Atlantic Geology
Journal of the Atlantic Geoscience Society
Revue de la Société Géoscientifique de l'Atlantique

GAC - Newfoundland and Labrador Section Abstracts: 2018 Spring Technical Meeting

Volume 54, 2018

URI : https://id.erudit.org/iderudit/1055424ar
DOI : https://doi.org/10.4138/atlgeol.2018.004

Aller au sommaire du numéro

Éditeur(s)

Atlantic Geoscience Society

ISSN

0843-5561 (imprimé)
1718-7885 (numérique)

Découvrir la revue

Citer ce compte rendu

(2018). Compte rendu de [GAC - Newfoundland and Labrador Section Abstracts: 2018 Spring Technical Meeting]. *Atlantic Geology*, *54*, 133–145. https://doi.org/10.4138/atlgeol.2018.004

Geological Association of Canada Newfoundland and Labrador Section

ABSTRACTS

2018 Spring Technical Meeting

St. John's, Newfoundland and Labrador

The annual Spring Technical Meeting was held on February 19 and 20, 2018, in the Johnson GEO CENTRE on scenic Signal Hill in St. John's, Newfoundland and Labrador.

This year Monday morning started with a session on Environmental Challenges followed by an afternoon sesson on Economic Resources and Tuesday featured an all-day session on Solid Earth. These sessions included oral and poster presentations from students and professionals on a wide range of topics. The Keynote Speaker was Dr. Peter Hollings from the Department of Geology, Lakehead University, Ontario, who presented a talk entitled "Using igneous petrology to unravel the tectonic triggers for porphyry mineralization". Dr Hollings is the 2017–2018 Geological Association of Canada's Howard Street Robinson Medal Winner and Lecturer. On Tuesday evening a Public Lecture entitled "Where does our 50% discount on global CO_2 emissions come from and how might it respond to climate change?" was presented by Dr. Sue Ziegler, Professor and Canada Research Chair in Boreal Biogeochemistry, Department of Earth Sciences, Memorial University of Newfoundland and Labrador.

As always, this meeting is brought to you by volunteer efforts and would not be possible without the time and energy of the executive and other members of the section. We are also indebted to our partners in this venture, particularly the Alexander Murray Geology Club, the Johnson GEO CENTRE, Geological Association of Canada, Department of Earth Sciences (Memorial University of Newfoundland), and the Geological Survey of Newfoundland and Labrador, Department of Natural Resources. We are equally pleased to see the abstracts published in Atlantic Geology. Our thanks are extended to all of the speakers and the editorial staff of the journal.

James Conliffe, Stefanie Lode, Anne Westhues, and Alexander Peace
Technical Program Chairs
GAC Newfoundland and Labrador Section

ATLANTIC GEOLOGY 54, 133-145 (2018) *doi: 10.4138/atlgeol.2018.004*
0843-5561|18|00081-145$3.10|0

Geophysical investigation of the Gullbridge tailings facility, central Newfoundland, Canada

ANDREW G. BLAGDON AND ALISON M. LEITCH

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

Recent concerns have been raised over the physical stability of the Gullbridge tailings dam at the site of an abandoned copper mine in central Newfoundland. The present research aims to understand the physical characteristics of the dam and map contamination in an adjacent wetland through non-invasive geophysical survey methods.

The Gullbridge mine was centered over a volcanogenic massive sulphide ore deposit consisting mainly of copper-zinc. Between 1967 and 1972, it produced 3 million tonnes of ore averaging approximately 1.1% copper. An earthenware dam was designed to act as a barrier separating copper tailings from wetlands immediately to the west. A small river runs along the western boundary of the wetlands, about 500 m from the tailings dam. It provides drinking water to the town of South Brook and flows into a salmon habitat, so contamination of the water is a concern.

In 2012 a section of dyke embankment collapsed, releasing tailings contaminated with copper and zinc into the wetlands. It is estimated that 100 000 m^3 of contaminated water spilled from the breach. In November 2013 the abutment height was reduced and the base widened to improve stability; however, there are still concerns about contamination from a new spillway and dam leakage. Tailings dams such as the one in Gullbridge require continuous monitoring over time, but monitoring at the Gullbridge site did not begin until 2011, 42 years after its construction. There is little information known about the construction history and design of the original dam, and it is expected that the physical properties over the dam have significantly changed over time. Historical tailings dam failures have been linked to issues such as internal and external erosion, the liquefaction phenomenon and overtopping. These changes lead to physical instabilities that geophysical methods can detect.

The focus of the present study is on targeting possible early stage seepage issues creating internal erosion and other potential structural issues. In particular, ground-penetrating radar (GPR), direct-current resistivity (DCR) and spontaneous-potential survey methods were used for detecting seep related erosion and delineating fluid flow through the embankment. As a secondary focus, the adjacent wetland was analyzed using the electromagnetic ground conductivity surveys with the aim of producing a ground contamination map. The copper tailings at Gullbridge have a signature conductivity high that can be mapped as seepage pathways associated with recent breaches.

Trilobite-based recognition of the Early–Middle Cambrian (Dyeran–Delamaran) boundary in the Labrador Group, western Newfoundland, Canada

W. DOUG BOYCE AND IAN KNIGHT

Geological Survey, Newfoundland and Labrador Department of Natural Resources, St. John's, Newfoundland and Labrador A1B 4J6, Canada

Paleontological and lithological studies of mixed siliciclastic—carbonate, predominantly shallow-water successions of the Forteau and Hawke Bay formations (Labrador Group), which have been ongoing since 1976 (34 measured sections; 434 fossil collections), have recently been reassessed. Until now, the succession has been broadly known to include late Early Cambrian to Middle Cambrian strata, but identification of the late Early Cambrian Dyeran Stage—early Middle Cambrian Delamaran Stage boundary has been elusive. Data collected from measured sections exposed in Chimney Arm, Canada Bay, have highlighted previously unidentified trilobite faunas, and indicate that the boundary is present in a thinly bedded, deeper water, fossiliferous succession of shale, siltstone, sandstone, and lime mudstone to packstone. The condensed succession lies close to the base of a unit of thinly bedded quartzose sandstone and shale previously placed in the lower half of the Hawke Bay Formation.

In ascending order, the taxa include: *Austinvillia virginica* Resser, olenellid gen. et sp. undet., *Olenellus howelli* Meek *in* White?, *Bonnia columbensis* Resser, *Bristolia mohavensis* (Hazzard and Crickmay), *Periomma* sp. undet., *Alokistocare* sp. undet., and *Syspacephalus* cf. *unca* (Walcott). Most of these are of known late Dyeran age. However, the genus *Alokistocare* is characteristic of the Middle Cambrian, which in Laurentia post-dates the last occurence of olenellid trilobites. *Alokistocare* sp. undet. appears 2 m above the last occurrence of *O. howelli*. A correlation with the early Delamaran *Amecephalus arrojoensis* Zone is suggested; the underlying, earliest Delamaran *Eokochaspis nodosa* Zone appears to be absent in Chimney Arm.

