliths is more silica-rich than that in the lava but has similar amounts of Al_2O_3 and K_2O as the lava. The lava is enriched in Na_2O, MgO, CaO, TiO_2, and FeO. With these preliminary petrographic and chemical data we can test a model in which Etnean lava infiltrates the xenolith and

dissolves quartz, and crystallizes secondary clinopyroxene. The amount of clinopyroxene crystallisation required to give the observed compositional trends is generally consistent with the petrographic observations. However, the extreme enrichment of K_2O in the most silica-rich glasses cannot be explained by such a model. We propose that potassium enrichment in the silica-rich glass occurs because K is preferentially partitioned into polymerised melts over depolymerised melts. The remainder of this study will focus on defining this behaviour using LA-ICPMS analyses of the coexisting high-silica and low-silica glasses.

Evaluation of Nexen interest and competitor land throughout the Corner Property, northeastern Alberta Canada

Daniel Macleod*

Department of Earth Sciences, St. Francis Xavier University, Antigonish, Nova Scotia, B2G 2W5

Located in northeastern Alberta, the Corner Property lies within the world's largest natural oil sands deposit known as the Athabasca Deposit. The Corner Property includes over six townships, in which the wireline for 680 wells was interpreted, and the core for 10 wells was logged as part of this study. The data supports the notion that the McMurray Formation was deposited during the Cretaceous within an estuarine environment that was dominated by four, temporally isolated, valley systems. Residing within these valley systems are the unconsolidated bitumen rich "pay" zones that have been the target of over 200 years of exploration and production. The main objective of this study was to evaluate the potential of Nexen as well as competitor land throughout the Corner Property by distinguishing between the various valley systems. Seismic information was incorporated to create an integrated geological and geophysical interpretation of the project area. The results of this study indicate that the younger valley incisions contain the most prolific pay zones and therefore should be the focal point of future work within the area.

Winner of the Canadian Society of Petroleum Geologists Award for the best petroleum geology-related presentation

Petrology of the Chuggin Road complex, Creignish Hills, Cape Breton Island, Nova Scotia, Canada

David S. Maguire and Sandra M. Barr

Department of Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia, B4P 2R6

The Chuggin Road complex is located in west-central Cape Breton Island at the northeastern tip of the Creignish Hills. It is situated in the Bras d'Or terrane, which is characterized by Neoproterozoic metasedimentary and plutonic rocks. The Chuggin Road complex is part of the Bras d'Or metamorphic suite, characterized by high-grade metamorphic units. An orthogneiss in the Chuggin Road complex previous yielded a U-Pb (zircon) age of 561 ± 3 Ma, interpreted to represent the igneous crystallization age of the tonalitic protolith of the orthogneiss and providing a minimum age for the metasedimentary components of the complex. However, the associated metamorphic and igneous rocks have not been examined or compared to other parts of the Bras d'Or metamorphic suite elsewhere in the Bras d'Or terrane, which is the goal of the present study. Eighteen samples were collected from the varied igneous and metamorphic rocks exposed in two quarries near Chuggin Road in order to investigate their petrography, mineral chemistry, and whole-rock chemistry. Samples include mafic orthogneiss, biotite-rich gneiss, mingled diorite and granite, hornblendite, tonalite, quartzite, quartzofeldspathic banded gneiss, calc-silicate rock, and marble. The rocks are cut by faults, sulphide-bearing shear zones, and mafic dykes. In the western side of one of the quarries, interlayered quartzite and marble are overthrust by gneiss. [Poster]

The geochemistry and genesis of calc-alkaline mafic dykes in the Dalradian Supergroup of County Donegal, Ireland

Alex Martell and Brendan Murphy

Department of Earth Science, St. Francis Xavier University, Antigonish, Nova Scotia, B2G 2W5

