The 66th Annual Atlantic Universities Geoscience Conference 2016

27th-29th October 2016
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ACENET is a regional partner of Compute Canada, the national organization responsible for advanced research computing infrastructure in Canada.

Through its resources and computational research expertise, ACENET has accelerated the pace of pure and applied research in Atlantic Canada, and advanced our capabilities in science and technology.

For more information, visit www.acceleratediscovery.ca, or email info@ace-net.ca.
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Welcome to the 2016 Atlantic Universities Geoscience Conference at Acadia University. The Earth and Environmental Science department is pleased to be hosting one of the oldest geoscience conferences in Canada, especially one focused on undergraduate research and networking and that brings together students from across Atlantic Canada. I would like to congratulate the organizing committee for putting together a great collection of field trips (which are a highlight of AUGC), interesting speakers and some fun evening activities. I am especially keen to attend the student talks which are always of a very high caliber and a great opportunity to take in current research in Atlantic Canada.

Make sure you take the opportunity to mingle and meet other students as well as professionals and professors that are at the conference; AUGC is a great opportunity to establish some new contacts and chat about graduate opportunities and employment prospects. Above all else enjoy your stay in Wolfville and at Acadia. See you at the conference!

Ian Spooner.
Head and Professor, Earth and Environmental Science
Acadia University, Wolfville, NS.
Dear Conference Attendees:

We are very excited to welcome you all to 66th Atlantic Universities Geoscience Conference!

The Acadia geology student body and Fletcher Geology Club are very proud to be hosting this year’s event. We hope that your time at the conference is full of great experiences, learning opportunities, and memories. We invite everyone to experience all that Acadia and the beautiful Annapolis Valley have to offer by taking part in the activities we have available, and taking some free time to explore campus and the area.

This year we have chosen field trips that showcase both the Valley and other geology-rich parts of Nova Scotia, in addition to offering a wonderful short course to learn a bit more about industry, made possible by the AAPG. In addition, we will also have a handful of keen high school students who will be taking part in Friday’s field trips. If you happen to be on a trip with any of them, please feel free to share your experiences, and help them to see the diverse opportunities available with an education in Geological Sciences!

We would like to thank all of our industry sponsors, Earth Science professors, and especially our department administrator Lynn Graves, as well as the Acadia student volunteers. All of them were necessary to make this conference possible.

Sincerely,

Alex Squires & Sarah Dunn

Co-Chairs
AUGC Organizing Committee
Conference Schedule

Thursday October 27th 2016

4:00pm – 7:00pm  Arrive at Old Orchard Inn and registration
7:00pm – 11:00pm  Challenge bowl at Old Orchard Inn Barn

Friday October 28th 2016

Field Trips

7:30am – 5:30pm:  The East Kemptville Tin Mine and Brazil Lake Pegmatite
9:00am – 5:00pm:  Rocks, mud, and scenery: an introduction to the amazing geology of the Wolfville area.
8:00am – 6:00pm:  Sedimentology, structure and metamorphism on the South Shore of Nova Scotia
8:30am – 4:45pm:  Using Seismic Data: From a Discovery to Early Field Development

8:00pm – 12:00pm  Social Event

Saturday October 29th 2016

9:00am – 5:00pm  Student Presentations in the K.C. Irving Centre on the Acadia Campus.
12:20pm – 1:00pm  Lunch in K.C. Irving Centre Garden Room
12:30pm – 1:00pm  Club presidents/executives K.C. Irving Centre Classroom
5:00pm – 5:30pm  Science Atlantic Earth Science Committee meeting Huggins Science Hall room 336
6:00pm – 10:30pm  Banquet with dinner, awards presentation and guest speaker at Old Orchard Inn Banquet Hall
10:30pm – 12:00am  Open Mic

Sunday October 30th 2016

11:00am  Hotel checkout
AUGC 2016 Organizing Committee

Sarah Dunn          Co-chair
Alex Squires       Co-chair
Dr. Sandra Barr    Faculty Advisor
Dr. Rob Raeside    Faculty Advisor

Ashton Baich       Judges Coordinator
Chloe Caldwell     Fundraising Coordinator
Carol Davis        Secretary
Brooklyn Herron    Field Trip Coordinator
Dillon Langelaan   Webmaster
Jackson Malone     Guest Speaker Coordinator
Chad Stines        Treasurer
Brendan Vibert     Chief of Public Relations
Alexander Whitney  Catering Manager

Special Thanks
Dr. Sandra Barr
Dr. Ian Spooner
Dr. Rob Raeside
Dr. Cliff Stanley
Lynn Graves
Judges
Judges

Sheldon Barron Geophysicist I.T.
Shell Canada Limited
Marine Imaging-Deep water Exploration imaging team
CSEG Representative

Ian Watson P.Geoph.
Northern Athabasca In Situ Development
Geoscience Supervisor
SAGD Development, Imperial Oil Resources

Jacey Neuman
CSPG Representative

Colin Price
ExxonMobil Canada

Dr. Scott Swinden
Swinden Geoscience Consultants Ltd, Wolfville

Amy Tizzard
Geological Consultant
Guest Speakers

Amy Tizzard

Amy Tizzard is a geological consultant based out of Oxford, Nova Scotia. She started her path into the geological sciences at Sir Sandford Fleming School of Natural Resources in Lindsay Ontario, followed by an Honours Degree at Acadia University, Masters Degree at the University of Victoria, and GIS diploma at the Centre of Geographic Sciences, Lawrencetown, NS. She has worked with government and private industry across Canada, Australia and Africa, specializing in mapping, compilation and prospectivity analysis. For the past 3 years Amy has been stationed at a dormant copper mine in Namibia to explore for additional and remnant resources sufficient to restart operations.

Dr. Fred W. Schroeder
fwschro@yahoo.com

Dr. Schroeder holds a BS in Engineering Physics from Lehigh University and a M.Phil and Ph.D. in Marine Geology from Columbia University; the highest degree was awarded in 1977. Fred started his petroleum industry career in 1977 when he joined Exxon Production Research (EPR, now URC) in Houston Texas. He began as a seismic stratigrapher, being mentored by Pete Vail and Bob Mitchum. Fred worked for Exxon and then ExxonMobil for 32 years, primarily in their research organization.

While at Exxon/ExxonMobil, Dr. Schroeder’s efforts focused on three main items: R&D of new methods, tools and techniques related to seismic analysis, applying cutting-edge technology in exploration offices, and teaching/mentoring. Fred received several awards for teaching excellence from ExxonMobil. His areas of expertise include seismic stratigraphic, basin modeling, seismic facies, seismic attributes, DHI/AVO, and visualization.

From late 2009 to late 2011, Fred was self-employed as a geoscience course developer and presenter. He worked for the training division of ExxonMobil, Texas A&M University, and Nautilus, a company that provides training to the petroleum industry. Fred worked full time for Noble Energy for 3.5 years starting in late 2011. He was the corporate expert is seismic/sequence stratigraphy.

Dr. Schroeder has also been awarded by AAPG’s Visiting Geoscience Program (VGP) for his teaching efforts. He has presented short courses on over 70 campuses, teaching 1500+ students and 150+ faculty members. He serves on the AAPG-VGP committee and the Education and Public Outreach standing committee for IRIS (Incorporated Research Institutes for Seismology).
# Student Presentation Schedule

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<td>Corin Jorgenson, Dalhousie University</td>
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<td>9:40 am to 10:00 am</td>
<td>Nicholas Lynch, Memorial University</td>
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<td>10:00 am to 10:20 am</td>
<td>Mark Richardson, University of New Brunswick</td>
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<td><strong>Lunch in Garden Room 40 Minutes</strong></td>
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<td>Mariah C. J. Williams, Saint Mary’s University</td>
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<td>1:20 pm to 1:40 pm</td>
<td>Jared E. Hansen, University of New Brunswick</td>
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<td>Philip Sedore, Dalhousie University</td>
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<td>Sean Murphy, Memorial University</td>
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Diagenetic effects and fluid flow along erosional boundaries in the Triassic Wolfville Formation at Rainy Cove, Nova Scotia

ERIN D. ANDERSON AND GRANT D. WACH

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 4R2  
Erin.Anderson@dal.ca

Rainy Cove is located along the south shore of the Minas Basin in the Pembroke area, Nova Scotia, Canada. Cliff outcrops along the beach preserve fluvial barforms and channel deposits of the Wolfville Formation, which is a member of the Fundy Group. The Triassic Wolfville sandstones lie unconformably over the steeply dipping metasediments of the Carboniferous Horton Group. The Wolfville Formation at this location is a coarse grained, subangular to angular red sandstone that is well cemented with a calcite cement. The fluvial sandstones plot in the ‘litharenite’ to ‘feldspathic litharenite’ fields on the QtFL (QuartzFeldspar-Lithics) classification after Folk (1968). The Wolfville sandstones have undergone varied paragenetic processes including mechanical compaction, cementation, partial dissolution of unstable feldspars and cements, and creation of secondary porosity. In the Rainy Cove outcrop, erosional surfaces separate lithofacies packages within the formation. These consist of bounding surfaces due to change or resurgence of fluvial sedimentation, as well as an intraTriassic unconformity where a cut and fill channel eroded previously deposited fluvial sediments. Heterogeneities in porosity and permeability along erosional boundaries could create preferential pathways, baffles, or barriers to fluid flow. Sixteen samples were collected during field work at Rainy Cove from an outcrop spanning approximately 200m. Samples were taken above and below bounding surfaces and from the main units within the formation. Thin sections from the samples will be described in detail. Descriptions can then be correlated to measured sections and erosional bounding surfaces seen in the outcrop. Planned scintillometer and permeameter readings will be used to describe lithology and permeability variance between packages. There may also be an opportunity to perform cathodoluminescence analysis on the samples and investigate phases in cementation and diagenetic history. The objective of this project is to investigate diagenetic variance across the erosional boundaries and potential impacts on fluid flow.
Initial field and petrographic examination into the nature and relative timing of emplacement of an ultramafic-to-mafic sill in the Ashuanipi Complex of southwestern Labrador, Canada

NIKKI BURSEY, GREG DUNNING, AND TIM VAN NOSTRAND

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

The southwestern region of Labrador is part of the Ashuanipi Complex, a subprovince of the Archean Superior Province that has been metamorphosed to granulite facies conditions. Geological mapping and sampling of an approximately 400x70 meter ultramafic-to-mafic sill that intrudes the migmatitic paragneiss, tonalite and diatexite of the Ashuanipi Complex was done to determine the igneous and metamorphic crystallization histories and to interpret the nature and the relative timing of emplacement of the intrusion. Field observations show evidence for deformation of the sill, and partial melting of the surrounding migmatite, which outlasted deformation. These ultramafic-to-mafic intrusions have a possibility of hosting economic mineral deposits associated with sulphide-bearing gossan zones. Twenty-eight polished thin sections of the sill and surrounding country rock were examined. Five of these are from gossan zones found within this sill and from a second major mafic gabbroic sill for comparison. Petrographic work has so far shown relict igneous textures and cumulate layering along with local pervasive alteration and metamorphic overprint within the sill. The electron microprobe will be used to determine olivine, pyroxene, amphibole, and feldspar chemistry in both igneous and metamorphic assemblages for selected samples. The Scanning Electron Microscope will be used to assess sulphide textures found within gossan zones.
Geological setting of Au-Cu-Ni-Pb occurrences in the Second Gold Brook area, southwestern Cape Breton Highlands, Nova Scotia

TAYLOR CHEW AND SANDRA M. BARR

Department of Earth and Environmental Science, Acadia University,
Wolfville, Nova Scotia B4P 2R6
115745c@acadiau.ca