Sediment core analysis of a post-glacial lake over a mineral prospect, eastern Newfoundland, Canada

JIANGUANG CHEN, ALISON LEITCH, AND ELLIOTT BURDEN

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

Geochemical analysis of lake sediment samples is often used in mineral exploration, and high values of key elements are used to identify prospects. However, these samples usually represent one random sample per lake near the surface. In order to study the optimal lake sediment sampling location and depth, we carried out a GPR-conducted bathymetric survey as well as geochemical

analysis followed by sediment coring on a post-glacial lake, Grassy Pond, which is lying over a low-sulphidation epithermal style gold-silver system in the Big Easy Prospect, Eastern Newfoundland. The results show very high contents of arsenic (42–277 ppm) and molybdenum (4–23 ppm) appearing in four variable-length sediment cores captured from different locations of this lake, which could be associated with the natural erosion of iron oxide minerals in the underlying alteration zone. High arsenic and molybdenum contents are seen in all samples, indicating random sampling is sufficient as a first pass. However, the enrichment of these two elements is highly variable both with depth and location in the lake, which suggest detailed sampling could be a valuable next step. Particularly, the down-core geochemical and radiocarbon analysis of our longest sediment core show a major enrichment peak of several key elements (Fe, Mn, As, Mo and V) 2.5 m from the sediment sub-bottom, which could be related to the transition to the dry period about 5 ka ago in this region. In conclusion, climate and topography affect lake sediment sampling, and the samples with the highest As and Mo occur at deeper levels and are associated with climatic changes.

Metamorphic evolution of low-pressure metapelite in the Escoumins Supracrustal Belt, central Grenville Province, Québec, Canada

Kirsten E. Costello and Aphrodite Indares

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

The Escoumins Supracrustal Belt (ESB) belongs to the low-pressure belt of the central Grenville Province and represents high levels of orogenic crust, which were metamorphosed at amphibolite-facies conditions during the Grenvillian orogeny (1090–980 Ma). It consists of Pinwarian age (1.50–1.46 Ga) metasedimentary and metavolcanic rocks (Saint-Siméon group) and their plutonic counterparts, interpreted as remnants of an oceanic arc system accreted to Laurentia around ~1.4 Ga, and was invaded by Grenvillian-age intrusions. Evidence for amphibolite facies conditions is provided by the presence of hornblende – plagioclase – epidote in metavolcanic rocks, and garnet – biotite – quartz – K-feldspar – plagioclase ± muscovite ± sillimanite ± cordierite in metapelitic rocks. Preliminary ages for the metamorphism in this area are 1001 ± 3 Ma and 983 ± 3 Ma (titanite from dacitic tuff).

Metapelites are an important constituent of the lower Saint Paul-du-Nord formation and were sampled in four distinct locations across the belt. This study documents for the first time the low-pressure metamorphism in this region. Detailed petrography, SEM–MLA analysis, phase equilibria modelling, and in-situ U–Pb dating of monazites are used to constrain the metamorphic evolution of these rocks. For instance, preliminary results of phase equilibria modelling have shown that these rocks reached their metamorphic peak between 600–690°C and pressures between 3.5–5 kb. The data are consistent with a large change in temperature relative to pressure in both the retrograde and prograde path, and imply a high geothermal gradient. These results will add constraints on the metamorphic evolution of the low-pressure belt which in turn, will aid in piecing together the tectonic model of the Grenville Province.

Sourcing methane from Tablelands, Gros Morne National Park, Newfoundland, Canada, and comparing extraction methods for dissolved gas sampling

Emily Cumming, Liam Morrissey, and Penny L. Morrill

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

The Tablelands massif in Western NL is a terrestrial site of serpentinization that possesses characteristics that are conducive to all three established pathways of methanogenesis – abiogenic, microbial, and thermogenic - or a combination thereof. Methanogenic characterization is traditionally accomplished by analyzing the stable isotope composition of the produced methane (the $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$) in conjunction with geologic, geochemical, and microbiological and genomic evidence. An ultra-basic, reducing spring (WHC2b) within the massif has been studied extensively. Previous geochemical characterization of WHC2b has included the $\delta^{13}C_{CH4}$ but this study constitutes the first analysis of $\delta^{2}H_{CH4}$ for the Tablelands. Additionally, two field sampling techniques for the collection of methane for isotopic analysis; vacuum extraction and gas stripping, were tested in the laboratory and then deployed in the field to determine if each method maintained the methane's isotopic ratios and to determine their relative suitability for methane provenance studies. The $\delta^{13}C_{CH4}$ value of methane collected in 2016 via vacuum extraction was -27.6 ± 0.3‰, while the $\delta^{13}C_{CH4}$ value of methane collected via gas stripping in 2016 was -27.7 ± 0.0‰. Carbon isotope values of methane were consistent, between differing sampling methods. The $\delta^{2}H_{CH4}$ values of methane collected via vacuum extraction and gas stripping, analyzed in 2016, were -181‰ ± 4 and -181‰ ± 2, respectively. Hydrogen isotope values of methane were consistent between sampling methods. The stable carbon isotope composition of methane in WHC2b was consistent over an eight-year span according to data collated from five individual studies of the spring, with a $\delta^{13}C_{CH4}$ value of methane of -27.1 ± 0.5‰ (n = 5), making isotope systematics a tool for discriminating between methane sources. Geochemical, microbiological, and statistical means of discriminating between methanogenic pathways were applied to WHC2b, and methane was characterized as non-microbial.

Lab and numerical experiments of how cracks influence the nonlinear interactions of P- and S-waves

MEGHDAD DARIJANI, MANDY SIN HUAY LIM, HERURISA RUSMANUGROHO, AND ALISON MALCOLM

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

Unconventional cracked (fractured) reservoirs play a significant role in producing hydrocarbons. Crack connectivity, orientation, and fluid content are all important for reservoir evaluation. The presence of cracks is a contributing factor to nonlinear elastic properties of rocks. In nonlinear elastic materials, two or more seismic waves interact causing traveltime delays, changes in amplitudes and frequency mixing, among other effects.

In a laboratory setting, we observe wave interactions by perturbing low-amplitude high frequency P-waves with high-amplitude low frequency S-waves. In addition, we study the nonlinear wave equation numerically to develop a better understanding of the elastic wave interactions. Our experimental and numerical results show that the nonlinear interaction of P- and S-waves is large when their particle motion is aligned with the crack orientation, physically indicating the higher intensity of crack dilation. By contrast, when the particle motions are perpendicular to the crack orientation, the interaction becomes less significant. This improved understanding of the relationship between microstructure orientations and nonlinear wave interactions allow for a better characterization of cracked reservoirs.

Experimental imaging of a vertical vein using controlled-source seismic interferometry

KRISELLE DIAS AND CHARLES HURICH

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

Seismic methods are commonly implemented in the imaging of economically viable hard rock mineral deposits, due to the technique's intrinsic higher resolution in comparison to traditionally used geophysical methods. Traditional surface seismic methods are inadequate in the imaging of steeply dipping targets, due to unfavourable geometrical relationships between the surface sources, surface receivers, and the target. There is poor recovery of data when geological features have a dip greater than, or approximately 65°, as the reflected wave propagates at unfeasible angles. Steep dips also cause the overall travel path to be much longer than the depth of the target, causing a loss of energy and associated amplitude and high frequency attenuation which results in associated processing issues.