The Grampian terrane is located in the Caledonian orogenic belt of Ireland and includes the ca. 428–400 Ma Donegal Granite Complex (DGC), which intrudes the Late Precambrian Dalradian Supergroup. Three stages of deformation that pre-date granite emplacement are recognized in the Dalradian metasedimentary rock. Coeval with granite emplacement was thermal metamorphism and the pelitic members of the host rock around most of the aureoles consist of rather fine-grained chlorite-muscovite-quartz schist that locally contains biotite and garnet. Classic studies of the DGC have provided fundamental insights into some of the mechanisms of intrusion of granitoid rocks. However, the time and spatial relationships as well as the mantle processes between the large DGC plutons and smaller, more mafic bodies that are associated with the complex are unclear. The area around the Ardara Pluton of the DGC, widely interpreted as a classic diapir, provides an excellent, local opportunity to study its genetic linkage with suites of mafic dykes (widely reported as lamprophyres) that occur adjacent to the aureole of the pluton. Petrographic and electron microprobe analyses of the mafic samples collected from the field indicate that most of the dykes contain primary hornblende; however almost all of the samples have been altered and are dominated by secondary

minerals such as chlorite and calcite. In addition, magmatic zircon has been recognized in several samples, and U-Pb dating of these zircons will test the widely assumed temporal relationship with the Ardara Pluton and the DGC. The geochemical data suggest that the classification of the mafic dykes as lamprophyres is in error. Given the often-cited genetic relationship between the presence of lamprophyres and mineral deposits, this conclusion has important implications for mineral exploration. The analytical results of the major elements indicate the mafic dykes in this region are potassic, calc-alkaline intrusions. Their rare earth elements are of the light rare earth element enrichment type. Moreover, they have high contents of Ti and P. Further understanding of the petrographical and geochemical characteristics of these mafic dykes can resolve the enigmatic relationship between the DGC and the associated mafic intrusions.

Petrology and geochemistry of the Jeffers Brook pluton, western Cobequid Highlands, Nova Scotia, Canada

Katie M. Mcculloch[1]*, Sandra M. Barr[1], and Trevor G. Machattie[2]

1. Department of Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia, B4P 2R6 ¶ 2. Department of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, B3J 2T9

The Cobequid Highlands of northwestern mainland Nova Scotia have a complex tectonic history, and are considered to form part of the southern margin of Avalonia. The area is generally interpreted to have developed as a series of volcanic arcs and back-arc basins on the periphery of Gondwana. The highlands are divided into two distinct fault-bound crustal blocks - the Jeffers block to the north and west, where the Jeffers Brook pluton is located, and the Bass River block to the south and east. Although the Bass River block contains widespread late Precambrian plutons, the Jeffers Brook pluton is the only dated late Precambrian pluton in the Jeffers block. Although mineral analyses and petrological studies have previously been done, the field relations have not been examined in detail and the pluton has not been systematically compared to plutons of similar age in the Bass River block. For this study, the pluton was mapped and sampled for petrographic study. It consists dominantly of coarse-grained granodiorite, with quartz diorite and tonalite components. They all contain fine-grained enclaves of diorite, quartz diorite and tonalite. Preliminary whole-rock chemical data from 10 samples of the granodiorite indicate that they are a calc-alkalic suite likely formed in a continental margin subduction zone, similar to coeval and potentially co-genetic plutons in the Bass River block. This project will lead to better understanding of the significance and implications of the current lithotectonic subdivision of the Cobequid Highlands.

Winner of the Science Atlantic Best Paper Award for best overall presentation

Exploration groundwork at Michichi (Mississippian stratigraphic architecture), Alberta Canada

Daniel Meagher

Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B2H 3C3

The Banff Formation of Southern Alberta is a Mississippian carbonate ramp deposit that has compelling oil and gas potential. Accordingly, the Banff Formation has been a focal point for exploration and development projects in the Western Canada Sedimentary Basin. Exploration groundwork involving the characterization of the sequence stratigraphic architecture of the Banff Formation was needed to extend Husky Energy's active development areas in Michichi, Alberta. Husky's exploration team had previously developed a core-based depositional facies model within a sequence stratigraphic framework for their active Michichi assets. The central objective of the present research was to build on this depositional facies model so that it fits the observed geology of the Banff Formation to the west of the active assets. The surrounding geology was assessed by direct observation of select drill core, typing core to wire-line well logs, correlating wells in a regional cross-section network, and producing isopach maps of the reservoir facies. The reservoir facies maps represent new play fairways and enhance the capacity to make informed bids on open crown land and to potentially extend Husky's active development in Michichi, Alberta.