Exploration and mining activity in the Gold Brook area of the southwestern Cape Breton Highlands dates back to the late 1800s, and focused on auriferous quartz veins in metasedimentary and metavolcanic rocks of what was then called the Precambrian George River Group. As a result of mapping in the 1980s, the metamorphic rocks were re-assigned to the Silurian Sarach Brook Metamorphic Suite. Subsequent work in the southern Cape Breton Highlands did not include the Gold Brook area, in spite of its apparent economic potential. Hence this study was undertaken to provide enhanced understanding of the geology of the Gold Brook area, including mapping, sampling, petrographic interpretations and chemical analyses. Results so far show that the area is underlain by mafic metavolcanic rocks (amphibolite) interlayered with metasedimentary rocks and intruded on the east by granite of probable Devonian age. Petrographic features indicate that the metamorphic grade increases from south to north across the area. Chemical characteristics of the mafic metavolcanic rocks suggest they are tholeiitic and mixed MORB plus within-plate characteristics suggest that they may have formed in a back-arc setting. Chemical similarity suggests that they are related to the Silurian Sarach Brook and MacRae Brook formations elsewhere in the highlands. No indications of economic Au or other mineralization are evident in the chemical signatures of the metamorphic rocks, suggesting that such occurrences may be confined to the areas of historical mining activity.
Quantification of water content in silicate melt inclusions via Raman Spectroscopy

CONNOR DALZELL AND JACOB HANLEY

Department of Geology Saint Mary’s University
C.Dalzell@hotmail.com

In silicate magmas, key physiological properties such as liquidus and solidus temperatures, viscosity, and phase assemblages during crystallization will be heavily influenced by melt water content. Additionally, water released from magmas during their crystallization and cooling is an important mechanism for metal transport during the formation of metallic ore deposits. The purpose of this study is to develop a method to analyze the water content of silicate melt inclusions via laser Raman spectroscopy. Raman analysis is useful in that it provides high-spatial resolution, is non-destructive to the sample, and can be performed on unexposed melt inclusions without advanced sample preparation or mounting techniques. Melt inclusions with known concentrations of water are being used to generate a calibration of the Raman spectrometer at Saint Mary’s University. Preliminary method development has been successful and work in progress is resolving key interferences with water signals including secondary fluorescence generated from coloured melts. This method will be applied to the analysis of felsic melt inclusions in ancient volcanic rocks from a variety of ore deposit settings in British Columbia and New Brunswick in order to track the degassing and crystallization history of ore-forming magmas, and hopefully predict the most productive (i.e., metal-fertile) magmatic events.
A geochemical and petrographic investigation of the distribution of cobalt within the Captain VHMS deposit, Bathurst Mining Camp.

JARED E. HANSEN\textsuperscript{1,2}, SEAN TIMPA\textsuperscript{2}, AND DAVID R. LENTZ\textsuperscript{1}

1. Department of Earth Sciences, University of New Brunswick, 2 Bailey Drive, Fredericton, NB E3B 3A3

The Captain deposit, located approximately 40 km southwest of Bathurst, is one of 46 volcanic-hosted massive sulphide deposits in the Bathurst Mining Camp. The Captain deposit was discovered by Captain Mines in 1956 and was the subject of the Geological Survey of Canada Report 66-18. Most recently, Stratabound Exploration conducted an extensive 39-hole drilling program of approximately 11 km of combined length of core on the deposit. The deposit is hosted by a sequence of argillite and quartz-feldspar-phyric rhyodacite of the Middle Ordovician Nepisiguit Falls Formation. The Captain deposit has a strike length of 146 m, a down-plunge length of at least 400 m and a maximum width of approximately 50 m. Within this zone stringers, veins, semi-massive, and massive sulphides occur within an envelope of chlorite altered quartz-feldspar-phyric rhyodacite. The similarity in host rocks and alteration types in both structural footwall and hanging wall suggest that the deposit formed as a disconcordant stock work rather than a stratiform body. Likewise, Cu and Co mineralization with relatively low Zn and Pb content is consistent with high temperature paragenesis typical of the stock work deposits. In thin sections, cobalt sulphides exhibit vein-styled mineralization within pyrite and chalcopyrite crystals. The distribution of cobalt mineralization in the Captain deposit is inferred to be controlled by the remobilization of earlier sulphides by later fluids. This is evident in multiple recrystallization events observed in pyrite within the mineralized body. Cobalt-rich sulphides are able to be investigated in detail, utilizing Micro X-Ray Fluorescence and Instrumental Neutron Activation Analysis in conjunction with various micro-analytical techniques including, Reflected-Light Petrography. Preliminary lithogeochemical data shows a relationship between the strongest cobalt enrichment and copper-poor zones. Further investigation of trace element geochemistry is warranted to completely understand the controls on cobalt mineralization within the deposit.

Funding:

New Brunswick Department of Energy and Resource Development; University of New Brunswick.
Predicting zones and potential sampling methods for elevated metal concentrations in urban soils, Halifax, Nova Scotia

FIONA H. M. HENDERSON AND ANNE MARIE RYAN

Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 4J79
fn414759@dal.ca

Canada lacks a uniform method for sampling metals in soils, posing challenges for comparing studies and hinders the recognition of trends. Although problematic, the absence of a standard methodology is not unfounded. The extensive variability of soil properties throughout time and space makes it difficult to evaluate a study area. This is particularly the case in urban areas, where soils may have been disturbed and soil horizons are not well developed. Developing a standard methodology thus holds substantial significance, both in soil science and for society. Methods designed to be used ubiquitously not only allow studies to be comparable, but may add to the effectiveness of environmental and health risk assessments. This study focuses on developing a protocol for predicting and potentially mitigating elevated metals in city soils within Halifax, N.S. One aspect of the study aims to predict where high metal concentrations may arise in a city, by identifying past land use activities that are strongly associated with a particular metal(s). Prediction methods include the creation of a Geographic Information System (GIS) map, which illustrates potential zones of high metal concentration. Another aspect of the study involves developing a consistent sampling protocol for urban soils, using samples from within the city of Halifax. A total of 50 depth-based samples will be obtained from various locations. At each site there will be a collection of 0-5 cm and 0-15 cm sample depths, which will be evaluated through X-ray fluorescence (XRF) analysis. Of these samples, those that have metal concentrations close to or above provincial and federal guidelines will be sieved to particle sizes of 1 and 2 mm. Comparison of metal concentrations relative to particle size and sample depth will potentially add to the identification of patterns. Pending results of soil sample analysis, remediation efforts may be explored by evaluating dilution effects on soils with elevated metal content, using mass balance considerations. Conclusions drawn from analysis will aid in the refinement of useful sampling methodologies. The intent of this study is to build a foundation for determining the ‘best practice’ for assessing elevated metal concentrations in city soils.
Sulfur solubility of carbonatites, with implications for mass transfer in Earth’s mantle.

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Carbonatites are rare, mantle-derived igneous rocks with >50 wt% carbon, compared to more typical SiO₂-rich compositions. Whereas the solubility of sulfur for mafic silicate melts has been extensively studied, equivalent data for carbonate-rich compositions has not been obtained. This research looks to determine sulfur solubility in molten carbonate to assess the potential for such melts as a mass transfer agent for sulfur, along with precious metals, in the mantle. The goal is to determine the importance of carbonatite metasomatism to establish precious-metal-rich source regions for magmatic ore deposits. The concentration of sulfur at sulfide saturation in molten carbonate will be measured as function of several variables, including melt composition and pressure to assess the sulfur solubility mechanism. Experiments are done using piston cylinder apparatus at the Dalhousie Laboratory for High Pressure Geological Research. Run products are analyzed using the electron microprobe analyzer using wavelength dispersive spectroscopy. We use a synthetic carbonate melt modeled after experiments that produced in the phase equilibrium experiments with a mantle peridotite assemblage. This material is mixed with a similar mass of FeS, doped with 1 wt% each of Ni and Cu, then loaded, along with ~ 5 wt% H₂O, into a graphite-lined Pt capsule. Capsules are placed into a pressure cell comprised of crushable MgO, with an outer graphite furnace and BaCO₃ sleeve. To date, one experiment has been done, at 1.0 GPa and 1100⁰C for 24 hours. Run-products consist of a crystalline pyrrhotite coexisting with quenched carbonate melt, represented by a fine-grained intergrowth of carbonate phases. Melt FeO concentrations are <1 wt%, and analyses reveal sulfur concentrations of ~700 ppm. This is in comparison to previous solubility measurements at similar conditions on silicate melt with ~10 wt% FeO containing ~1000 ppm sulfur or less. Results thus far suggest similar solubilities for carbonate versus silicate melts, although the FeO contents are significantly different. Additional experiments to test the effect of melt FeO content are in progress. Future experiments will be doped with Au, Ag, and platinum group elements in order to measure carbonatite-sulfide partitioning of precious metals. Further results from this study will provide a better understanding of sulfur solubility mechanisms, and the role of molten carbonate to dissolve and transport sulfur, as well as precious metals, which is currently unknown.
Winter House Canyon is incised into the ultramafic Tablelands Ophiolite massif in western Newfoundland. The canyon contains springs characterized by high pH, large negative Eh values and the active precipitation of carbonate. The unusual electro-chemical and magnetic properties of these springs indicates that geophysical techniques may be able to determine the extent, geometry and location of the underground streams which feed the springs. The reducing waters emerging from the springs have Eh values of ~ -700 mV. As the self-potential (SP) geophysical method involves measuring electrical potential differences, the Eh contrast between the springs and the surrounding area should produce SP anomalies related to the reducing fluids percolating through the subsurface. The high alkalinity of the reducing springs is thought to be the result of active serpenrinization of ultramafic rock. Since low temperature serpentinization results in the production of magnetite, there should be magnetic anomalies which correspond to areas of past and present serpentinization. Based on these considerations, a 100m x 30m area next to a known spring was surveyed by SP using new, low-noise electrodes built for this project, and a magnetic survey, using a fast, GPS enabled Overhauser magnetometer was carried out over an area of 1500m x 200m along Winter House Canyon, in an effort to locate and map the reducing groundwater. The geophysical data revealed that the known spring sites produce strong, coherent magnetic and SP responses, and a previously unknown spring was discovered based on its associated magnetic anomaly. Processing and analysis identified underlying structural elements of the ophiolite massif not visible on the exposed outcrop. Correlation of the surveys revealed sets of parallel, linear magnetic and SP anomalies. The strike of these anomalies indicates that reducing fluid is traveling within conduits which are perpendicular to the streambed and appear to predate incision of the canyon. This study presents a new exploration technique for locating new springs sites within Winter House Canyon and elsewhere in the Bay of Islands Ophiolite.
Morphology and geochemistry of the enigmatic Ediacaran Palaeopascichnus in the Fermeuse Formation, Ferryland, Newfoundland.