This study investigates the viability of using vertical seismic profiles (VSP) in combination with seismic interferometry as a new method of imaging thin and nearly-vertical veins, and develops techniques for the same. A thin, nearly vertical barite vein at the Collier Point Barite property in Eastern Newfoundland serves as a well constrained target for study. Seismic interferometry is a technique in which, a signal pair is cross-correlated to reproduce a virtual source-receiver pair and reconstruct the associated wavefield. These methods can virtually move a source into a downhole location, which avoids the geometric limitations associated with surface-seismic methods. The parameters of the field experiment are optimized using ray-tracing analysis, finite-difference modelling and a study of the physical properties to ensure reflection detectability. The unprocessed dataset is highly contaminated by tube-waves, which are removed using spiking deconvolution and F-K filtering. The pre-processed dataset is then subjected to seismic interferometry methods and is processed using standard CMP processing flows.

It is noted that the seismic response to the barite target varies significantly through the profile. A 1D synthetic seismogram modelling program is used to study the variations in the seismic response of the target, and propose a geological interpretation for the same, which is consistent with descriptions in prior geological reports. The study demonstrates that VSP's in combination with the seismic interferometry procedure has proven to be an appropriate tool towards detecting and imaging vertical to near-vertical subsurface bodies of economic importance, which may otherwise not be imaged appropriately using surface-seismic methods.

Marathon's Valentine Lake Property – A developing multi-million ounce gold camp in central Newfoundland, Canada

SHERRY DUNSWORTH AND PHILLIP WALFORD

Marathon Gold Corporation, 10 King Street East, Suite 501, Toronto, Ontario M5C 1C3, Canada

Marathon Gold Corporation's 100% owned Valentine Lake Property hosts four orogenic-type structurally controlled gold deposits and numerous gold occurrences. The gold occurs in quartz-tourmaline-pyrite (QTP) veining that intrudes quartz porphyry, trondhjemite and lesser mafic dike units of the late Proterozoic (ca 562 Ma) Valentine Lake Intrusive Suite. The mineralization lies along and proximal to the more than 30+ km strike length of the Valentine Lake Thrust Fault. This major fault forms part of a deep crustal suture that extends NE-SW through central Newfoundland, forming part of the root system of the Appalachian Mountain Belt, and providing an extensive conduit for the migration of the CO_2 – rich gold-bearing fluids which gave rise to the Valentine Lake gold deposits.

The dominant style of Au-QTP veining at the Valentine Lake Property occurs as shallow SW-dipping en-echelon

stacked extensional veining orientated normal to the moderate to steeply N-NE-plunging penetrative regional L_1 stretching lineation. Lesser shear parallel Au-QTP veining occurs along the moderate to steeply NW- dipping regional S_1 foliation and shear fracturing. Recent geochronology on hydrothermal rutile collected from QTP veins within Marathon's Valentine Lake Property places mineralization occurring near the very end of the Salinic orogeny, coinciding with the transition from regional compressive to oblique strike- slip tectonics.

Since 2010, Marathon Gold Corporation has discovered the Marathon and Sprite gold deposits, enlarged the Leprechaun and Victory gold deposits, exposed a multitude of new gold occurrences in trenching along a 20 km strike length associated with multiple first-order splay faults off the Valentine Lake thrust fault, and developed a structural model for the evolution of this gold camp. Additional gold occurrences have recently been found along the same structural trend northeast of the Valentine Lake property. The November 30, 2017 published NI 43-101 compliant, mainly open pit constrained resource for the Valentine Lake Gold Camp totaled 1 847 000 oz. gold at 1.88 g/t (measured and indicated) and 1 012 000 oz. gold at 1.65 g/t (inferred). All the deposits located on the property to date are open along strike and to depth. The Marathon Deposit is potentially the largest having been traced with shallow holes for 1.5 km along surface and to depths of 1 km and is still open along strike and to depth.

Metallurgical testing on material from the Leprechaun and Marathon deposits achieved 98% recoveries using standard milling processes and cyanidation. In addition, initial heap leach testing obtained preliminary recoveries in the range of 70% from column tests on the Leprechaun and Marathon material which comprise more than 90% of the current resources. A Preliminary Economic Assessment (PEA) is currently underway with consideration being given to open pit and underground mining as well as different mill and heap leach combinations to maximize the economic value of the project.

Amplitude variation with offset (AVO) inversion modeling with a local elastic solver

Ligia Elena, Jaimes Osorio, and Alison Malcolm

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

Conventional amplitude variation with offset (AVO) inversion analysis uses Zoeppritz equations, which are based on a plane wave approximation. However, since real seismic data are created by point sources, the wave reflections are better modeled by spherical waves than planar waves. Indeed, spherical reflection coefficients vary from planar reflection coefficients near to the critical and post-critical angles. This implies that the Zoeppritz equations are not applicable in the presence of critical angles in AVO analysis.

Spherical reflection methods such as full waveform inversion provide a solution to the limitation of the Zoeppritz approximation, since they can handle near and post-critical reflections. Additional advantages of full waveform inversion are its applicability to heterogeneous models and its iterative multiparameter inversion. In this study, we propose to model amplitude variation with offset (AVO) using an elastic solver to model the wavefields and then compare these results with the Zoeppritz approximation.

Investigating the influence of soil organic matter and Fe/Al-oxyhydroxides on nanoscale titanium dioxide ($nTiO_2$) transport in natural sediment

Leanne M. Fisher-Power and Tao Cheng

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

Engineered nanoparticles (ENPs) are increasingly being used in medical, industry, wastewater, and remediation applications, and consequently are being released into the environment in unprecedented and unknown quantities. Many ENPs are toxic to plants, animals, and ecosystems, and have a tendency to facilitate the transport of environmental pollutants. Knowledge of ENP migration in subsurface environments is essential for evaluating environmental impacts. Most laboratory ENP transport studies use quartz sand as the porous media, however, natural sediments are far more complex with heterogeneous compositions that may influence nanoparticle transport.

The objective of this research was to investigate the effects of natural organic matter (NOM) and Fe/Al oxyhydroxides in a natural sediment on ENP transport. A natural sediment was treated to deplete either soil organic matter (SOM), Fe/Al-oxyhydroxides, or both; and used as transport medium to study nanoscale titanium dioxide ($nTiO_2$, a widely used ENP) transport. Results indicated $nTiO_2$ transport was strongly influenced by pH and sediment composition. When influent pH = 5, $nTiO_2$ transport was low, as positively-charged $nTiO_2$ was attracted to negatively-charged minerals and SOM. $nTiO_2$ transport was slightly enhanced in sediments containing SOM due to the leaching of dissolved SOM which adsorbed onto $nTiO_2$ surface, stabilizing it in pore water. When influent pH = 9, $nTiO_2$ transport was high since negatively-charged medium repelled negatively-charged $nTiO_2$. However, in sediments with SOM or amorphous Fe/Al-oxyhydroxides depleted, transport was low due to pH buffering by the sediments causing attraction between $nTiO_2$ and crystalline Fe-oxyhydroxides. Our results demonstrate the important influence of SOM and Fe/Al-oxyhydroxides on ENP transport in natural sediment and their dependence on pH and electrostatic forces.

Developing an algorithm for predicting stream dissolved organic carbon concentrations from UV-visible light absorbance

Christian Gaviria, Allison Myers-Pigg, and Susan Ziegler

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

The export of carbon from terrestrial ecosystems may constitute a significant and climate-responsive carbon loss from forests, impacting downstream aquatic ecosystems. However, the magnitude of terrestrial carbon mobilized from the landscape is difficult to accurately capture during typical sampling campaigns. Therefore, accurate and high-resolution determination of dissolved organic carbon (DOC), the major transport medium of carbon from terrestrial to aquatic ecosystems, is imperative.