An exploration into ancient fluid chemistry in the Canadian Shield at the Lupin orogenic gold deposit, Nunavut, Canada

Daniel Meagher, Jacob Hanley, Mitchell Kerr, and Kevin Neyedley

Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3

The objectives of this senior thesis are to: (i) characterize the volatile chemistry and origin of hydrocarbon-carbon-dioxide-nitrogen-rich fluid inclusions occurring in the Lupin deposit, an Archean orogenic gold system hosted within banded iron formation in Nunavut, Canada, (ii) compare the fluid chemistry and origin of these Archean volatiles to those in modern petroleum -natural gas systems as well as other orogenic gold systems, in order to discern whether volatile compositions are diagnostic of their formation via abiogenic vs. biogenic processes, and (iii) develop exploration criteria that can be used to locate Archean gold systems under buried cover.

An extensive analytical study of the chemistry of the fluid inclusion gases in the Lupin deposit was undertaken by using in-line crushing gas-chromatography, laser Raman microscopy, microthermometry, and N-S-C-H isotope

systematics of inclusion fluids and associated altered host rocks. These analytical tests constrained the temperature-pressure window of entrapment of these phases. Comparison to gas chemistry in conventional hydrocarbon systems was done to establish petrochemical criteria as to the diagnostic aliphatic hydrocarbon species that allow differentiation between biogenic (bacterial reduction, thermal maturation) vs. abiogenic (polymerization, Fischer-Trophsch) synthesis, and differentiation between barren and mineralized metamorphic rock suites in Archean greenstone belts.

Specific questions at Lupin that the research is addressing include: (1) What fluids transported gold and what physiochemical mechanisms caused its precipitation? (2) Does the fluid inclusion record support key elements of the genetic model for the deposit? – timing of ore fluid formation and migration with peak metamorphism? – coincident with the emplacement of Archean granitoid batholiths (3) Do the chemical characteristics of fluids provide any indication of their source (and therefore, gold source)? (4) Can deposit-scale variations in the gold grade associated with the quartz veining be rationalized with the local fluid characteristics? [Poster]

Effects of solid-to-solution ratio on copper (II) and zinc (II) adsorption onto natural sediment: an experimental and modeling study

Kazuhito Mizutani*

Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, A1C 5S7

Adsorption of heavy metal ions to sediments in the subsurface significantly influences the fate and transport of heavy metals. Laboratory batch experiments, in which sediment samples are mixed with heavy metal-spiked solution, are frequently used to study heavy metal adsorption and to determinate partition coefficient (*K*D) for heavy metals. However, the solid-to-solution ratio in most laboratory experiments is much lower than that in natural soil or aquifers. Therefore, it is not clear that if those batch experiments can mimic heavy metal adsorption in natural environment. The objective of this study is to investigate if solid-to-solution ratio influences heavy metal adsorption. Copper and zinc adsorption onto a natural sediment was examined in the pH range of 3.0 to 8.0 using batch experiments at solid-to-solution ratio of 25 and 250 g/L respectively, and results showed that the partition coefficient is strongly influenced by solid-to-solution ratio for certain pH ranges. Cu and Zn adsorption to the sediment was simulated using surface complexation modeling approach via computer software Visual MINTEQ, and model prediction showed that Cu and Zn adsorption is controlled by solid-to solution ratio under specific conditions, in agreement with the experimental measurements. This study demonstrates that the partition coefficients of heavy metals measured by laboratory batch experiments could not be an appropriate proxy for partition coefficients in natural environments under certain conditions.