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Palaeopascichnus is an exclusively late Ediacaran fossil comprised of a series of bedding parallel, crescentic, uniserially-arranged lobes, which can be straight, sinuous, curved, branched, or meandering. It has been described from tuffs, cherts, carbonates, claystones, siltstones, sandstones, and dolomitic sandstones. It is known from Southern Australia, the UK, northern Norway, the Ukraine, southern China, and Newfoundland. Palaeopascichnus was originally described as a trace fossil, but more recently it has been considered to be a multi-chambered body fossil of a xenophyophoran protist, specifically, a benthic agglutinating foraminifera. This study aims to better constrain the morphology and biogeochemistry of Palaeopascichnus, as well as its biogeochemical signature. Polished blocks from the Fermeuse Formation were cut perpendicular and parallel to bedding through the fossils. The blocks were then geochemically analysed using the SEM (EDAX) to produce elemental maps that could be directly related to the fossil material. The same fossiliferous blocks were then used to make petrographic thin sections to better appreciate the associated sedimentary fabrics. This study aims to determine whether there are any mineralogical or biogeochemical differences between the inferred chambers, and the host sediment. The results of this biogeochemical analysis are discussed in the context of the possible palaeobiology and affinity of this enigmatic Ediacaran. A sort of ‘halo’ surrounding the chambers, composed of for example the titanium bearing mineral rutile would suggest an agglutinating origin, however in our preliminary SEM modeling that does not appear to be the case, except perhaps in one sample.
Three-dimensional morphological characterization of the trace fossil
*Parahaentzschelinia ardelia*, Atoka Formation, Oklahoma

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The value of trace fossils lies in their use as indicators of paleoenvironment and depositional setting; however, there remains an issue in that some ichnotaxa have been poorly and inadequately defined from their sample material. One such example is Parahaentzschelinia ardelia from the Atoka Formation (Oklahoma), the focus of this research. Trace fossil material discovered in the Winterhouse Formation (Newfoundland), while similar to P. ardelia, contains additional morphological features revealed through three-dimensional reconstruction. This poses a taxonomic problem in that the type material is considered to be inadequately described. Revising ichnotaxonomic groups using modern methods and applications is one way of resolving this type of issue, in the hopes that taxonomic interpretations can be better implemented and regulated. A sample of the trace fossil P. ardelia was collected from an area south of Hartshorne, Oklahoma (N 34°76’47.59” W 95°57’91.71”) relying on information reported during its original discovery in 1971. P. ardelia was obtained within a float rock from thinly bedded Pennsylvanian sandstones of the Atoka Formation, a 7620m thick stratum dominated by greyblack shales with intermittent brown to light grey, thinly bedded quartz arenites. The sample exhibits both epirelief and full relief preservation, vertical upward branching burrows, and a highly weathered conical depression, similar to the trace fossil holotype. Burrow fill is primarily homogeneous mudstone with high colour contrast with the host rock. This toptotype material was implemented with a three-dimensional approach to reconstructing and describing the fossil burrows using techniques developed at Memorial University of Newfoundland. Use of the serial grinding procedure with a Denford VMC 1300 3 axis CNC milling machine for the purpose of modeling three-dimensional features has not previously been performed for Parahaentzschelinia. The objective of this research is to fully characterize the type material from Oklahoma with the purpose of relieving all taxonomic issues. This will allow for a comparison in the morphology from the paratype material to other fossil material described as Parahaentzschelinia. The resultant morphology can be further compared with modern vertical burrows to better understand the ethology. Only once this work is complete will Parahaentzschelinia become a meaningful name and concept.
McMurray reservoir assessment in the northern Athabasca Oil Sands deposits, Alberta

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The McMurray formation was deposited 130 million years ago in the Early Cretaceous period. During this time the Western Canadian Sedimentary Basin was dominated by three drainage systems: The Spirit River, The Edmonton Channel and The McMurray Valley System. The McMurray Valley system is confined to the North Eastern portion of Alberta by the highlands of the Canadian Shield and Grossmont High. Fluvial processes that deposited the McMurray Formation dominated the low land regions. The McMurray formation unconformably overlies the Devonian waterways formation and generally consists of sand, mud, and a variety of other minerals, water and bitumen. The bitumen of the McMurray Formation in Alberta is arguably one most of the important and economic hydrocarbon accumulation in the world. Therefore, extensive geological mapping is necessary to identify the resource potential in a specific region. Approximately 45 km North East of Fort McMurray 3 townships were analyzed with the use of Petrel Studio to understand the resource potential. The examination of 445 well logs, 10 cores, provided sufficient data to establish resource potential and quality, as well as the presence of top gas. Concluding results have shown that: (1) there are three pay zones present within the study area. (2) there is a wide range in reservoir quality. A qualitative analysis was conducted to assess the reservoir quality based on thickness, volume of shale, resistivity and water saturation. (3) Gas saturated zones at the top of the McMurray formation is common within the study area and could potentially be structurally and stratigraphically trapped. Through this detailed geological analysis the resource potential was successfully analyzed to increase reservoir mapping in the Athabasca Oil Sands Deposit.
Lithospheric flexure is an important control on dynamic topography and geomorphic processes. Isostatic response to surface unloading is critical in predictions for past, present and future environmental changes. The Northwest Passages consist of a series of deep channels (approximately 500m in areas), some of which are bounded by fault-line scarps. Passages were deepened by fluvial and glacial incision through Cenozoic sediments. The Beaufort Formation was a Pliocene coastal plain deposit believed to stretch from the Northwest Territories to Ellesmere Island along the western Canadian Arctic Archipelago. The fluvial sediments and marine equivalents thicken toward the Canada Basin to as much as 3 km, despite having been deposited in a short time between 3.8 and 2.7 Ma. Paleoflow directions and the upper and lower contacts of the Beaufort Fm suggest that the coastal plain was contiguous, and while the large straits may have previously existed between the islands, they were filled during the Pliocene. How may have islands in the Canadian Arctic responded to the replacement of the eroded Cenozoic sediment with glaciers or seawater? Numerical modeling for lithospheric flexure is conducted using a new open source lithospheric flexure program. From initial loads gathered from bathymetric data in the channels, isostatic response was calculated using an iterative solution. 2-dimensional models were constructed for 3 transects using this method, varying effective elastic thickness values (30km, 60km, and 90km). Each model considers excavation of sediment based on a paleo topographic gradient and infilling with seawater to modern sea level. Estimated isostatic uplift ranges between 50-150m along the northern and southern flanks of Banks Island and Prince Patrick Island. Further models include 2-dimensional modeling considering erosion on islands, 2-dimensional models including affect of glaciation, and 3-dimensional models. Additionally, the second part of the thesis looks into deposition of the Beaufort Formation, specifically looking into possible rift flank uplift or sediment loading along the eastern Beaufort Sea margin to explain distribution of the Beaufort Formation.
Interpreting the geology of the Rocky Brook area, 
western Cape Breton Island, Nova Scotia

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The Rocky Brook area is situated in a remote and rugged part of the Cape Breton Highlands, about 15 km southeast of the town of Chéticamp. This study is aimed at better understanding the characteristics of and relationships among the various rock units and mineral occurrences in the Rocky Brook area. The area was mapped during June 2016, and approximately 125 samples were collected for petrographic study and chemical analysis. The area is underlain mainly by the Cambrian(?) Jumping Brook Metamorphic Suite (JBMS) which consists of metasedimentary and metavolcanic rocks. It is bounded on the west and south by the Devonian Fisset Brook Formation, which in places unconformably overlies the JBMS and in other places is faulted against it, and on the east by a faulted contact with the Devonian Margaree Pluton. The JBMS in the study area is divided into two formations, the Faribault Brook Formation (FBF), consisting mainly of metabasalt and minor metagreywacke, interlayered with and overlain by the Barren Brook Formation (BBF), consisting of metagreywacke and quartz-muscovite schist. Petrographic study and chemical data indicate that the protolith of metabasalt in the FBF is mid-ocean ridge basalt (MORB). An area of conglomerate is inferred to overlie the Barren Brook Formation. Petrographic study of clasts in this conglomerate has shown that it contains clasts of JBMS, varied granitoid rocks, and basalt of the Fisset Brook Formation, the latter in particular constraining its age to Devonian at the oldest and suggesting that it may be an intraformational conglomerate in the Fisset Brook Formation. The JBMS in the study area has been intruded by two different, but possibly related, porphyries: red quartz-feldspar porphyry and orange quartz-feldspar porphyry with intense stockwork quartz veining. Petrographic and chemical data will be used to investigate the tectonic setting of the porphyry bodies and their possible relationship to felsic rocks in the Fisset Brook Formation or to other felsic units in the region. Portable XRF analysis has provided a large chemical database to investigate the distribution of economic elements in the rocks.
Influence of mineralogical composition and texture on induced polarization (IP) effects in gold-bearing rocks from the Herbert-Brent gold showing, Yellowknife Greenstone Belt

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On July 29th, 2016, two 400 m long IP/resistivity survey lines, with 5/10 m electrode spacing (multi gradient array), were completed over TerraX Minerals Inc. Hebert-Brent (HB) gold showing. The HB gold showing is located within the Barney Deformation Corridor of the Yellowknife Greenstone Belt (YGB), Northwest Territories. In June 2015, geological mapping discovered significant concentrations of gold in HB situated within an 11 m-wide highly sulphidized sericite-ankerite schist shear zone, hosted in a 10-15 m-wide, quartz-feldspar porphyry. Thirty-three samples were collected from the survey site across the main mineralized zone at 0.45 m increments using a rock saw. This study is designed to explore the viability of different interpretations for bodies (variably gold mineralized and non-mineralized sulphide-bearing zones) that are strongly anomalous in resistivity or chargeability. The resistivity and chargeability of each sample will be determined by using a two-electrode lab apparatus to measure IP effects both in the frequency domain (measuring resistivity as a function of frequency), and in the time domain (determining chargeability from the voltage decay that follows a step change in current across the sample). Detailed textural examination of polished samples using reflected petrography aided by microXRF (EDS mapping) for point analysis is being used to identify the various mineral phases, and also identify if there are any significant non-sulphide IP sources. Polished thin sections are also being used in order to investigate the dependence of IP effects on sulfide type, concentration, texture, grain shape and size. Once these analyses are completed for each sample, the results will be used to help interpret the vertical IP section of estimated subsurface resistivity and chargeability. Results from these steps will be used to better define lithological and mineralized units in the subsurface and help define drill targets for gold exploration.
1D modelling approach to the investigation of Mesozoic source rocks in several offshore Newfoundland basins

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During the break-up of Pangea, numerous rift basins formed along the conjugate margins of the Atlantic Ocean. Sedimentary basin formation is complex in this region, posing challenges when evaluating the potential for oil and gas. Petroleum systems modelling (PSM) is a predictive tool that aids the understanding of basin development and the assessment of uncertainties. The objective of this study is to build upon the understanding of source rock distribution, potential, and maturation of offshore Newfoundland. The project focuses on the evaluation of the Late Jurassic Egret Member source rock, using one-dimensional modelling with PetroMod PSM software. Fourteen wells distributed across five basins are modelled: Carson, Horseshoe, Jeanne d’Arc, Outer Ridge Complex and Whale basins. Data is obtained from NRCan’s BASIN database. Boundary conditions such as, paleo-water depth (PWD), surface-water interface temperature (SWIT), and heat flow are vital controls for the output of the model. Boundary conditions are manipulated and changed based on the interpretation of the dataset and previous work. Previous studies of this area tend to focus on one basin, whereas this study encompasses multiple. Preliminary results suggest that each basin has varying heat flow models, although these basins may have formed during the same rifting event. These fourteen 1D models provide a foundation for further development of 2D, 3D, and 4D models and adds to the geologic understanding of this region and possibly lead to further oil and gas development.
There is a widely accepted concept at the Sudbury Igneous Complex, Ontario, of hydrothermal fluids derived from ancient saline groundwaters with unique compositional characteristics having been involved in the concentration of ore metals in sulfide deposits. The overall objective of this study is to determine whether there are different fluids in each area or if the same fluid flowed through both regions, and if so how did that fluid evolved compositionally. A comparison of fluid inclusion trace element compositional data from the Sudbury Igneous Complex and the nearby East Bull Lake intrusive suite, Ontario, was done in order to determine if the previously mentioned concept is true, or if all deep groundwaters in the Canadian Shield from that time period (1.85 Ga) are the same at a regional scale. Epidote-quartz pegmatite and quartz vein samples from the East Bull Lake yielded over 350 fluid inclusion analyses by optical microscopy, microthermometry, and laser ablation inductively-coupled plasma mass spectrometry (LA-ICPMS). The study involved two types of fluid inclusions: (i) two-phase liquid-vapour and (ii) three-phase liquid-vapour-halite inclusions. Parameters compared between East Bull Lake and Sudbury were the bulk fluid salinity (in NaCl eq wt%), and a large suite of major and trace elements as elemental concentrations and ratios. In particular, trace elements that occur in elevated concentrations in both fluids are Ba, Zn, Pb, Mg, Fe, Rb and Sr suggesting, tentatively, that the saline fluids in both settings are related to a common source. Continued data interpretation is being carried out and stable isotope work is planned to further link the two different hydrothermal fluid systems.
Petrology and thermobarometric modeling of high-grade metamorphic rocks from the New Quebec Orogen, Nunavik.