To better determine DOC export from forests to headwater streams within Newfoundland and Labrador, we explored the relationship between light-absorbing chromophoric dissolved organic matter (CDOM) and bulk DOC. Such a relationship would allow for rapid prediction of DOC concentrations based on absorbance characteristics, and through usage of an in-situ spectrophotometer, high-resolution determination of exported DOC.

We modeled the CDOM-DOC relationship from 4 headwater stream catchments across the province, using ~240 discrete samples collected over 5 years. Due to the heterogeneous composition of DOC within headwaters, which can alter this relationship, we included samples representative of sources to our streams, including nearby soil and groundwater inputs. Parameters used in multiple regression models were varied in each iteration to capture potential spatial and/or temporal differences potentially affecting DOC prediction accuracy. The ability of each model to successfully predict future observations was assessed by calculating $R^2_{Predicted}$, while validation sets were further used to confirm model accuracy.

The most robust model ($R^2_{Predicted}$ = 0.90, validation R^2 = 0.83) included a combination of all sample types (soil, stream and groundwater). However, prediction accuracy was reduced when the model was applied to samples from an additional forest catchment outside of the training sample set, suggesting a sensitivity of predicted DOC to catchment characteristics. Therefore, our results indicate the need for a catchment specific establishment of a CDOM-DOC algorithm before high-resolution estimates of carbon exports from terrestrial to aquatic environments can be accurately determined.

Recent advancements in scanning electron microscopy-mineral liberation analysis (SEM-MLA)

Dylan Goudie and David Grant

CREAIT SEM-MLA Facility, Bruneau Centre for Research & Innovation , Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 1T5, Canada

Scanning Electron Microscopy-Mineral Liberation Analysis (SEM-MLA) has become an important and versatile analytical tool in mineralogical research. This project will present some recent advancements in sample preparation and analytical methodology, which contribute to increased accuracy, precision and throughput of SEM-MLA data.

The first advancement is the development of a single-step trans-vertical method for preparing epoxy grain mounts. Traditional round mounts can be affected by density stratification: heavier minerals sink through the epoxy as it cures, causing an over-abundance of heavy minerals on the analysis surface of the sample. The trans-vertical mounting method eliminates this density stratification bias and is less labour intensive than other multi step trans-vertical mounting methods. This method also leads to increased throughput as more unique samples can fit inside the SEM chamber than traditional 30 mm round mounts.

Another recent development is the ability to distinguish between hematite and magnetite via SEM-MLA. Typically, SEM-MLA used X-ray spectra to identify minerals based on reference spectra. However, in the case of hematite and magnetite, their X-ray spectra are virtually identical. Instead, a method is presented to distinguish between them based on their brightness in backscattered electron (BSE) images. Accurately distinguishing between hematite and magnetite in an economic iron ore deposit can lead to more accurate estimates of the grade of the deposit.

Taconian subduction zone paths of metamorphosed mafic rocks west of the Red Indian Line in Vermont, USA

Ian Honsberger

Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada

A north-south-trending swath of metamorphosed mafic rocks embedded within peri-Laurentian rift clastic rocks and slope-rise deposits west of the Red Indian Line in Vermont preserve the latest Cambrian–Early Ordovician (Taconian) subduction zone metamorphism. In northern Vermont, high pressure facies series subduction zone metamorphism is preserved between the Tibbit Hill volcanic rocks and the Burgess Branch fault zone, the southern extension of the St. Joseph fault/Baie Verte-Brompton Line in southern Quebec. Eclogite/blueschist of the Tillotson Peak Complex (TPC) marks the northernmost limit of subduction zone metamorphism and preserves the highest metamorphic

pressures in Vermont. The TPC is perhaps correlative with eclogite within the Fleur de Lys Supergroup on the Baie Verte Peninsula. South of the TPC, subduction zone metamorphism is inconspicuous and preserved only in the cores of zoned amphibole grains retained in greenstones and amphibolites. Electron microprobe studies show that amphibole cores are barroisite/winchite in composition, whereas amphibole rims are greenschist facies actinolite. In general, conditions of metamorphism for these barroisitic rocks are not well constrained. However, some insight into subduction zone conditions has been gained from barroisite-bearing greenstone within a tectonized ultramafic-mafic-pelitic package in central Vermont that marks the known southern limit of the Taconian subduction swath. Thermodynamic modeling and amphibole isopleth calculations show that barroisite/winchite in the tectonized package grew at ~0.95 GPa (~32 km) and ~425°C prior to penetrative greenschist-facies overprint; peak conditions are interpreted as lower blueschist facies.

Exhumation mechanisms for these mafic subduction zone rocks are still in question. Local geologic and structural relationships suggest that a serpentinite-rich channel above the subducting slab may have facilitated exhumation at the greatest depths, whereas a sediment- and fluid-rich subduction channel may have played a major role at shallower levels.

Hunting unconformities on Fogo Island and Change Islands, Newfoundland, Canada: stratigraphic constraints and preliminary U–Pb geochronological data

ANDREW KERR[1] AND MICHAEL A HAMILTON[2]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶ 2. Jack Satterly Geochronology Laboratory, Department of Earth Sciences, University of Toronto, Toronto Ontario, M5S 3B1, Canada

Detailed mapping by students from Cambridge University (UK) in 2013 suggested that an important formational boundary on Fogo Island might instead be a cryptic unconformity. The strongest evidence is that upright volcanic rocks of the Brimstone Head Formation locally rest topographically above structurally inverted sandstones of the underlying Fogo Harbour Formation. A stratigraphic gap between the two formations also resolves some previously noted inconsistencies in their mutual contact relationships, and also with granites of the nearby Fogo Island Intrusion. To test this idea, U–Pb zircon ages (CA-TIMS) were obtained from the basal Brimstone Head Formation and from a felsic tuff unit close to the top of the Fogo Harbour Formation. The 421 ± 1 Ma age from the Brimstone Head Formation confirms that it is Silurian, and contemporaneous with at least some granites of the Fogo Island Intrusion. The zircon population from the Fogo Harbour Formation is more complex. Variably discordant Precambrian ages (from 544 Ma to 1775 Ma) imply inheritance and/or a detrital component, but the youngest grains, superficially of magmatic appearance, are concordant at 440 ± 1 Ma. Such results imply a 20 m.y. time gap between the two formations, consistent with the cryptic unconformity hypothesis, but they are not fully diagnostic. Further work using methods with high spatial resolution (e.g., LA-ICPMS) is needed to better characterize the younger population and any detrital age spectrum, but this has so far proved difficult to facilitate.