Winner of the Atlantic Geoscience Society Award for the best Environmental Science presentation

Chemostratigraphy of Late Proterozoic carbonate units in the northern Selwyn basin, east-central Yukon, Canada

Colin Padget

Department of Earth Sciences, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3

The stratigraphic relationships between Proterozoic successions on opposite sides of the Dawson thrust in central Yukon, Canada, have previously been ambiguous, but recent mapping suggests correlation of the Hyland Group (Selwyn basin) with upper parts of the Neoproterozoic Windermere Supergroup (Yukon block). In order to test this stratigraphic correlation, a focus has been placed on the sedimentological, petrographic and chemostratigraphic characteristics of two carbonate markers in the Selwyn basin for comparison with well-studied strata of the Windermere Supergroup. The δ^{13}Ccarb chemostratigraphic data from these carbonate strata support correlation of the lower carbonate marker (part of the Yusezyu Formation of the Selwyn basin) with the Gametrail Formation and the upper marker (Algae Formation of the Selwyn basin) with the Risky Formation of the Windermere Supergroup. The δ^{13}Ccarb values in the Yusezyu Formation carbonate define a clear trend from ~-13‰ (VPDB) at the base to ~0‰ at the top of this unit. This δ^{13}Ccarb excursion has been correlated with the Ediacaran Shuram/Wonoka Anomaly, which is documented globally in rocks deposited ~580–560 Ma. Preliminary δ^{13}Ccarb data from the Algae Formation record subtle oscillations between -0.7 and 5.6‰, which is broadly similar to previously published results from the Risky Formation. The large negative excursion documented at the top of the Risky Formation in some platformal sections has not been identified in basinal strata of the Algae Formation. The stratigraphic relationships substantiated by these correlations suggest that deposition of the Hyland Group and final rifting of the NW Laurentian margin took place during the late Ediacaran.

The only known tin deposit in the Chilean Andes: Tignamar district, Arica

Nathan Pidduck and Marcos Zentilli

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

Within the Central Andes lie metal deposits associated with magmatism arising from oceanic lithosphere from subduction under the South American continental crust. The famous tin-rich deposits containing some of the highest concentrations exist in the Andes of northwestern Argentina, southern Peru, and Bolivia are associated with Paleozoic to Pliocene igneous rocks. Chile geographically adjacent has magmatic centres of similar age and yet does not contain any tin deposits., with one exception, the Capitana Mine, located in northern Chile in the Belén-Tignamar district, in the heights of the Andes near Arica (18°35'S; 69°30'W). The initial reporting of Capitana ore vein hosted 7% Sb, 0.1% Ag, 5% Cu, 2.5% Pb, 11.8% Bi, and 4.7% Sn. The Capitana system is a high- to- intermediate sulfidation polymetallic epithermal system formed within a Miocene volcanic centre intruding Mesozoic and Cenozoic volcanic rocks. A unique hand sample of vein quartz with ore collected in 1963 was studied exhaustively for this project. Ore-microscopy recognized pyrite, sphalerite, chalcopyrite, tetrahedrite-tennantite, covellite, bismuthinite and traces of orpiment and stibnite. X-ray diffraction confirms the presence of some rare sulphosalts containing tin.

The geological map offers some clues concerning the presence of this unique tin deposit in Chile. The Belen-Tignamar District is underlain by a tectonic slice of Proterozoic-Paleozoic metamorphic rocks known as the Belen Metamorphic Complex (BMC), with rocks identical to those in the basement of the Bolivian tin province. Lead isotopes in the Capitana ores match those of the BMC. Either the tin in Capitana was remobilized from these rocks, or carbon-rich pelitic schist in the BMC interacted with the Tertiary magmas reducing them and leading to the concentration of divalent tin in residual fluids responsible for the unique epithermal tin deposit. [Poster]

Thermal history of the Silurian Passamaquoddy Bay mafic sills, New Brunswick, Canada

Mark W. Richardson and Cliff Shaw

Department of Earth Sciences, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3

The mafic sills in Passamaquoddy Bay, New Brunswick are part of the Coastal Volcanic Belt, a 4 km-thick belt of bimodal volcanic rocks. In Passamaquoddy Bay, there are four cycles of mafic and felsic volcanism, intruded by mafic sills throughout. The Silurian Passamaquoddy Bay mafic dyke swarm likely fed many of these mafic sills. Currently, little is known about the thermal history of Passamaquoddy Bay sills. The current study determined the cooling history of three separate mafic sills in the Passamaquoddy Bay region by developing 2D thermal models. The magma is constrained to the dimensions of the examined intrusions; however, the duration of the magma flow is unknown. To replicate prolonged magma flow, the temperatures of the sills were held constant for defined periods of sill flow. After a series of static conduction simulations and thermal profiles were developed, the models were compared against petrographic observations and field relations. Surprisingly, preliminary results suggest that the sills in the Passamaquoddy Bay region were rapidly injected into lithified sediment, and then rapidly cooled to the solidus within a period of fifteen days. In addition, the current estimates for duration of magma flow were found to be less than 5 hours. These results provide new information and insight into the complex history of the Passamaquoddy Bay volcanism.