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The New Quebec orogen is a Paleoproterozoic mountain belt located in the eastern part of the Canadian Shield known as the Southeastern Churchill Province. It was formed through primarily transpressional collision between the Archean Core Zone and Superior craton which occurred between 1.82 and 1.80 Ga. The New Quebec orogen is made up of a collage of autochthonous rocks deposited adjacent to the Archean Superior craton (the Kaniapiskau Supergroup) and by allochthonous metavolcanic and metasedimentary assemblages accreted to the cratonic margin (the Rachel-LaPorte zone). The Core Zone is divided into the Gabriel terrane and the Leaf Bay terrane. The metamorphic grade is typically greenschist facies in the Kaniapiskau Supergroup, to upper greenschist and lower amphibolite facies in the Rachel-LaPorte zone, increasing to upper amphibolite and granulite facies rocks in the Gabriel and Leaf Bay terranes. This project will examine rocks of the Gabriel and Leaf Bay terranes using thin section petrography and thermobarometric modelling to better integrate metamorphic data with new geochronology and structural mapping done in the area. This study will use TheriaK-Domino, a program for the calculation and plotting of equilibrium mineral assemblages in conjunction with petrographic interpretations. Preliminary work has allowed for the interpretation of pressure and temperature condition in two important rock units; a retrogressed granulite in the northern Leaf Bay terrane, and a garnet muscovite schist from the Gabriel terrane. The pseudosections and mineral assemblages of garnet, orthopyroxene, and amphibole, suggest that the retrogressed granulite experienced peak metamorphic conditions of 600°C – 800°C and 0.5 – 1.0 GPa. Pseudosections and mineral assemblages of garnet, biotite, muscovite and apatite suggest that the garnet schist experienced peak metamorphic conditions of at least 310°C and 0.3 GPa. Future work will focus on expanding the suite of samples examined and on integrating the results with known geochronology and structural data.
Apatite chemistry as a pathfinder for tungsten skarn deposits, Cantung District, NWT, Canada

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The Cantung District is home to one of the largest tungsten skarn deposits, the largest outside of Asia. The tungsten ores recovered from Cantung are some of the highest grade (1-3% WO₃), making it world class. The goal of the research is to determine if the chemistry of apatite in heavy mineral separates from surficial stream sediments and tills can be used to find hidden tungsten skarn deposits in the mineral apatite was identified by mapping polished 1 inch pucks containing coarse fractions on a Scanning Electron Microscope (SEM). The heavy mineral separates were gathered from upstream and downstream of the Cantung deposit along the Flat River valley, NWT. Minerals were identified, and representative compositional data was collected in both weight percentage and compound percentage. Based on the fourteen pucks analyzed forty-two apatite grains were located. Out of the forty-two grains three different types of apatite were located. This work was in preparation for the next step, which is to determine the trace element make-up of the apatite using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Apatite from the hydrous skarn phase at Cantung is uniquely characterized by elevated As, W, LREE, and Sr. Analysis of apatite from heavy mineral separates will determine if apatite with these features was introduced into the sedimentary record surrounding the deposit.
Assessing the ecological integrity of forested wetlands in western Nova Scotia with breeding bird surveys: Establishing a human disturbance gradient using GIS

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Forested wetlands are frequently impacted by forestry activities, watershed changes that alter their hydrology and urban and commercial projects that drain or fill these important habitats. Forested wetlands include shrub and treed swamps, bogs and fens and are among the most common wetlands in Nova Scotia. Despite their prevalence in the landscape, their significance in controlling and purifying water flowing through watersheds and the biodiversity they support, very little is known about their ecology here or what reflects a healthy condition. In 2015, a study was initiated to assess the ecological integrity of forested wetlands in western Nova Scotia using bird communities. The overall goals of the project are to identify best biotic indicators for developing an index of forested wetland integrity, improve knowledge of forested wetland species-habitat associations and refine priorities for conservation and management of these unique ecosystems. We used the wetland and forest inventory to identify potential field sites and surveyed 225 forested wetlands (82 in 2015 and 143 in 2016) in three broad classes (shrub swamps, treed swamps, shrub peatlands) for breeding birds using two, ten minute point counts per site between May 31 and July 5. Sites were at least 2 ha in size and approximately evenly distributed among wetland types and among the Western, Valley and Central Lowlands, and Fundy Shore Ecoregions. Using ArcGIS and Google Earth, wetland boundaries will be estimated. Land use/land-cover within 500m, 1000m and 5000m of the wetland edge will be characterized with ArcGIS and used quantify human disturbance in those landscapes. Sites will be ranked along the established gradient of human disturbance so that the responses of individual bird species to human disturbance can be assessed.
Early-Middle Jurassic coastal sabkha depositional environment variability in the Mohican I-100 Cores 7 and 8, Scotian Basin

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Taken from the Scotian Basin, based on the interpretation of 15 thin sections taken at select intervals throughout Early—Middle Jurassic aged well Mohican I-100 cores 7 and 8, and the full core logs of both cores, a determination of depositional environment variation has been recorded and interpreted. This analysis is conducted in part to gain a better understanding of Early—Middle Jurassic carbonate and evaporitic strata emplaced along the modern central Atlantic margin during the formation of the proto-Atlantic ocean. As well, it provides an updated facies classification as conducted by Robertson et al. 2000 (see figure 1). These dolomitized sections will be further studied for source rock and/or reservoir potential, as well as larger-scale study of lithological intervals within the individual cores. The cores penetrate early—Middle Jurassic strata, and yield environments classified as a coastal, predominantly sabkha section which varies from semi-arid/coastal plain to inner shelf believed to be caused by base-level changes occurring on a regional scale theorized to be induced by the Pangea Breakup. This has been determined through an analysis of the microfacies in thin section, and the larger facies transitions in the full cores against evidence of diagenesis, micro-organisms, and other relevant variations in section. Classifications of environments is based on Robertson et al. 2000 with additional classifications created in study.
An investigation of hybridization of Halifax Pluton, South Mountain Batholith, Nova Scotia

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An investigation of magmatic growth history of the K-feldspar megacrysts in the Halifax Pluton, a Late Devonian age granite intruded into the Meguma strata bedrock, is ongoing. Specifically, the rocks being investigated outcrop along the coast by Prospect and Sambro Head, Nova Scotia. Several outcrops in these areas contain clusters of large mafic enclaves, which differ texturally from country-rock, metasedimentary xenoliths, and appear to be of a magmatic origin. The presence mafic enclaves suggest that a period, or periods, of magma mixing may have occurred. Magma mixing has been documented at Sambro Head, where a mafic intrusion has been injected into the still partially molten granitic host. Similar partial mixing zones have been described in other granitic intrusions of the same age in southwest Nova Scotia. Large K-feldspar phenocrysts (megacrysts) are present in both the granitic rocks and in some mafic enclaves by Prospect. Of note are enclaves which show megacrysts crosscutting their margins, suggesting that both the host granite and enclave were at least partially liquid during megacryst growth. This study will use field observations, petrography, whole-rock analysis and detailed electron microprobe analysis to study these mafic enclaves, surrounding host granitic rocks and in particular, the large megacrysts. Chemical zoning preserved in granitic feldspar megacrysts, where no obvious mafic enclaves occur, suggest that hybridization of this granitic pluton may have been more widespread than previously documented.
A non-invasive, surficial approach to studying bedforms in the nearshore

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Bedforms in nearshore environments are undulatory sedimentary structures formed by wave-forced fluid-sediment interactions at the seabed. Signature characteristics imprinted on the sediment fabric may be used to infer environmental conditions in the past by comparison to bedforms in the geologic record. Lunate megaripples and cross-ripples are bedforms with complex geometries that have been observed in nearshore environments, however they are not well studied in the literature and the conditions required for their formation are unclear. Previous surveying methods have recorded observations using instruments installed in the seafloor, which can disturb the sediment and obstruct fluid flow. The purpose of this study is to refine methodology for observing lunate megaripples and cross-ripples non-invasively. The study site, Crystal Crescent Beach, in Sambro, Nova Scotia, was selected for its sandy bottom and clear water. A low cost, human-powered surface vehicle was utilized as the platform for mounting (1) a video imaging device to record bedform morphologies at varying depths, and (2) a sonar device to detect and document ocean floor topography. Sand samples were obtained for analyzing grain sizes characteristic of the bedforms. Weather, wind, and wave conditions were recorded before, during, and following fieldwork to document potential physical conditions associated with bed geometries. These observations can be used as a basis for further studies of bedform development in nearshore environments using instrumented surface vehicles.
Rifted margin and sedimentary structure of the Porcupine Abyssal Plain, outboard of Goban Spur, southwest Ireland

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Goban Spur is a relatively shallow submarine plateau located 250 km southwest of the Irish mainland. This sediment-starved bathymetric feature overlies ancient Hercynian continental crust. Various periods of uplift and erosion were documented following Leg 80 of the Deep Sea Drilling Project-International Phase of Ocean Drilling (DSDP-IPOD). Syn-rift sediments as old as Barremian age unconformably overly the Hercynian basement, and are deposited in extensional listric faults dipping westward with throws of up to 4 km. Post-rift sediments overly a regional unconformity of Aptian age. Goban Spur remained structurally high in the Aptian, receiving lesser sediment influx than juxtaposed basins.

A recent seismic refraction survey has revealed a 120 km wide indeterminate region between the first magnetic anomaly related to seafloor spreading and thinned continental crust. High velocities and Poisson’s ratio values are reported within the upper 1.5 kilometers of basement 70 km seaward of the Pendragon escarpment. This region is interpreted to be a 70 km wide zone of serpentinized exhumed mantle. A bathymetric rise of 400 m is encountered to the west corresponding to a series of basement ridges. This 50 km wide region is persistent up to magnetic anomaly 34, which marks the beginning of seafloor spreading.

New regional seismic reflection data were acquired by the Petroleum Affairs Division (PAD), Energy and Natural Resources, Government of Ireland. These seismic lines will be reprocessed incorporating independent results. The intent is to produce an improved image of the transition from the rifted margin of the Goban Spur into the Porcupine Abyssal Plain, which is to be interpreted adhering to geological constraints from DSDP-IPOD Leg 80.
Atlantic Universities Geoscience Conference (AUGC) – Awards

Judging

Oral and poster presentations at AUGC are evaluated by a panel of at least 3 qualified judges with diverse geoscience expertise. In consultation with the award sponsors (as described below), the AUGC student organizers are responsible for assembling the panel of judges. At least four weeks before the date of the conference, the student organizers should contact the Science Atlantic Earth Science Committee and ask that they suggest at least one appropriate and available judge. Similarly the student organizers should contact Imperial Oil, CSPG, CSEG, and the Mining Society of Nova Scotia to invite them to send representatives to the conference. If such representatives are present at the conference, they may take the lead in judging the awards of those organizations. Professors at the host university can also be asked by the student organizers for advice in assembling the judging panel. Note: In all cases where plaques are awarded, the winner’s department is responsible for ensuring that the plaque is suitably engraved and that it is returned to the AUGC in the subsequent year so that it is available to be given to the next recipient.

Science Atlantic Best Paper Award

The Science Atlantic Presentation and Communication Award is given for the best overall student paper on any geoscience topic presented orally at the annual AUGC (Atlantic Universities Geoscience Conference).

Judging

The award is judged primarily on the basis of the scientific quality of the topic, the amount of original work done by the student, and his/her understanding of the subject. Evaluation criteria include: Abstract – Clear statement of problem, objectives, principal findings Presentation – Clarity, visual aids, organization Scientific merit – Experimental design, innovative approach, and interpretation of data Understanding - Overall knowledge and response to questions

The award will be judged by a panel of at least 3 qualified judges with diverse geoscience expertise as described under judging above.

The Award

The award consists of a monetary prize ($500 in 2015) and letter of commendation for the presenter, as well as a plaque which resides at the winner's university for one year, after which the winner’s university is responsible for bringing the plaque to the next annual conference. The award is usually presented by a representative of the Science Atlantic Earth Science Committee at the annual banquet of the AUGC.

Sponsor Information

This award (previously known from 2004-2012 as the APICS-NSERC Award) is the AUGC version of the Science Atlantic Undergraduate Research Award and Communication Award offered at all Science Atlantic-sponsored conferences. The Communication part of the award is sponsored by Canadian Science Publishing. A separate Communication Award is not offered at AUGC.
Imperial Oil Best Poster Award

The Imperial Oil Best Poster Award is given to the student presenting the best overall student poster on any topic at the annual AUGC.