On Change Islands, there is angular discordance at the contact between turbiditic sandstones assigned to the early Silurian Badger Group and subaerial volcanic rocks and terrestrial sedimentary rocks assigned to the younger Lawrenceton Formation. Deformed and altered diabase dykes are prominent within the Badger Group, but cannot be traced across this contact. Outcrops are obscured by later brittle faulting in many places, but sedimentary breccia-like rocks containing greywacke fragments exist locally beneath the pyroclastic flows. The features support previous interpretation from GSC mapping as an angular unconformity. This location has obvious potential for geochronological studies using both U–Pb and Ar/Ar methods, and interest in such research is invited. As the Lawrenceton Formation sits *beneath* rocks assigned to the Fogo Harbour Formation, this might be a discrete older unconformity, subject to the validity of stratigraphic correlations between the islands. An alternative interpretation is that the Brimstone Head and Lawrenceton formations are correlative (despite lithological contrasts) and that parts of the Fogo Harbour Formation should be reassigned. This less interesting option requires only one unconformity. There remain more questions than answers on both islands, but more investigation could give valuable insights into the timing of tectonic events and magmatism in this fascinating part of the Newfoundland Appalachians.

A new strategy for higher resolution time – lapse velocity inversion

MARIA KOTSI[1,2], JONATHAN EDGAR[1], ALISON MALCOLM[2], AND SJOERD DE RIDDER[1]

1. Total E&P UK, Geoscience Research Centre, Westhill, United Kingdom ¶ 2. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada

Time lapse seismic methods have been extensively used over the past two decades to monitor oil reservoirs under production. Time-lapse changes can result from amplitude changes and/or time shifts. Amplitude changes can be caused by new structures in the target area or reflectivity differences at interfaces. Time shifts are usually the result of physically shifted geological boundaries or velocity perturbations along the wave path. Understanding which of these two mechanisms control the observed time shifts

is important to better estimate and interpret the time-lapse changes. Full Waveform Inversion (FWI) is a promising tool for time-lapse seismic imaging and shows promise for this type of imaging. However, for a successful application of FWI, low frequency data and large offsets are required; these prerequisites are difficult to meet when we are interested in a small region. FWI is robust in recovering amplitude changes but is often not able to resolve the kinematics. Image Domain Wavefield Tomography (IDWT) is a method that uses migrated images along with a warping function to deliver a velocity model of the subsurface. This method is better at recovering time-shifts and can be applied without long offset data. In real case scenarios, the 4D signal is a complicated combination of time shifts and amplitude changes. This can result in a decrease in performance in both methods, depending on the nature of the complication. In this study, we present a form of time-lapse waveform inversion that we call Dual Domain time-lapse Waveform Inversion (DDWI), in which we combine FWI and IDWT in a single inverse problem. We test DDWI on several synthetic examples, and we observe that the method delivers more accurate results when compared to each of the methods used separately.

Provenance and porosity of onshore reservoir sandstones of the Anticosti Basin, western Newfoundland, Canada, using scanning electron microscopy combined with mineral liberation analysis (SEM-MLA)

Stefanie Lode[1], Luke Beranek[1], Dylan Goudie[2], and David Grant[2]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶
2. CREAIT SEM-MLA Facility, Bruneau Centre for Research & Innovation , Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 1T5, Canada

The Anticosti Basin of Atlantic Canada contains numerous conventional and unconventional hydrocarbon plays. This project applies an integrated field and laboratory approach to investigate the provenance and porosity evolution of Cambrian rift-drift and Ordovician foreland basin reservoir sandstones of the southern and central Anticosti Basin in the Port au Port peninsula and Bay of Islands areas of western Newfoundland. Polished thin-sections of the sandstones were analysed using SEM-MLA, which produces high-resolution digital maps that quantify the modal mineralogy, effective porosity, and grain-composition of the sample, including dissolution/ precipitation reactions. This method was further successfully applied and tested on unpolished rock samples, such as thin-section cut-off blocks. The SEM-MLA is non-destructive and results simultaneously provide information regarding provenance and porosity without having to perform petrophysical procedures on the core, or detailed petrographical point-count methods on thin-sections.

SEM-MLA showed that the foreland basin sandstones contain chromite and mafic volcanic rock grains, which represent easterly-derived debris from ophiolite complexes, whereas the rift-drift sandstones typically have abundant lithic (igneous, metamorphic, sedimentary) grains and heavy minerals (e.g., garnet) with west-derived, Laurentian basement provenance. The high-resolution maps clearly delineate secondary dissolution porosity in K-feldspars and chloritized (ultra-) mafic volcanic rock grains, as well as carbonate cements that fill in initial macro pores. This feature allows the visualization of the spatial resolution of occurrences of porosity in relation to matrix, rigid, and ductile grains in the SEM-MLA maps.

These methods enable us to simultaneously identify the primary and secondary porosity textures and provenance characteristics of prospective rift-drift and foreland basin reservoir sandstones. The results of this study are of significance not only for petroleum industry and exploration of onshore sandstones in the Anticosti Basin, but also have exploration implications for other conventional sandstone reservoirs globally.

Computational modelling of geophysical data without meshing the physical models

Jianbo Long and Colin G. Farquharson

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

Geophysical data modelling involves synthesizing theoretical responses, i.e., measurements to be expected over a known physical model, namely, an Earth model with inhomogeneous physical properties in the subsurface. A key ingredient in the modelling is how to represent the geometries of the physical model, the so-called discretization, which will determine how much details of the model structure to be recovered and what might be the most suitable numerical mathematical method to do the modelling. This research focuses on modelling electromagnetic (EM) data for 3D Earth models with complex geometric structures. Complex Earth models can have arbitrary orientation and surface structure, and therefore are more realistic scenarios of the real world than simplified prisms and spheres. However, the discretization of such complex models in 3D is not a trivial task, since accurate geometric representation is not the only requirement; accuracy and efficiency of mathematical methods can also be significantly affected. Currently available modelling methods require the physical model meshed, and are sensitive to the structure of the discretization. These methods are hence called mesh-based methods. An alternative are meshfree modelling methods that do not generate meshes. An important advantage of meshfree methods is that numerical performance is much less dependent on the model discretization. Also, the creation of such discretization can be greatly simplified and

speeded up. We will introduce how one can apply meshfree methods to synthesize geophysical data, and present possible directions to the solution of EM data modelling with them.

Solid phase extraction of dissolved organic matter from across the terrestrial to aquatic interface

ALEXANDER NEWMAN, SUSAN ZIEGLER, AND JAMIE WARREN

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

Understanding the chemical heterogeneity of dissolved organic matter (DOM) originating from different land positions along the terrestrial to aquatic interface can provide insights into a poorly constrained global carbon flux. By applying holistic analytical approaches, such as nuclear magnetic resonance (NMR), the location and extent of transformation of terrestrial DOM in response to direct and indirect climate effects can be ascertained and contribute to our understanding of C-climate feedbacks.

Solid phase extraction via a styrene-divinylbenzene copolymer (SPE-PPL) is a chemical isolation method that is commonly used to prepare dissolved organic matter (DOM) samples for solution-state NMR analysis. Despite its growing popularity, SPE-PPL has been hypothesized to select against some major components of DOM; however, this is likely dependent upon how the SPE procedure is carried out. This study investigates how the methodological parameters used in SPE-PPL may affect extraction yields and selectivity of DOM sourced from different land positions along the terrestrial to aquatic interface (stream, soil and ground water). Quantitative analysis of dissolved organic carbon and nitrogen (DOC/DON) was used to assess the relationship between SPE-PPL yields and flow rate, sample volume and sample type. Solution-state hydrogen (H) NMR was performed to investigate how chemical selectivity may relate to DOC and DON yield and the SPE-PPL parameters used (e.g. sample volume and application rate).