Geomatics applications in planetary science: an investigation into the geological environment of the Nili Fossae region of Mars using remote sensing data and GIS

Catheryn Ryan[1], Livio Tornabene[2], Andrew Macrae[1], and Randolph Corney[1]

1. Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3 ¶ 2. Centre for Planetary Science and Exploration, University of Western Ontario, London, Ontario, N6A 3K7

The Nili Fossae trough is an early-mid Noachian graben structure northwest of the Isidis Impact Basin and north of the volcanic Syrtis Major Planum on Mars. This site has been presented as a candidate for the Mars 2020 sample return mission because it has a geological environment with diverse mineralogy (clay minerals, carbonates, and ultramafic minerals), and origin (impact, volcanic, and sedimentary). ArcGIS has been used to create detailed geological maps of the area near the landing ellipse, based on HiRISE and CTX imagery from the Mars Reconnaissance Orbiter. Our preliminary results include numerous structural and sedimentary features: faults and fractures; a possible hydrothermal alteration system characterized by polygonal surface cracks; breccia and potential melt ridges associated with the ejecta blanket of nearby Hargraves Crater; zones of debris flow and mass wasting; and erosional surfaces indicative of past aeolian and fluvial activity. This study also involves the use of multi-spectral data from HiRISE and CRISM in order to characterize the mineralogical environment in more detail. As well, we are currently developing stratigraphic relationships between geological units using cross-cutting relationships, alteration products, and crater-counting methods. Future work may examine the potential for this environment to contain biologically relevant materials and be used to help decide on its suitability for the Mars 2020 rover.

Preliminary evaluation of the compositional sedimentary variation of the Jurassic Iroquois and Mohican formations of the Scotian Basin, Nova Scotia, Canada

Philip Sedore[1], Ricardo L. Silva1[1], Naomi Plummer[2], and Grant Wach[1]

1. Basin and Reservoir Laboratory, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4J1 ¶ 2. Department of Geosciences, University of Texas at Dallas, West Campbell Road Richardson, Texas 75080-3021

The compositional sedimentary variation of the Jurassic Iroquois and Mohican formations of the Scotian Basin (Canada) was evaluated in 9 wells (566 cutting samples) using a Thermo Scientific Niton xl3t goldd+ XRF analyser and the SandClass geochemical compositional classification based in major elements. Our data shows that these two formations present a large inter and intra unit compositional variation, even between closely related wells. It is clear that these units represent very dynamic depositional systems with apparent lateral facies variability. The integration of our data with those previously published will enable refinement of the currently accepted stratigraphic frameworks and/or the definition of new paleoenvironmental models, through finer-tuning of the sedimentological, biological, and hydro-atmospheric conditions correlative of sedimentation for the referred time interval. We acknowledge the industry and government partners of the Basin and Reservoir Lab and the consortium Source Rock and Geochemistry of the Central Atlantic Margins for their support of this project. [Poster]

Microfacies analysis of the well Mohican I-100 cores 7 and 8 from the Scotian Basin, Nova Scotia, Canada

M. Soukup, Ricardo L. Silva, Philip Sedore, and Grant Wach

Basin and Reservoir Laboratory, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

The Scotian Basin is located offshore Nova Scotia; larger than the Gulf of Mexico, it covers an area of approximately 300 000 km^2. Half of the basin lies on the present-day continental shelf under 200 m of water, with the remainder on the continental slope in 200 to 4,000 m of water. It is a classic passive conjugate margin, recording about 250 million years of sedimentation (Mesozoic to Cenozoic). In Nova Scotia, offshore hydrocarbon exploration began in 1959. Nonetheless, the Scotian Basin remains underexplored given the low number of exploration wells (127 out of 207 total) and their concentration in the central Sable Sub-basin. Historically, testing focused on the successful rollover anticlinal plays (gas), yet the source and timing of hydrocarbon generation and migration pathways are not yet fully understood).