Judging
The award is judged primarily on the basis of the scientific quality of the topic, the amount of original work done by the student, and his/her understanding of the subject. Evaluation criteria include:

- Abstract – Clear statement of problem, objectives, principal findings
- Poster design – Clarity, organization, visual appeal
- Scientific merit – Experimental design, innovative approach, and interpretation of data
- Understanding – Overall knowledge and response to questions

The award will be judged by a panel of at least 3 qualified judges with diverse geoscience expertise as described under judging above. When a representative of Imperial Oil is present, he/she will take the lead in judging this award.

The Award
The award consists of a monetary prize for the student presenter.

Sponsor Information
This award has been sponsored by Imperial Oil since 2007. Imperial Oil recognizes that business success depends on the economic, social and environmental health of the communities where they operate and views community investment not simply as a responsibility but as an essential component in building a strong society. Imperial Oil gives back to local communities through financial contributions, in-kind donations and volunteer efforts and supports scientific research with a number of awards and sponsorship.
Canadian Society of Petroleum Geologists (CSPG) Award

The Canadian Society of Petroleum Geologists Award is awarded annually for the best presentation of a petroleum geology-related paper at the annual AUGC. If the winner of the Science Atlantic Best Paper Award gave a petroleum geology-based presentation, then the CSPG award will go to the petroleum geology-based paper judged to be next best.

Judging
The award will be judged by a panel of at least 3 qualified judges with diverse geoscience expertise as described under judging above. When a CSPG representative is present, he/she will take the lead in judging for the award.

A plaque is presented to the winner at the AUGC banquet as well as a monetary prize ($500 in 2015), preferably by a CSPG member or representative. The plaque will reside at the winner’s university until the next AUGC, when the winner’s university is responsible for bringing the plaque to the next conference.

Sponsor Information
This award is sponsored by the Canadian Society of Petroleum Geologists. Founded in 1927, the mission of the Society is to advance the professions of the energy geosciences – as it applies to geology; foster the scientific, technical learning and professional development of its members; and promote the awareness of the profession to industry and the public.
Canadian Society of Exploration Geophysicists (CSEG) Award

Established in 2008, the CSEG award is given to the student who presents the best overall geophysics paper at the AUGC conference (typically awarded for an oral presentation; however, poster presentations are also eligible). Geophysics is a diverse discipline with many different areas of study, and this award could be awarded to any student whose work falls under this broad category.

Judging
Students will be evaluated on the scientific merit of their work, their general understanding of the material covered and their ability to effectively communicate this to the judges. This award will be judged by the panel of judges chosen by the conference organizers. Ideally one of these judges should have a geophysics background. The CSEG will typically send representatives to attend the conference so if a geophysics judge cannot be found locally then one of these representatives may be asked to judge. The award may not be presented if the judges and the CSEG representatives determine that no presentation fulfills the spirit of the award.

The Award
The award consists of a monetary prize ($500 in 2015) for the student presenter, as well as a plaque which resides at the winner’s university for one year, after which the winner’s university is responsible for bringing the plaque to the next annual conference. The award is usually presented by Imperial Oil’s representative at the annual banquet of the AUGC. The monetary prize of $500 comes from the funds ($4,500 in 2015), the IOL commits to the conference. It is a responsibility of the school that hosts the conference to prepare and distribute a cheque for the winning presenter.

Sponsor Information
The Canadian Society of Exploration Geophysicists began in 1949 at around the time of the petroleum production boom of the Leduc and Redwater discoveries. As a result of these 4 significant discoveries, there was a need for increased knowledge, skill and professional attributes in the field of geophysics. Today, the CSEG is a thriving organization. CSEG’s mandate is to promote the science of geophysics among its members, especially as it applies to exploration, and to promote fellowship and co-operation among those persons interested in geophysical prospecting.
Frank S. Shea Memorial Award in Economic Geology

The Frank S. Shea Memorial Award honours the student making the best presentation regarding an aspect of or with implications for economic geology. If the winner of the Science Atlantic Best Paper Award gives an economic geology presentation, then the Shea Award will go to the economic geology judged to be next best.

The award was established by the Mining Society of Nova Scotia at its annual meeting in June 1981 to honour Frank Shea, a long-time member and former president.

About Frank Shea
During some 27 years, Frank Shea was engaged in mineral resources exploration and development activities in the Atlantic region. For more than 10 years he served as Chief Geologist and division director of the Mineral Resources and Geological Services Division in the former Nova Scotia Department of Mines. Frank graduated from St. Francis Xavier University in 1954 with a BSc in geology. He continued his studies at Dalhousie University, receiving his Master’s degree in 1958. Frank had a great love for his native province and promoted its welfare by assisting mineral exploration and research projects whenever and wherever he could. He was a strong supporter of educational programs in geology such as the geology field school at Crystal Cliffs near Antigonish and prospector training.

Judging
Student papers are reviewed and judged for content in economic geology or implications for economic geology by a panel of practicing geologists. For practical purposes, this will be done the same panel of judges as evaluates the other awards. If there are no papers on economic geology or none deemed worthy during the annual AUGC, the award may not be given.

The Award
The award consists of a cheque ($500 in 2015) for the winning student and a $100 cheque for the geoscience club that the student represents.

Sponsor Information
The Frank Shea Memorial Award is sponsored by the Mining Society of Nova Scotia. Organized in the 1890s to promote the mineral industry, to share technical knowledge and to encourage fellowship, this Society was one of the founding members of the Canadian Institute of Mining and Metallurgy (CIM), the premier mining organization in Canada. The Society is pleased to support this award honouring a student, the contributions of Frank Shea, and the economic impact of geology on the Canadian economy.
Atlantic Geoscience Society (AGS) Environmental Geoscience Award

The Atlantic Geoscience Society Award was established in 2015 by the Atlantic Geoscience Society to recognize the best project (talk or poster) at the annual AUGC involving a significant component of environmental geoscience.

Judging
Student papers are reviewed and judged for content in environmental geoscience or implications for environmental geoscience by the same panel of judges as evaluates the other awards.

The Award
The award consists of a monetary prize ($100 in 2015) to the winning student and a plaque that will reside at that student’s university until the next AUGC.

Sponsor Information
The Atlantic Geoscience Society exists to promote a better and wider understanding of the geology of Atlantic Canada, both to its members and to the public. An entirely volunteer association, the AGS brings together earth scientists from universities, government institutions, the environmental, mining, and petroleum industries, and consultants in the Atlantic provinces.
## Short Course Schedule

**Using Seismic Data: From a Discovery to Early Field Development**

**AUGC  Oct 28, 2016**

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<th>Time</th>
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<tr>
<td>8:30 AM</td>
<td>00-L  Introduction</td>
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<tr>
<td>8:40 AM</td>
<td>01-L  Project Status and Goals</td>
<td>0:25</td>
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<td>9:05 AM</td>
<td>02-L  Geophysics 101</td>
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<td>9:40 AM</td>
<td>03-L  Well-Seismic Ties</td>
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<td>10:25 AM</td>
<td>03-E  Tying the Exploration Well to the Seismic Data</td>
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<td>11:00 AM</td>
<td>04-E  Mapping the Green Fault</td>
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<td>12:00 PM</td>
<td><strong>LUNCH</strong></td>
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<td>05-E  Mapping the Top of the Reservoir</td>
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<td>06-L  Seismic Data Analysis</td>
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<td>07-L  Components of Reservoir Quality</td>
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<td>07-E  Estimating Recoverable Reserves (EUR)</td>
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<td><strong>BREAK</strong></td>
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<td>3:45 PM</td>
<td>08-E  Designing &amp; Placing a Platform</td>
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Field Trip Guides:

*Sedimentology, structure and metamorphism on the South Shore of Nova Scotia*

**Leader:** Robert Raeside

Department of Earth and Environmental Science, Acadia University

The Meguma terrane is the farthest outboard terrane of the Appalachian Orogen. Most of the terrane is made up of Cambro-Ordovician rocks of the Meguma Supergroup, which comprises two units: the Goldenville and Halifax groups. On this trip, we will visit several of the formations that make up these groups, we will see the evidence for their deformation, and trace them into the contact metamorphic aureole of the South Mountain Batholith.

The South Shore of Nova Scotia is largely underlain by rocks of the Meguma Supergroup, a thick (~12 km) sequence of Cambro-Ordovician siliciclastic sedimentary rocks that have been deformed in the Neoacadian Orogeny into a series of upright large-scale folds. They were subsequently intruded by granite of the Devonian South Mountain Batholith, the heat from which resulted in a contact metamorphic overprint up to 2 km from the pluton. Mineralization (gold, arsenopyrite) post-dated the folding and metamorphism, and is focused in saddle-reef structures and a variety of bedding-parallel and cross-cutting veins. Excellent outcrops of the contact aureole, the effects of the folding, and the mineralization can be found around the shores of the LaHave Islands, Mahone Bay, and at Blandford on the Aspotogan Peninsula (Fig. 1).

The first part of this field trip will focus on the stratigraphy of the Goldenville and Halifax groups, particularly near the contact between these two groups (Fig. 2). The overall thickness of the two groups is in excess of 11,000 m, but much of that is placed in the Goldenville Group (about 8000 m), and restricted to inland areas and the eastern part of the Meguma terrane. The Goldenville Group is dominated by thickly bedded metasandstone, with rare interbedded slate, the Green Harbour Formation. This trip will first visit the top of the metasandstone, and the overlying Government Point and Moshers Island formations, and then outcrops of the Cunard and Feltzen formations of the Halifax Group. The second part of the field trip will examine the effect of contact metamorphism on rocks of the Cunard Formation as a result of intrusion by the South Mountain Batholith.

**STOP 1. GREEN BAY: Green Harbour and Government Point formations, Goldenville Group**

This locality lies at the contact between the top of the Green Harbour Formation (south of the canteen) and the base of the overlying Government Point Formation (north of the canteen).

The Green Harbour Formation consists of massive metasandstone showing internal scour-and-fill structures, a variety of dewatering features, and rare grazing trace fossils. The metasandstone beds are deposits of high-concentration turbidity currents and lack Bouma sequences. Scattered calcite concretions and diffuse carbonate-cemented areas are visible on weathered surfaces. This outcrop represents the top of 4000 m of massive metasandstone and scarce alternating slate beds. The actual contact is unexposed under a short section of beach. North of the beach, the base of the Government Point Formation consists of slate and subordinate graded, ripple cross-laminated metasandstone showing Bouma Tbc and Tc sequences.
Figure 1. Regional geology of the Mahone Bay area, showing the locations of field trip stops (after White and Barr, 2012).
STOP 2. BUSH ISLAND, LAHAVE ISLAND: Government Point Formation, West Dublin Member

The upper part of the Government Point Formation has been mapped as the West Dublin member, and is distinguished as thinly bedded metasandstone and slate, deposited as Bouma sequences, Ta to Td. Accessible outcrops can be found east of the public wharf on Bush Island, and in a disused quarry opposite Tumblin Road on LaHave Island.

STOP 3. BELLS POINT, WEST DUBLIN: Moshers Island Formation and base of the Cunard Formation (Goldenville-Halifax groups contact).

The Moshers Island Formation is a very distinctive unit, comprising 300-500 m of greenish-grey to purple, well laminated metasiltstone to slate, interbedded with thin metasandstone beds. It is characterized by steel-blue manganiferous nodules and laminations, which at higher metamorphic grade form pink coticule beds and lenses due to the growth of spessartine garnet.

The rocks of the Moshers Island Formation appear fairly coarse-grained and are less well cleaved than the overlying black slate, however thin sections show that the coarse grains are all metamorphic garnet, probably spessartine, and that the original grain size was very fine. Manganese-rich horizons can be recognized by their distinctive grey-brown to black weathering colours. They contain manganese carbonate (kutnohorite or manganoan calcite) and spessartine. These layers behaved extremely competently during regional deformation; almost all the small-scale buckling was controlled by the manganese-rich layers, and the small (1 to 3 cm) manganiferous concretions are only slightly deformed.