Average SPE-PPL DOC yields ranged from 50–80%, while DON yields ranged from 15–40%. SPE-PPL yields and selectivity were independent of sample application rates. However, higher sample loading volumes of soil water DOM exhibited selective loss of O-alkyl C relative to aliphatic C. However, this volume dependent selectivity was not observed with groundwater where O-alkyl C represented a smaller fraction of the total DOM. This source dependency of volume-induced selectivity represents an important caveat for applying the SPE-PPL technique to DOM across the terrestrial-to-aquatic interface.

Mineralogical controls on carbon reservoirs across a boreal forest climate transect

MACKENZIE PATRICK AND SUSAN ZIEGLER

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

Boreal forests contain ~30% of global soil organic carbon (SOC) within a region that is predicted to undergo some of the greatest increases in temperature and precipitation over the next century, yet the controls on SOC reservoirs remain poorly understood. A considerable portion of SOC resides within the mineral soil, where mineralogy can play a significant role in its stabilization. The Newfoundland and Labrador Boreal Ecosystem Latitudinal Transect is a climate transect across boreal landscapes exhibiting increased temperature and precipitation similar to what is expected in the next century. The regions have common vegetation and soil type, but variable geological parent materials, allowing one to assess the impact of mineralogy and climate on C cycling in a natural system. In this contribution, the relationships between mineral soil characteristics and ecosystem parameters influenced by climate with SOC were assessed across this transect using an information theoretic approach. This method of model selection allows us to rank models by their ability to describe the response variable, an advantage here where multiple factors and their interactions potentially play a role. The strongest models, describing 81–83% of variance in SOC, included the poorly crystalline Al pool involved in podzolisation with either soil surface area or litterfall inputs. However, the Al pool was the stronger predictor variable, explaining 75% of the variance in SOC. The remainder variance of 17–38% may be described by dissolved organic carbon inputs, hydrology, or by temperature and precipitation, which were not included as they were captured in the regional effect. These results suggest that mineralogical mechanisms are more important for controlling SOC stocks in these mineral soils than forest inputs or climate effects. This may also be responsible for the observed maintenance of SOC stocks despite the increased fluxes into and out of these mineral soils across this climate transect.

Structural, petrological, and potential field analyses of the Mesozoic Notre Dame Bay intrusions, onshore Newfoundland, Canada, and their link to North Atlantic opening

ALEXANDER L. PEACE[1], J. KIM WELFORD[1], MEIXIA GENG[1], BRANT D. GAETZ[1], SARAH S. RYAN[1], GREGORY DUNNING[1], AND HAMISH SANDEMAN[2]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶
2. Geological Survey, Newfoundland and Labrador Department of Natural Resources, St. John's, Newfoundland and Labrador A1B 4J6, Canada

The magma-poor Newfoundland margin formed after a period of rifting, followed by breakup resulting in separation of the Grand Banks from Iberia, and northern Newfoundland from Ireland. Mesozoic–Cenozoic magmatic rocks have been documented on- and offshore Newfoundland that are contemporaneous with rifting and breakup, with further magmatism occurring offshore post-breakup.

One such occurrence of early rift-related igneous rocks is the group of Jurassic–Cretaceous intrusions near Notre Dame Bay, Newfoundland. Here, the Budgell Harbour Stock (BHS) is surrounded by multiple sets of lamprophyre dykes, in addition to the nearby, potentially related, Dildo Pond Intrusion and Leading Tickles Stock. Although exploration wells penetrate the BHS, it has minimal surface exposure, such that its deeper structure, magmatic evolution, and relationship to pre-existing structures remained unknown.

Here, the results of field-based geological mapping and petrological analysis, in addition to inversion of Full Tensor Gradiometry and aeromagnetic data, are presented to examine the deeper structure. Our results show that the lamprophyre dykes are located in clusters at the surface terminations of density anomalies, interpreted to be lobe-like magmatic conduits, contrary to earlier interpretations of the dykes as structures radiating from the BHS. Furthermore, the analysis demonstrates the irregular geometry and south-westward-dipping nature of the BHS, in addition to the presence of multiple, near-surface anomalies that may correspond to igneous bodies. The subsurface geometry of the BHS suggests emplacement was influenced by pre-existing structures. Structural analysis indicates that the dykes have both interacted with pre-existing structures and have been deformed post-intrusion, potentially via reactivation of pre-rift faults. In addition, lineation data from dyke margins and the potential field investigations suggest multiple dyke sources and bodies similar to the BHS may exist. Finally, this study demonstrates that margins considered to be non-volcanic may host significant rift-related magmatism, challenging the concept of a simple distinction between magma-rich and magma-poor margins.

Episodic lithospheric orogenic collapse of the Newfoundland Appalachian orogen

JEFFREY POLLOCK

Department of Earth and Environmental Sciences, Mount Royal University, Calgary, Alberta T3E 6K6, Canada

The Appalachian orogen is a linear mountain belt formed by the early Palaeozoic closure of the Iapetus and Rheic oceans and is considered to be the classic example of an ancient accretionary–collisional orogen. In contrast to continent–continent type collisional orogens, the tectonic evolution of the Appalachians records a complex history resulting from the sequential accretion of a collage of numerous oceanic and continental arc terranes and microcontinents to the margin of Laurentia.

Continental convergence in arc–continental and arc–arc collision zones results in crustal shortening and elevated topography that is controlled by the mechanical balance between the horizontal stress of tectonic convergence and vertical compression caused by gravity. Any change in the regional stress equilibrium will disrupt the gravitationally unstable crust and cause the elevated surface to extend resulting in a loss of topography. Extensional tectonics as a mode of deformation in shortened and thickened lithosphere has been reported as a feature in several orogens: e.g., present Tibetan plateau; Miocene Alps; Palaeozoic Caledonides; and Proterozoic Grenville Orogen.

The model proposed focuses on the role of repeated extensional deformation in the Ordovician–Silurian–Devonian Appalachian orogen of Newfoundland; areas of brittle detachment have been previously attributed to Taconic faults reactivated due to collision-related thrusting during Acadian tectonism. I suggest that the Appalachian orogen in Newfoundland has undergone at least two episodes of extensional collapse in the Late Ordovician and Late Silurian, related to separate arc–continent and arc–arc collisions responsible for the Taconic and Salinic orogenies, respectively. The model accounts for many features in Newfoundland including—but not limited to—development and exhumation of metamorphic core complexes, prominent regional unconformities, tectonic reactivation of obducted ophiolite sequences, intrusion of bimodal plutons, eruption of subaerial volcanic rocks, extensional faulting, and rapid denudation of the uplifted orogen.