In this study, we have analysed 15 thin sections from the cores 7 and 8 of the well Mohican I-100 (Scotian Basin) and observed, recorded, and interpreted the microfacies in order to better understand the local variations in the depositional environments within the broader context of the Scotian Basin. We also aimed to investigate the source rock and/or reservoir potential of this carbonate succession. Overall, these cores record the highly dynamic nature of these kinds of transitional to marine depositional environments, ranging from coastal plain to marginal marine; tempestites and evaporitic facies are identified as well. Ongoing research is focused in studying the organic matter content, mineralogy, and stratigraphic sequence components. [Poster]

Modelling backscatter at mid-frequencies from sandy sediment in the northern Gulf of Mexico, USA

Shannon-Morgan Steele[1,2] and Sean Pecknold[2]

1. Department of Earth Sciences Dalhousie University, Halifax, Nova Scotia, B3H 4R2 ¶ 2. Defence Research and Development Canada -Atlantic, Dartmouth, Dartmouth, Nova Scotia B2Y 3Z7

High- and mid-frequency sonar is an important tool for the detecting and classifying proud and buried targets along the seafloor. The scattering from sediments degrades the acoustic signal received from targets, indicating that modelling sediment backscatter is integral for target detection. In order to be able to quantify sediment backscatter knowledge of geophysical and topographical sediment properties must be known. In this study, geophysical properties measured by a cone penetrometer and bathymetric data collected at mid-frequencies during the Target and Reverberation Experiment (TREX2013) has been used as inputs into a sediment backscattering model known as the Composite Roughness Approximation (CRA). For grazing angles between 40 and 90 degrees the CRA model shows angular dependence similar to that of Lambert's Law, except with a μ of -34. Below 40 degrees the CRA model behaves significantly different from Lambert's Law: showing a significant decrease in scattering at lower angles. The CRA model indicates that at lower angles sediment interface roughness dominates scattering, but at larger angles volume scattering dominates. The CRA model predicts much lower sediment backscatter than what has been measured for sandy sediment in the past. It is possible that at mid-frequencies the CRA model does not completely account for volume scattering due to scattering from sediment heterogeneities and discrete scatterers. The next step in this study will be to attempt to quantify volume scattering in two different ways: (1) from sub-bottom profiler data collected during TREX2013 and (2) using physical rather than empirical relations to estimate volume backscatter in the model.

Polymetallic Ni-Co-As-Bi-Ag-U veins with co-precipitating bitumen at Copper Pass, southern Slave Province, Northwest Territories, Canada

Corwin Trottier* and Jacob Hanley

Department of Geology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3

Polymetallic veins have a distinctive history of precipitation in stages. Nickel-cobalt arsenides are ubiquitous in their mineralogy while other elements such as uranium may be lacking due to absent stages. Similar polymetallic veins have been identified in few locations across North America and Europe. Historically economic varieties of these veins were mined in the Thunder Bay and Cobalt districts of Ontario and the Great Bear Lake region of Northwest Territories. The latter was mined for native silver and uraninite. Veins at Copper Pass, near Great Slave Lake, do not contain economic volumes of either resource but do host an interesting relationship between a subdued uraninite stage and solid bitumen. Mineral and fluid inclusions are examined within vein quartz from Copper Pass. The uraninite stage, along with solid bitumen and Ni-Co arsenides, is hosted wholly within a specific layer of quartz growth. This study focuses on constraining the mechanisms for the co-precipitation of these elements and characterizing their fluid source using various petrographic techniques. Microscope-cathodoluminescence (CL) was used to identify growth patterns within individual quartz grains, which were subsequently analysed with secondary ion mass spectrometry (SIMS; University of Manitoba) to identify their isotopic oxygen ratios. These ratios range from 3.9 to 21.8 ‰ δ^{18}O V-SMOW, increasing from core to rim with variations along specific growth zones, implicating a major physical or chemical shift during vein formation (e.g., fluid mixing or cooling). Micro-thermometry of fluid inclusions will compliment this data by reconstructing salinity and homogenization temperatures of source fluids for the different quartz growth zones. Compositional and textural features within the uranium bearing growth zone were identified using SEM and Raman spectrometry. The Raman spectrometer was also used to compare the chemistry of included organics with hydrocarbons from other deposits. This may provide insight into the role of organics in polymetallic deposits. Continuation of this study will focus on determining the nature of fluid mixing that triggered the co-precipitation of these phases.