At Bell Cove, the overlying Cunard Formation of the Halifax Group is well exposed. The Cunard Formation consists of black to rust-brown slate and minor metasiltstone. The formation is over 2000 m thick, and represents an extensive period of restricted sediment input in a deep ocean basin, and the abundance of pyrite, arsenopyrite and pyrrhotite suggests deposition under anaerobic sea-floor conditions (Fig. 4).

On the south side of Bell Cove black slate and pyrite-rich siltstone dip toward the shore, and display extensive acid-rock drainage along bedding and foliation planes. At the north side of the cove, the slate is folded into an antiform, and the intersection of bedding over the fold hinge with axial planar cleavage results in the production of pencil slate. Also, in this outcrop, the cause of the extensive oxide weathering and acid rock drainage can be seen where some beds enriched in arsenopyrite porphyroblasts.

Figure 1 Stratigraphy of the Goldenville and Halifax groups (after White, 2010).

Figure 3 Classical Bouma sequences in a turbidite deposit (Bouma 1962).
STOP 4. FELTZEN SOUTH: Mushroom folds and strained burrows.

The Feltzen Formation occurs only in the cores of synforms and its top is not seen. It is light grey to blue-grey slate, rhythmically interlayered with laminated fine-grained metasandstone.

The first outcrop below the graveyard is a glacially striated humback, with a prominent glacial groove etched into it. The rocks here are complexly deformed interbedded slate and metasandstone. On the main humpback, find the layer of white banded metaturbidite – follow it around until you return to where you started. You should have walked around a complex “mushroom shape”, the result of folding in two directions and erosion through the fold structure.

If you look carefully on the back of the outcrop you will find interesting carvings made in the 19th century by ship owners. Some of these are good subjects for taking rubbings.

To the east of the humback outcrop is a small outcrop with finely bedded slate, exposed over the hinge of an anticline. As a result, bedding and cleavage are not parallel here, and many vertical U-shaped burrows are visible. Viewed from above, these burrows are distinctly elliptical, the result of deformation. These burrows have been ascribed to the ichnogenus Arenicolites, common in the littoral zone and might indicate that the Feltzen Formation was deposited in alternating deep and shallow water environments.

STOP 5. BLANDFORD: contact aureole of the South Mountain Batholith.

The South Mountain Batholith intruded chlorite-zone black slate and metawacke of the Cunard Formation (Halifax Group). At 200 m north from the junction of Highway 329 in Upper Blandford (opposite house #42), bedding (shallow dip) and cleavage (steep dip) are well preserved, and the offset of the silty layers along the cleavage is clearly evident. However, the rocks lack the extreme fissility characteristic of slate, suggesting that the slaty cleavage has been at least partially annealed. The most obvious evidence of contact metamorphism here is the presence of small (1-5 mm) chiastolite porphyroblasts. These clearly postdate the cleavage, although they tend to be concentrated along cleavage planes, probably because they are enriched in aluminous minerals. In thin section, chiastolite is seen to be completely replaced by sericite, chlorite and quartz. Small, ovoid, inclusion-choked cordierite spots can be seen in thin section although they are very difficult to see in outcrop. Chlorite is stable and biotite is absent.

North along the road 700 m is a pull-off at a small pier at house #198. The outcrops north
of the pier consist of black, very hard hornfels. The slaty cleavage has almost disappeared although its effects can still be seen where silty layers are offset against the pelite (resembles “ripples”). The mineral assemblage consists of andalusite + cordierite + biotite + plagioclase + quartz + muscovite. Biotite typically rims cordierite and muscovite is relatively fine-grained and largely confined to the matrix. In comparison to the previous outcrop, the overall grain size has increased, although andalusite (chiastolite cross not as well developed) and cordierite (much larger with fewer inclusions) still form distinct porphyroblasts. The matrix has partly recrystallized, but relicts of the slaty cleavage in the matrix, and straight inclusion trails in cordierite porphyroblasts can be seen in thin section.

STOP 6. DEEP COVE: hornfels cut by granite

On route 329 is a large rusty-weathering cliff at Deep Cove (3.7 km north of the Upper Blandford intersection). The outcrop is the west end of the 150 m high Aspotogan Mountain, which owes its existence to the hardness of the hornfels that composes it. The rubble here is loose, and not for climbing on! The actual contact is not exposed, but granite outcrops at the top of the hill, and granite veins cut the hornfels part way up the rock face. The matrix is considerably coarser than at the last stop. Cordierite is the dominant porphyroblast phase and is rimmed by biotite and muscovite. Andalusite, now lacking the chiastolite texture, takes on a very spongy appearance and is mainly interstitial to the cordierite. Fibrolite is present, although not visible in hand specimen. The sulphide responsible for the iron staining here is pyrrhotite. The abundance of secondary muscovite suggests that some K-feldspar may once have been present in the matrix. The granite veins here contain andalusite, probably of igneous or hydrothermal origin, since it forms euhedral, zoned crystals unlike those seen in the hornfels.

References


Rocks, mud, and scenery: An introduction to the amazing geology of the Wolfville area

Leaders: Sandra Barr and Ian Spooner

Department of Earth and Environmental Science, Acadia University

Stop 1: PENNY BEACH AND HORTON BLUFF

(a) Penny Beach

At Penny Beach you can see excellent examples of coastal erosion and local strategies to mitigate the process. Coastal erosion in the Minas Basin can be as much as 30 cm/year, and locally rates greater than 1 m/year have been noted. Most erosion occurs during the winter months, as storms are frequent and often accompanied by northwesterly winds allowing waves to build up over a maximum distance (fetch) of 30 km. Storms that coincide with the highest tides are especially damaging. Local strategies for dealing with erosion are varied. Property owners with money have used North Mountain basalt, South Mountain granite, and other local rocks as armour. Some have used (with much less success) coarse fill and brush. In many cases the placement of armour has exacerbated the problem or, worse yet, transferred the problem down the coastline.

Penny Beach is migrating landward. The migration is over salt-marsh peat that is up to 2.5 m thick and is accumulating in the basin landward of the present beach. This basin was formerly more extensive and the peat underlies the present sand beach, in places cropping out on the beach face.

(b) Horton Bluff

In addition to observing the effects of present-day and recent-past beach and shorelines processes, we will also walk along the shore to look at outcrops of sedimentary rocks of the Horton Group. The Horton Group is a major rock unit in Nova Scotia; it is over 1200 m in thickness and of early Carboniferous age (about 360-350 million years old).

The rocks of the Horton Group display a variety of sedimentary features, which can be used to interpret the environment in which the original sediments were deposited. These features include fossil footprints made by a large labyrinthodont amphibian. William Logan first discovered these (or similar) tracks in this area in 1841. In 1979, a team from the Nova Scotia Museum examined this trackway in detail and made casts of the footprints in fibreglass for permanent display at the museum. They measured a total of 27 footprints from a trackway 30 m long. The largest track was 30 cm in length. Few tracks remain now because of continued erosion. The animal that made the tracks was four-footed, had four toes on each foot, and looked a bit like a huge salamander! In addition to the tracks (which can be viewed only at low tide), the rock record numerous other indicators of the environment of sediment deposition including ripple marks, raindrop imprints, mudcracks, bi-lobed trace fossils, fish scales, and plant fossils.
Stop 2:  GASPEREAU RIVER VALLEY

At Stop 2 you will see a classic example of a Gilbert-style delta, a coarse-grained delta most commonly associated with deglaciation. These deltas are common in the Gaspereau Valley. Gilbert deltas develop when sediment-laden glacial meltwater enters a standing body of water. This delta is now perched above sea level as land has rebounded from the weight of the glaciers, resulting in a relative sea level drop. Notice the clay balls that are incorporated in the coarse sediment, an indication that the source of the sediment was ice and that the transport distances were very short.

The Gilbert-style deltas located in the Gaspereau Valley characteristically are found on the south side of the Valley and have very distinct “flat” tops. Why is this?

Stop 3:  HALIFAX GROUP

Interbedded slate and metasiltstone of the Halifax Group are almost vertical in this outcrop. Axial planar slaty cleavage (formed during regional greenschist-facies metamorphism associated with the Neoacadian orogeny at ca. 400 - 380 Ma) is approximately parallel to bedding. Some beds contain cross-laminations which you can use to interpret younging direction - are younger beds to the north or to the south? Those with sharp eyes for fossils may find well preserved graptolites on some bedding planes. They have been identified as Rhabdinopora flabelliformis

Flabelliformis, an Early Ordovician species.

The outcrop is intruded by a large gabbro sheet with chilled margins. Would you call this intrusion a sill or a dyke?

Stop 4:  SOUTH MOUNTAIN BATHOLITH AT BLACK RIVER LAKE

South Mountain Batholith underlies much of southern Nova Scotia and forms a topographic feature known as South Mountain (maximum elevation ca. 250 m). The South Mountain Batholith consists of ca. 380-370 Ma granodiorite and granite which have been divided into many mappable units based on in most cases subtle differences in texture and mineralogy. All units of the South Mountain Batholith are peraluminous, meaning that they contain high Al₂O₃ relative to CaO, Na₂O, and K₂O. This chemical characteristic is reflected in the mineralogy, which is dominated by quartz, plagioclase, K-feldspar, and biotite, with accessory aluminum-rich minerals such as muscovite, cordierite, and andalusite. No hornblende is present.

At this location near Black River Lake, we are in a major biotite monzogranite unit that forms much of the northern part of the batholith. Large phenocrysts of K-feldspar show some alignment due to flow during magma emplacement. Xenoliths of metasedimentary rocks indicate that stoping may have played a major role in magma emplacement in this part of the batholith.

The rocky, uneven topography produced by weathering of the granite demonstrates why most areas of Nova Scotia underlain by South Mountain Batholith are sparsely populated!
Stop 5: WHITE ROCK FORMATION

The Silurian White Rock Formation in the Wolfville area consists mainly of quartzite. The original quartz sands were likely deposited on a beach. The quartzite weathers light grey (hence the name of the small community after which the formation is named) but shows a lot of iron oxide staining as a result of groundwater movement along joints and fractures.

The quartzite is a popular building stone in the Wolfville area, and was used, for example, in the construction of the gymnasium/arena complex at Acadia University.

From this stop one can also see the highly incised upper portion of the Gaspereau River. This incision is about 70 m deep and could not be formed by the river in its present condition. The incision was almost certainly formed by subglacial meltwater erosion during the waning stages of deglaciation. It is a classic example of a tunnel valley.

LUNCH at Noggins Farm

Stop 6: CORNWALLIS RIVER

The Cornwallis River at this location is still part of a tide-dominated estuarine system. If the tide is low enough, it may be possible to see large current dunes developed on the river floor, an indication that the current has sufficient strength to both transport and deposit appreciable amounts of sand. Similar deposits to these are prolific oil producers in western Canada. Dykes protect these farmlands from flooding.

Stop 7: WOLFVILLE FORMATION, KINGSPORT

Along the beach at Kingsport, we can see the effects of coastal erosion, and what land-owners are doing to try to stop it. We can also see very well the rocks which form the Wolfville Formation, easily eroded fluvial sandstone and conglomerate deposited more than 200 million years ago. The rate of erosion here is as much as 1 m/year – so one hundred years ago, the rocky bluffs were 100 m farther out in the basin. "The Canada", one of the largest sailing ships ever built in Canada, was constructed here at the wharf in Kingsport more than 100 years ago. Try to imagine what this place must have looked like then (1891).

Stop 8: BLOMIDON FORMATION, HOUSTON BEACH

A walk along Houston Beach brings us to outcrops of the Blomidon Formation, composed of shale and siltstone deposited in a mainly lacustrine (playa lake) environment. What evidence can you find in these rocks for the type of climate in this area back in the Triassic?

The bedrock is overlain by thick glacial outwash sediments. Together, the two are eroding to produce a great beach (when the tide is high!).
Stop 9: THE LOOK-OFF - more than just scenery!