Aggregation of $nTiO_2$ and illite colloids: effect of co-presence of phosphate and calcium

ZAHRA SADAT RASTGHALAM AND TAO CHENG

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

The stability and aggregation of nanoscale and colloidal-sized fine particles, which are commonly found in soil and

groundwater, have important implications to water quality and contaminant transport. Extensive studies have been conducted on the aggregation of nanoscale titanium dioxide particles ($nTiO_2$) and illite colloids under simple water chemistry conditions. In natural aquatic systems, however, water chemistry could be complicated and suspended $nTiO_2$ and illite particles could encounter multiple water components simultaneously, yet, the combined effects of some components have not been investigated. In this study, the aggregation of $nTiO_2$ and illite colloids was examined in the presence of phosphate (0.1 mM) and Ca ions (0.5 mM) at different pH and under low ionic strength conditions (1.5 mM). Results obtained from the batch experiments indicated that the hydrodynamic diameter of the $nTiO_2$ was strongly influenced by phosphate and Ca ions, which both modified $nTiO_2$ surface charges. Calcium cations also had a substantial effect on the zeta potential of $nTiO_2$ at pH 9 where the particles were positively charged for any phosphate concentration up to 0.1 mM. Illite aggregation was studied under the same water chemistry conditions. Results showed that illite colloids carried negative charge at pH 5 and 9 and the presence of phosphate and Ca did not have a substantial effect on the zeta potential and hydrodynamic diameter of the particles. This study revealed that the combined effect of Ca and phosphate on the aggregation of the $nTiO_2$ can be different from that of their individual influence. In addition, natural suspended particles, including illite, can be much less sensitive to the water chemistry compared to the engineered metal nanoparticles such as $nTiO_2$. These findings are important for understanding of the fate and transport of $nTiO_2$ and illite in natural aquatic systems where various anions and cations coexist.

Petrographic, geochemical, and sulphur isotope studies of the Montagnais Gabbro, the Labrador Trough, Canada – Implications for Ni-Cu-PGE exploration potential

ANDREW J. SMITH[1], JAMES CONLIFFE[2], AND DEREK WILTON[1]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶
2. Geological Survey, Newfoundland and Labrador Department of Natural Resources, St. John's, Newfoundland and Labrador A1B 4J6, Canada

The Labrador Trough is a Paleoproterozoic (2.17 to 1.87 Ga) fold and thrust belt straddling the Québec-Labrador boarder. The Labrador Trough comprises the Kaniapiskau Supergroup, which was intruded by the Montagnais Gabbro sills (1884 ± 1.6 Ma). The Ni–Cu–PGE potential of the Montagnais Gabbro has been recognized since the 1950s. Recent exploration results from the Northern Shield Resources (NSR) Huckleberry Prospect in Québec have highlighted the potential for new discoveries in this underexplored region. Fieldwork was completed in 2017 and lithological samples collected from gabbro sills and sulphide-rich shales within the Howse Lake and the Moss Lake areas, as well as from the Huckleberry prospect, 100 km north along strike in Québec. Whole rock geochemical data, including Pt, Pd and Au assays, were used to quantify possible Ni–Cu–PGE enrichments in the sulphide-rich gabbro samples. In addition, the data were used to assess the potential of these gabbro sills to host economically significant base-metal occurrences. Mineralized gabbro samples from the Howse Lake and Moss Lake areas were analyzed by Scanning Electron Microscope-Mineral Liberation Analysis (SEM-MLA) to provide detailed petrographic information on sulphide minerals, to locate and identify platinum group minerals (PGMs), and to ascertain their relationship with sulphide and silicate minerals. Secondary Ion Mass Spectrometry (SIMS) microanalyses were used to determine the stable S-isotopic ($\delta^{34}S$) ratios of pyrrhotite and chalcopyrite within the mineralized gabbros and sulphide-rich shales proximal to the gabbro sills. Thus, the S-isotopic data provide insight into the S source and amount of contamination related to the melting of the host shales. Results obtained from the three areas will be compared to determine factors, which may have contributed to the mineralization, as well as to classify the occurrences within a deposit model.

A fresh perspective on the middle Cambrian trilobites from Manuels River, Conception Bay South, Newfoundland, Canada

ROD S. TAYLOR[1,2]

1. Manuels River Hibernia Interpretation Centre, 7 CBS Highway, CBS, Newfoundland and Labrador A1W 3A2, Canada ¶
2. Department of Earth Sciences, Memorial University of Newfoundland, 300 Prince Philip Drive, St. John's, Newfoundland and Labrador A1B 3X5, Canada

The trilobite-rich middle Cambrian strata at Manuels River, Conception Bay South (CBS), Newfoundland and Labrador, were originally described by B.F. Howell in 1925. Howell identified and described a sequence of 125 discreet beds through his study area, comprising the Chamberlains Brook Formation (beds 1–35) and the overlying Manuels River Formation (beds 36–125). These formations are dominated by green, grey or black shales interbedded with minor to massive limestone deposits, achieving a combined total thickness of just under 100 m. Howell also provided a detailed description of the fossil fauna associated with this sequence, which is dominated by trilobites from the Orders Redlichiida, Ptychopariida, and Agnostida. In 1962, R.D. Hutchinson re-examined the trilobite fauna of this sequence as a part of a description of Cambrian stratigraphy and trilobite palaeontology in southeastern Newfoundland. While there have been subsequent studies examining specific components of the middle Cambrian trilobite fauna from Manuels River and associated localities,

there has been no systemic overview of the trilobite fauna from this sequence in several decades.

The Manuels River Hibernia Interpretation Centre is located adjacent to the CBS Highway in Manuels, approximately 2 km southward from the end of Manuels River. Although the primary mandate of this facility is education, work has commenced there to re-examine the middle Cambrian trilobite fauna found on the river. Preliminary efforts will include a summation of the previously published literature relevant to the trilobite fauna of the area. Longer term goals include bed-by-bed collection of new material throughout the entire middle Cambrian sequence on Manuels River, followed by identification and description of this new material and reconsideration of the present fauna in regional and global contexts.

Constructing a crustal-scale 3D Earth model of offshore-to-onshore western Newfoundland, Canada, using seismic reflection, gravity, magnetic, and well data

Ederson Villamizar and Kim Welford

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

Western Newfoundland is characterized as a geologically complex zone. It records multiphase deformation of a Cambrian–Ordovician passive margin and Ordovician to Devonian foreland basins formed during the Taconian, Salinian, and Acadian orogenic events. Hydrocarbon seeps are known to occur in western Newfoundland and the area contains three main basins capable of generating oil: the Anticosti Basin, the Deer Lake Basin and the Bay St. George sub-basin. These basins have been important targets for petroleum exploration and they have proven oil accumulations and oil potential.

Geophysical studies in western Newfoundland have mainly focused on petroleum exploration and understanding the development of the Appalachian Mountains in the region. Seismic acquisition in this area was performed prior to 2000 and in many cases, the data are poor and difficult to interpret. However, potential field methods, such as gravity and magnetic methods can be useful for studying complex regions, as they can build a bridge between seismic studies. Constrained gravity and magnetic studies have been used before in different geological areas and they have provided interpretable results down to the lithospheric scale.

No comprehensive attempt has been made to incorporate gravity and magnetic data from Western Newfoundland into tectonic models. Accordingly, this research project aims to provide new information at a regional scale to better understand the complexity of the Appalachian structure and how it may have evolved by constructing a crustal-scale 3D Earth model of offshore-to-onshore western Newfoundland using seismic reflection, gravity, magnetic, and well data.

The Satellite gravity data from the WGM2012 model and the high resolution magnetic data were analyzed using mathematical tools such as Euler Deconvolution, Spectral Analysis, and Curvature. These results, along with a refraction seismic profile, are used as a first approach to build the 3D model. The interpretation of selected seismic lines and well data further constrained the model. The preliminary results show interesting geophysical behaviour offshore western Newfoundland that possibly are caused by crustal faults or fractures and which have not yet been investigated in detail.