Winner of the Frank S. Shea Memorial Award for best economic geology presentation

Impact of regional geology on water quality in the Cumberland Marsh Region, Canada

Max Turner[1], Ian Spooner[1], Amanda Loder[2], and Mark Mallory[2]

1. Department of Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia, B4P 2R6 ¶ 2. Department of Biology, Acadia University, Wolfville, Nova Scotia, B4P 2R6

The Cumberland Marsh Region, located on the coast of the Bay of Fundy, is a major feeding ground for waterfowl and contains significant coastal wetland systems. At this site there is concern over the mobility and toxicity of metals in lake sediments and management practices that may influence these processes. Metals are partitioned amongst soluble phases, suspended and bottom sediments and biota in lake systems. Metals have strong affinities for particulate organic matter, necessitating the study the factors that influence in-lake productivity including nutrients sources and pathways to better understand the capability of lake sediment to sequester metals.

This study focusses on evaluating nitrogen and phosphorous in both surface and ground water. A three-month study was carried out near the Beuabassin Research Centre that included collection and analysis of surface and ground water samples, identification of natural and anthropogenic sources, and consideration of the influences of regional geology and geomorphology. The water quality analyses were conducted weekly on eleven surface water sites and a groundwater site using the persulfate and acid persulfate digestion method. Water chemistry parameters were measured in conjunction with sample collection. Preliminary results indicate the impact of regional sources on the sampled wetland sites is relatively small, and phosphorus loading is primarily autochthonous. This has been supported by low nitrogen readings at all sites with little seasonal variation, and higher (eutrophic) phosphorus levels that fluctuate without external input. Although land use may not be an important contributor to nitrogen levels in surface water, a spike in ground water levels suggest that significant anthropogenic sources exist.

Future research will include an investigation of the associations between water quality and chemistry parameters with strata, geomorphology, land use and time. Conclusions will be made on the nature of nutrient cycling and loading within these systems, and what geological variables affect them.

Distance education: what do terrestrial serpentinites tell us about methane on Mars?

Kate G. Woods and Richard Cox

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 4R2

Serpentinization is an exothermic, shallow subsurface or surficial alteration process requiring liquid water. Serpentinites and their protoliths have been documented on Mars. Both water ice and carbon dioxide ice have been documented in the Martian polar ice caps, and there is increasingly strong evidence for seasonal meteoric water. Serpentinization produces molecular hydrogen, a reactant in the Sabatier abiotic methanation process. According to the European Space Agency, methane was detected in the Martian atmosphere in 2003 and 2006. In addition, spectroscopic analysis has shown the mineral contents of some of the Martian serpentinites. Proxy studies will be conducted using appropriate terrestrial serpentinite and current data from Martian examples. This presentation is a meta-analysis of existing publications on terrestrial analogues for Martian processes. Original research by the authors has commenced at Dalhousie University, and will serve as the foundation for an undergraduate honours thesis. This study begins with selective characterization of serpentinized mafic/ultramafic rocks from stratiform and podiform magmatic ore deposits and will eventually encompass ophiolitic and orogenic samples. Bulk chemical and mineralogical analyses will be completed using an electron microprobe at Dalhousie University. Stable isotope analysis will be carried out at the University of Ottawa; results will be compared against published Martian values. The goal of this study is to identify terrestrial serpentinite analogues for Martian examples. If successful, future work will consider implications for abiotic methanation and requisite liquid water on Mars. [Poster]