The view from the Look-off shows how geology controls topography and land use in the Wolfville area. The North Mountain Basalt "caps" North Mountain between Cape Blomidon and Brier Island, a distance of more than 180 km, and forms a protective barrier from the cold winds of the Bay of Fundy. The basalt is underlain by the Blomidon and Wolfville formations, which are less resistant to erosion and underlie the Annapolis Valley. The sandstone and mudstone of the Blomidon and Wolfville formations erode to form the fertile red soils of the valley, and the red mud of Minas Basin. On the south side, the valley is protected by South Mountain, underlain by resistant metamorphic and plutonic rocks that we saw earlier. These rocks are unconformably overlain by the Wolfville and Blomidon formations. Carboniferous sedimentary rocks underlie the Avon River area to the east - if it is a clear day, you may be able to see outcrops of these rocks around the lighthouse at Horton Bluff which we visited earlier today and on the Cheverie shoreline on the northeast side of the Minas Basin.

On top of the bedrock, varied effects of glacial and post-glacial erosion and deposition and post-glacial erosion and deposition have produced the detailed topography of river valleys, gentle rolling hills, and the Minas Basin itself.

Stop 10: ROSS CREEK (basalt, chert, zeolite minerals, agate, and amethyst)

North Mountain Basalt formed as a result of fissure eruptions about 200 million years ago as Africa and North America began to rift apart. The basalt is well exposed along the Bay of Fundy shoreline. In synclinal bays, sedimentary rocks of the overlying Scots Bay Formation are also preserved. The calcareous sedimentary rocks of the Scots Bay Formation were deposited in lakes and hot springs on top of the basalt, and reach thickness of several kilometres under the Bay of Fundy.

North Mountain Basalt is composed of up to 18 basaltic flows, ranging in thickness from a couple of metres to 60 m, with a total thickness of about 250 m. At Ross Creek, we will look at the uppermost flow of the sequence. As you walk from Ross Creek to the southwest along the shore you are seeing a section through this flow from near the bottom to the top. Because of this, you will notice an obvious change in texture. The lower part of the flow shows columnar jointing, and is cut by veins containing chalcedony (agate) and zeolite minerals. Toward the top, the flow becomes highly amygdaloidal, and the amygdales contain the same minerals as the veins. You can walk through the top of the flow into the overlying Scots Bay Formation.

The Scots Bay Formation is mainly well bedded limestone, but contains abundant large chert nodules (which may represent algal structures or silicified tree remains?). Cavities in the chert nodules commonly contain well developed quartz crystals, in places with purple colour (amethyst). The chert was popular with and widely traded by native people in the area who used it to make arrow heads and other tools.

End of Trip and Return to Old Orchard Inn
The East Kemptville Tin Mine and Brazil Lake Pegmatite

Leader: Cliff Stanley

Department of Earth and Environmental Science, Acadia University

Abstract

This field trip will investigate two mineral deposits in western Nova Scotia. The day will first include a visit to the now closed East Kemptville Tin Mine, where we will tour the site, have a chance to view mineralization in the low-grade stockpile, and learn about the ongoing environmental remediation efforts to ensure that acid rock drainage from the tailings impoundment is treated adequately before it leaves the site. This will be followed by an examination of drill core recently drilled into the potentially economic zones that remain to view the economic and hydrothermal alteration minerals within the mineralized zones at East Kemptville. Finally, we will visit surface exposure of the Brazil Lake Pegmatite Deposit’s north zone, which has recently been cleared of overburden and is now fully exposed at surface.

Overview

The 2016 Atlantic Universities Geologic Conference at Acadia University presents a field trip that will visit a number of places of geo-economic importance in southwestern Nova Scotia. The trip takes place on Friday, October 29, 2010. Departure will be at 7:30 AM from the Old Orchard Inn parking lot, we will have a box lunch at an appropriate time during the trip, and participants will be returned to the Old Orchard Inn by 5:00 PM.

The field trip will involve three extended stops:

1. East Kemptville Tin Mine site (operated by BHP Billiton),
2. Avalon Advanced Materials Exploration House and Core Storage Farm, and
3. Brazil Lake pegmatite (North Zone).

Geological Background

Southwest Nova Scotia is part of the Meguma Terrane and contains several important rock packages. These include:

i) Meguma Supergroup, a sequence of Neo-Proterozoic to Ordovician clastic sedimentary rocks deposited as proximal and distal turbidites on the west coast of Africa; these folded sedimentary rocks are intruded by a number of granitoid rocks, including the early Carboniferous Wedgeport pluton, the middle Ordovician Shelburne pluton, the early Devonian Barrington Passage pluton, and …

ii) South Mountain Batholith; this is the largest granitoid complex in the Appalachians; it has peraluminous affinities, also has a late Devonian Age, and is host to the East Kemptville Sn deposit, and several other Sn prospects;

iii) Yarmouth Syncline, a sequence of Paleozoic clastic sedimentary and volcanic rocks deposited on top of Meguma Supergroup rocks; these are folded into a NNE-SSW synclinorium with fault boundaries (the Chebogue Point and Cranberry Point Shear Zones), are intruded by the Ordovician Breton pluton, and associated rare metal pegmatite bodies near Brazil Lake; the Yarmouth Syncline separates two distinct parts of the Meguma Supergroup, as stratigraphy on the north and south side of the syncline are subtly different, suggesting that rocks on the French (northwest) and South Shores, were deposited in different sub-basins.

**East Kemptville Sn Deposit**

**Early History**

The East Kemptville Sn deposit was discovered 55 km northeast of Yarmouth, Nova Scotia in 1978 by Shell Canada Resources during follow-up of a regional till geochemistry program. Drilling commenced in 1979, but once the margins of the deposit were known, the property was sold to RioCanex (later to become Rio Algom Ltd.) in 1982, who increased the drill core density to allow calculation of a mining reserve, and subsequently built the mine and brought the property into production in 1985. Initial reserves consisted of 56 M tonnes of 0.165 % Sn (at a cut-off of 0.050 % Sn), and mining took place via a large-scale open pit with production rates of 10,000 tonnes/day.

Unfortunately, the mine opened just as the International (Malaysian) Tin Cartel went broke (due to their failed attempt to support the Sn price in the face excess supply produced by artisanal mining of Sn from river gravels in Bolivia). This caused the price of tin to plummet from $7.50 USD to $2.75 USD, squeezing the mine’s profit margin.

Further woes affected the project, as the initial Sn recovery was much lower than expected (30 %, instead of 75 %) due to previously unappreciated deformation of the ore (which caused the formation of composite grains during milling and reduced the grade of the recovered...
concentrate). The lack of Sn recovery limited revenue, and prevented Rio Algom from achieving the production milestones required by their loan agreement. As a result, the banks that funded the project took over control of the property, but because they didn’t know how to mine it, they put out tenders to operate the mine via contractors. Ironically, Rio Algom won the contract to mine the deposit, but eventually purchased it from the bank at a fire sale price.

Over the years, Rio Algom mining engineers came to understand the ore better and thus increase Sn recovery to 65%. Then, in 1990, the mine added a flotation circuit to recover the accessory chalcopyrite and sphalerite. Both of these factors served to make mining of the ore more profitable. Lamentably, the price of Sn didn’t recover sufficiently, and the mine closed in 1992. Since 1992, the East Kemptville has been dis-assembled and environmental reclamation and remediation has been taking place.

**Geology**

The East Kemptville Sn deposit consists of a ENE-trending, sub-vertical sheeted quartz vein system and hydrothermal alteration zone developed within but near the top and side of a late Devonian muscovite-bearing leucogranite phase of the Davis Lake pluton of the South Mountain batholith. The leucogranite contains few mafic minerals, and is highly evolved, with Rb, F, and Sn concentrations exceeding 1000, 4000 and 1000 ppm, respectively. It intruded folded and metamorphosed beds of quartz arenite from the Green Harbour Formation of the Goldenville Group along the ENE-WSW trending East Kemptville (East Dalhousie) Shear Zone. Mineralization is thought to have occurred in mesothermal conditions (between 3.5 and 4 kbars pressure; 10 to 12 km deep), a feature that is typical of peraluminous granites. Two zones of mineralization were mined: the large but low grade (0.165 % Sn) Main Zone to the ENE (hosting greisen-type mineralization), and the smaller but higher grade (0.400 % Sn) Baby Zone to the WSW (hosting greisen- and breccia-type mineralization).

Three different granite compositions (G1, G2, and G3) have recently been identified at East Kemptville, based on a number of high field strength trace element concentrations (e.g., Zr, Y, Ce, Th). These phases generally cannot be identified independently, as textural and mineralogical variations amongst these granites are cryptic. Using lithogeochemical data, these granite compositions appear to occur in a stacked array, with G1 occurring above G2 in the Main Zone, and G2 occurring above G3 in the Baby Zone. As a result, these granite compositions may reflect hangingwall fractionation within an evolving granite melt, and could suggest that the Baby Zone has been faulted upwards relative to the Main Zone, and thus reflects mineralization at a deeper level. Given that grades within the Baby Zone are higher than the Main Zone, this may suggest that additional higher-grade mineralization may exist at depth beneath the Main Zone.
Three alteration haloes exist adjacent to these veins: proximal (hottest) ‘topaz only’ (TOPZ), intermediate ‘topaz + quartz’ (TOQZ), and distal (coolest) ‘muscovite + quartz’ (MUQZ) alteration zones (collectively, these are traditionally referred to as ‘greisens’, largely because they contain topaz). Lithogeochronology of these rocks has constrained the concentrations of the minerals (alkali feldspar is OR\textsubscript{20}: K\textsubscript{1/5}Na\textsubscript{4/5}AlSi\textsubscript{3}O\textsubscript{8}; muscovite is Fe\textsubscript{50}-phengite: K\textsubscript{2}Fe\textsubscript{1/2}Al\textsubscript{5}Si\textsubscript{13/2}O\textsubscript{20}(OH)\textsubscript{4}; topaz is F\textsubscript{25}-topaz: Al\textsubscript{2}SiO\textsubscript{4}(OH)\textsubscript{3/2}F\textsubscript{1/2}) and the geochemical reactions responsible for these three alteration styles.

Mineralization in the greisens is zoned, with cassiterite, dark (Fe-rich) sphalerite and chalcopyrite in the ‘topaz + quartz’ zones, mostly cassiterite only in the ‘muscovite + quartz’ zones, and no significant ore minerals in the ‘topaz only’ zones. This zoning can be related to temperature changes in the hydrothermal fluid, the availability of Fe\textsuperscript{+2} necessary for precipitation of the ore minerals, and how hydrothermal alteration changed fluid pH.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Host Rock</th>
<th>Reactants</th>
<th>Alteration Products</th>
<th>Metasomatic Addition</th>
<th>Metasomatic Removal</th>
<th>Volume Change</th>
<th>Mineralization</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUQZ</td>
<td>10 ALKF</td>
<td>2 Fe\textsubscript{50}-PHNG + 17 QRTZ</td>
<td>+2 Fe\textsuperscript{+2} +2 K\textsuperscript{+} + 4 H\textsuperscript{+} +2 H\textsubscript{2}O</td>
<td>-8 Na\textsuperscript{+}</td>
<td>-5 %</td>
<td>Sn</td>
<td></td>
</tr>
<tr>
<td>TPQZ</td>
<td>4 Fe\textsubscript{50}-PHNG</td>
<td>10 F\textsubscript{25}-TOPZ + 16 QRTZ</td>
<td>+17 H\textsuperscript{-} +5 F\textsuperscript{-}</td>
<td>-2 Fe\textsuperscript{+2} -9 H\textsubscript{2}O -8 K\textsuperscript{+}</td>
<td>-27 %</td>
<td>Sn, Cu, Zn</td>
<td></td>
</tr>
<tr>
<td>TOPZ</td>
<td>2 QRTZ</td>
<td>2 F\textsubscript{25}-TOPZ</td>
<td>+4 Al(OH)\textsuperscript{+2} +3 H\textsubscript{2}O + 1 F\textsuperscript{-}</td>
<td>- 7 H\textsuperscript{+}</td>
<td>+111 %</td>
<td>&lt;barren&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Specifically, when the cooler ‘muscovite + quartz’ alteration took place, Fe\textsuperscript{+2} was consumed by the formation of Fe-phengite, so Fe\textsuperscript{+2} necessary for the precipitation of Fe-bearing sulphide minerals (pyrite, pyrrhotite, chalcopyrite and Fe-bearing sphalerite) was not present, and thus these minerals are scarce in this zone. In contrast, when ‘topaz + quartz’ alteration took place, Fe\textsuperscript{+2} was liberated, facilitating the precipitation of these same Fe-bearing sulphide minerals. Lastly, when the high temperature ‘topaz only’ alteration occurred, Fe\textsuperscript{+2} was very soluble (Fe solubility varies proportionally with temperature), so precipitation of Fe-bearing sulphide minerals also did not take place.

In contrast, cassiterite likely precipitated due to two factors: adiabatic reductions in temperature caused by fluid ascent (decompression), and by increases in fluid pH caused by the different alteration reactions. For example, in both the ‘muscovite + quartz’ and ‘topaz + quartz’ alteration, H\textsuperscript{+} is consumed, raising pH and triggering the precipitation of cassiterite by the reaction:

\[
\text{Sn}^{4+} + 2 \text{H}_2\text{O} \Rightarrow \text{SnO}_2 + 4 \text{H}^+.
\]
However, during ‘topaz only’ alteration, H⁺ is produced, lowering pH and preventing cassiterite precipitation.

The greisen alteration zones hosting mineralization are developed almost exclusively in leucogranite, and occur in two forms: regional and zoned greisens. Regional greisens exist at scales up to 10’s of meters wide, and likely formed when host rocks were hot, and thus above the brittle-ductile transition. Aqueous fluid migration under these conditions was diffusive along mineral grain boundaries. Evidence for these conditions is the prevalence of pyrrhotite instead of pyrite in the regional greisens (an indicator of hotter conditions), and an abundance of disseminated sulphide minerals in the ‘topaz only’ and ‘topaz + quartz’ zones (a product of diffusive fluid flow in rocks with porosity developed by previous, volume loss hydrothermal alteration reactions).

Zoned greisens exist at scales up to meters wide, and generally occur along faults and shear zones. These likely formed when the rocks were cooler, below the brittle-ductile transition (in fact, zoned greisens are observed cross-cutting earlier regional greisens, suggesting that mineralization occurred during cooling of the hydrothermal system. Aqueous fluid migration associated with zoned greisens was advective, and thus largely through steeply dipping fractures (veins), although minor diffusive fluid flow likely occurred to form the alteration envelopes observed adjacent to the veins. Evidence for these conditions is the prevalence of coarse-grained pyrite instead of pyrrhotite (an indicator of cooler conditions), and the presence of sulphide mineralization in the ‘topaz + quartz’ zones.

**Recent History**

In 2005, Avalon Rare Metals, Inc. (now Avalon Advanced Materials, Inc.) recognized the latent potential of the East Kemptville deposit. Advanced gravitational and flotation recovery methods for Sn, Cu and Zn were available, and metal prices were relatively high. In addition, previously unrecognized indium (In) concentrations in the ore had potential as an important by-product. As a result, Avalon obtained a Special Exploration License from Rio Algom in 2005, and initiated a desktop study of all available information about the deposit. This was completed in 2010, and a resource estimate was prepared from this data. Archived drillcore stored at the Nova Scotia Core Storage Facility in Stellarton was sampled to undertake metallurgical testing.

Finally, in 2014, an agreement with the Rio Algom was signed to allow access to the minesite. As a result, confirmation drilling of 7 (twinned) diamond drill cores was undertaken in 2014, and an additional 22 diamond drill cores was undertaken in 2015. These allowed the refinement of the resource estimate in the Main Zone (from ‘inferred’ to ‘indicated’ categories), identification of the boundaries of mineralization in the Baby Zone, and identification of new mineralization in the South Grid area. At present, the resource estimate at East Kemptville consists of 18.47 M tonnes of indicated mineralization at grades of 0.176 % Sn, 0.173 % Zn, and 0.064 5 Cu (with a
0.10 % Sn cut-off), and 16.95 M tonnes of inferred mineralization at grades of 0.148 % Sn, 0.122 % Zn, and 0.062 % Cu (with a 0.10 % Sn cut-off).

Avalon Advanced Materials Inc. continues to advance the East Kemptville project to

The Brazil Lake Pegmatite

History

The Brazil Lake prospect was discovered in 1960 after a spodumene-bearing glacial erratic boulder was discovered beside Holly Road, 25 km northeast of Yarmouth in Yarmouth County, Nova Scotia. Several pegmatite dykes up to 200 m long, and 10-20 m wide were identified (the North, South, and Army Road pegmatites), but little was known about them until the Nova Scotia Dept. of Natural Resources drilled 5 diamond cores through them in 1993, as the area is covered by a thick layer of glacial till.

In 1998, Gwalia Consolidated Mining Co. of Perth, Australia evaluated the pegmatites for their Ta potential but didn’t continue evaluation when the Ta grades ended up being too low. Champlain Resources Ltd. subsequently worked the property between 2002 and 2004, drilling an additional 32 diamond drill cores. Recent increases in lithium demand due to the use of Li batteries has renewed exploration of the property by Champlain Mineral Ventures Ltd. They have completely uncovered the North and South pegmatites, and have undertaken metallurgical studies that have demonstrated that the pegmatites contain high quality quartz, albite, microcline, and muscovite industrial mineral resources, as well as Li, in spodumene [LiAlSi₂O₆], and Rb, in microcline and muscovite, minor beryl [Be₃Al₂Si₆O₁₈], and low concentrations of tantalum, tungsten and tin.

Geology

The pegmatite bodies intrude amphibolite-grade metavolcanic and metasedimentary rocks of the Silurian White Rock Formation within the Chebogue Point Shear Zone. In general, the pegmatite bodies dip steeply SE (70-80°) and occur en-echelon to each other, trending NE-SW and obliquely cross-cutting host rock foliation that strikes NNE-SSW and dips steeply WNW.

The pegmatite bodies cut interbedded grey-to-white quartzite (quartz arenites), plagioclase-hornblende schist/gneiss (mafic tuffs) and garnet-biotite-staurolite-muscovite schist (pelites) that occur locally within the White Rock Formation stratigraphy. A late Devonian U-Pb tantalite age for the pegmatite is contemporaneous with the age of the South Mountain batholith, and petrologic constraints indicate that crystallization took place between 3.5 to 4 kbars (10 to 12 km depth) and 600 °C.

The pegmatite bodies are enriched in large ion lithophile and high field strength elements (Li, Cs, Ta, Be, Rb, and Sn), and thus are members of the LCT (Li-Cs-Ta) pegmatite class. Because they also contain abundant albite and spodumene, they further belong to the albite-
spodumene sub-class of the LCT pegmatite class. These features indicate that the Brazil Lake pegmatites are derived from a highly evolved granite melt.

Collectively, the pegmatite bodies exhibit four mineral assemblages:

(i) \{SMAQ\} coarse grained spodumene + muscovite + albite (as cleavelandite) + quartz ± microcline,
(ii) \{KFAB\} blocky microcline + albite,
(iii) \{ALBT\} aplitic albite, and
(iv) \{SPQU\} very coarse grained spodumene + quartz.

In each pegmatite, these assemblages were produced as a result of an initial intrusion of a melt that crystallized predominantly coarse-grained microcline, quartz, spodumene, and muscovite. This was subsequently subjected to shearing and Na metasomatism, converting the microcline into cleavelandite, and replacing the spodumene by other Li-bearing minerals.

The Army Road pegmatite differs from the North and South pegmatite in that it consists of several dykes interbedded with the host rocks, instead of one thick pegmatite body; it also differs from the North and South pegmatites in that it lacks spodumene.

Accessory minerals within the pegmatite bodies consist of: biotite \([K(Fe,Mg)_3AlSi_3O_{10}(OH)_2]\), epidote \([Ca_2Al_2Fe^{3+}Si_3O_{12}(OH)]\), chlorite \([Fe,Mg)_9Al_6Si_2O_{20}(OH)_{16}]\), garnet \([Fe,Mg,Mn)_3Al_5Si_3O_{12}]\), tourmaline \([Na(Fe,Mg)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4]\), fluorapatite \([Ca_5(PO_4)_3F]\), zircon \([ZrSiO_4]\), cassiterite \([SnO_2]\), wolframite \([Fe,Mn]WO_4]\), tantalite \([Fe,Mn](Ta,Nb)_2O_6]\), and titanite \([CaTiSiO_5]\); rare/first-documented minerals consist of: lithiophilite-triphylite \([Li(Fe,Mn)PO_4]\), fillowite \([Na_2Ca(Mn,Fe)_7(PO_4)_6]\), amblygonite/montebrasite \([(Li,Na)Al(PO_4)(OH,F)]\), and cookeite \([Li_2Al_{10}Si_6O_{20}(OH)_{16}]\).

Both the host rocks and pegmatite bodies have been hydrothermally altered, likely by deuteric fluids emanating from the pegmatite bodies. Within pegmatite, spodumene and quartz in the SMAQ and SPQU zones have partially altered to other Li-bearing minerals, whereas in the quartzites hosting the pegmatite bodies, alteration occurred in four styles: (a) host rock recrystallization, (b) footwall B and Li metasomatism, (c) hangingwall Ca metasomatism, and (d) late propylitic alteration. The B and Li metasomatism is most abundant and thicker (up to 7 m) in the pegmatite footwalls, and is associated with hornblende \([NaCa_2(Fe,Mg)_4Al_2Si_6O_{22}(OH)_{12}]\) + plagioclase \([(CaAl,NaSi)AlSi_2O_8]\) + biotite destruction and quartz + tourmaline ± titanite ± apatite ± calcite \([CaCO_3]\) formation. Ca metasomatism resulted in the formation of calcite, rhodochrosite \([MnCO_3]\), titanite, apatite, and vesuvianite \([Ca_{10}Mg_2Al_5Si_6O_{34}(OH)_4]\). Propylitic alteration is characterized by three geochemical reactions, whereby: (i) hornblende alters to epidote + chlorite + calcite + titanite + ilmenite \([FeTiO_3]\), (ii) plagioclase alters to zoisite \([Ca_2Al_3Si_3O_{12}(OH)]\) + calcite, and (iii) biotite alters to chlorite.
Fieldtrip Itinerary

7:30 AM – Departure from the Old Orchard Inn

From the Old Orchard Inn (Wolfville), turn left (north) on NS Hwy 358, proceed under Hwy 101, and immediately turn left again (west) onto the Hwy 101 on-ramp. Proceed 81 km to Exit 20, and stop there to pick up your field trip leader. Re-enter Hwy 101 (west), and proceed and additional 82 km to Exit 27. Turn left and proceed on Hwy 1 south for 6 km through Weymouth, turning left (east) when you reach Hwy 340. Follow Hwy 340 (east, then south) for 52 km until you reach Carleton. There, turn left (east) on Hwy 203 and proceed 19 km to East Kemptville, and then past it 7 km to the East Kemptville Tin Minesite, on the right.

10:00 AM – 12:30 PM – Stop # 1 – East Kemptville Tin Mine [LUNCH]

Turn left (west) when leaving the East Kemptville Tin Mine, and proceed 6 km on Hwy 203 to East Kemptville and the Avalon Advanced Materials Exploration House and Core Storage Farm on the left.

12:30 PM – 1:30 PM – Stop # 2 – Avalon Advanced Materials Core Storage Farm

Turn left (west) onto Hwy 203 when leaving the Avalon Advanced Materials Exploration House and Core Storage Farm and proceed 20 km to Carleton. There, turn left on Hwy 340 and proceed south for 5 km to Pleasant Valley, turning right (west) onto Holley Road (a well maintained dirt road). Proceed approximately 3 km to a clear-cut area on the right where the Brazil Lake pegmatite deposit is exposed.

2:00 PM to 3:00 PM – Stop # 3 – Brazil Lake Pegmatite

Turn left onto Holley Road and proceed east 3 km to Hwy 340. Turn left and proceed to Weymouth. There turn right onto Hwy 1, proceed through Weymouth approximately 6 km and turn right onto Hwy 101. Follow Hwy 101 back to Wolfville, Nova Scotia (163 km) dropping off your fieldtrip guide at Exit 20 in Bridgetown.

5:30 PM – Arrival at the Old Orchard Inn
References