Simultaneous in-situ U–Pb dating and Hf-isotope ratio determination of zircons with laser ablation ICP-MS

Markus Wälle and Rebecca Lam

CREAIT, Bruneau Centre for Research and Innovation, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1C 5S7, Canada

Laser ablation inductively coupled plasma-mass spectrometry (ICP-MS) has become a common method for U–Pb dating of zircon, especially when large numbers of grains have to be analyzed. The same is valid for laser ablation multi collector ICP-MS Hf isotope determination in zircons. These two measurements are commonly done independently, leading to a potential mismatch of ages and Hf isotope ratios in heterogeneous grains. Recently, some laser ablation ICP-MS laboratories introduced a split stream approach, where the laser ablation aerosol is split into two parts. One part is used for U–Pb dating, commonly on a single collector ICP-MS, the other part is used for Hf isotope determination on a multi-collector ICP-MS. This method allows a simultaneous in-situ determination of both, the U–Pb dating and the Hf isotope determination. This split stream approach has been implemented at Memorial University and the performance of the setting is presented here.

The 91500 zircon is commonly used as primary standard for dating; however, over the past few months, secondary zircon standards (Plesovice, 02123, Temroa-2) were also analyzed. These yielded average $^{206}Pb/^{238}U$ ages of 336.5 ± 0.7 Ma for Plesovice (comparably, data obtained using isotope dilution-thermal ionization mass spectrometry (ID-TIMS) yielded 337.13 ± 0.37 Ma); 291 ± 1 Ma for 02123 (ID-TIMS: 295 ± 1 Ma); and 412.9 ± 2.1 Ma for Temora-2 (ID-TIMS: 416.78 +/- 0.33 Ma). The accuracy of mass interference and mass bias corrections applied to $^{176}Hf/^{177}Hf$ are validated by analyzing synthetic zircons doped with Lu and Yb, along with natural zircon standards. Recent results include $^{176}Hf/^{177}Hf = 0.282302 \pm 38$ for 91500 (solution ICP-MS: 0.282308 ± 6) and $^{176}Hf/^{177}Hf = 0.282757 \pm 45$ for R33 (solution ICP-MS: 0.282764 ± 14).

New age constraints in the St. Alban's map area, southern Newfoundland, Canada

ANNE WESTHUES[1] AND MICHAEL A HAMILTON[2]

1. Geological Survey, Newfoundland and Labrador Department of Natural Resources, St. John's, Newfoundland and Labrador A1B 4J6, Canada ¶ 2. Jack Satterly Geochronology Laboratory, Department of Earth Sciences, University of Toronto, Toronto, Ontario M5S 3B1, Canada

The St. Alban's map area in southern Newfoundland (NTS 01M/13) is the focus of a bedrock mapping project and incorporates detailed magnetic and radiometric airborne geophysical data. A major feature of this area is the Day Cove Thrust that defines the boundary between the Gander Zone and the Exploits Subzone of the Dunnage Zone. The Little Passage Gneiss of the Gander Zone is intruded by the Gaultois Granite and Northwest Brook Complex in the southwest corner. The Baie d'Espoir Group of the Dunnage Zone is intruded by the North Bay Granite Suite in the west.

Lithogeochemistry of felsic to mafic metavolcanic rocks of the Baie d'Espoir Group shows distinct features of subduction-related processes, suggesting an emplacement of these rocks in an intra-oceanic island-arc volcanic environment. A metavolcanic rhyolite of the Isle Galet Formation was dated by isotope dilution-thermal ionization mass spectrometry (ID-TIMS) U–Pb zircon geochronology and yielded a Darriwilian age of 465.73 ± 0.46 Ma, which is slightly younger than, but overlaps within error of, a Dapingian age (468 ± 2 Ma), previously determined for a felsic metavolcanic of the Twillick Brook Member of the St. Joseph's Cove Formation. A non-foliated post-tectonic quartz monzonite is dated at 419.65 ± 0.46 Ma and provides a limit on the end of deformation during the Salinic orogeny.

Several sulphide- and Au-mineralized quartz veins and base-metal massive sulphides occur within the Baie D'Espoir Group, which has been a focus of exploration activity in the area for its base metal, Sb, As, and Au potential. New Au and Ag anomalies have been identified as a result of this mapping project.

MLA-SEM and fluid inclusion analyses – A twin-track approach to the study of cuttings from the Margaree A-49 well, offshore Newfoundland and Labrador, Canada

DEREK WILTON[1], JON HUNT[2], MARTIN FEELY[2], ALESSANDRA COSTANZO[2], AND DAVID NORRIS[3]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶ 2. Geofluids Research Group, Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway, Ireland ¶ 3. Nalcor Energy, 500 Columbus Drive, St. John's, Newfoundland and Labrador A1B 0C9, Canada

This study is based on twenty-one cuttings samples from the Margaree A-49 well in the East Orphan Basin, offshore Newfoundland; eight samples were from the Upper Cretaceous limestone (Wyandot Formation equivalent) and thirteen from two different sandstone intervals, defined as Targets A and B, within the Upper Jurassic Tithonian-aged interval (Jeanne d'Arc Formation equivalent). Mineral liberation analysis–scanning electron microscopy (MLA-SEM) techniques were used to evaluate both stratigraphic relationships within well and detritus provenance in all samples, and aqueous and hydrocarbon-bearing fluid inclusions (FIs) were examined from the thirteen Jeanne d'Arc Formation equivalent samples.

The MLA-SEM analyses indicate that the two sandstone intervals were composed of well to moderately sorted, subangular to subrounded, high sphericity detrital quartz grains, but the intervals also exhibit distinctive mineralogical and physical attributes. Texturally, Target B sandstone appears to be slightly more mature than Target A sandstone as indicated by better sorting and grain sphericity in the former. Mineralogically, the Target B sandstone appears to contain an enhanced igneous input, as suggested by Heavy Mineral indices calculated for the samples from the MLA data. Also, Target B sandstone contains enhanced siderite cement compared to Target A sandstone, suggesting an increased availability of iron within the former interval. The MLA-SEM analyses suggest that the uppermost limestone sample (Wyandot Fm. equivalent) was hydrothermally altered, possibly in near surface conditions, as it is the only limestone sample that contains Mn-bearing mineral phases and the only one that experienced significant dolomitization.

FI studies identified the presence of aqueous (2–20 μm) and hydrocarbon-bearing (<2–15 μm) fluid inclusions. Microthermometric data from the aqueous FIs indicate the presence of two distinct fluids: a low salinity-medium temperature fluid (~1 eq. wt.% NaCl and ~118°C) and a medium salinity-low temperature (~ 4 eq. wt.% NaCl and ~82°C) fluid. The hydrocarbon-bearing FIs (HCFI) exhibit a yellow/green fluorescence colour indicating oil with an estimated API gravity of 30°–35°. They occur along grain boundaries and in annealed microfractures suggesting at least two hydrocarbon trapping events. In general, the HCFI-bearing samples were identified by the MLA-SEM as being more mature with significant remnant carbonate cement.

The twin-track approach adopted for this project facilitates the generation of data on provenance, stratigraphic relationships and oil charge history. The material used for this study was drill cuttings, which are typically very challenging to use for petrographic and textural studies due to their broken, fine-grained, disaggregated nature (in contrast to competent drill core). The MLA-SEM grain mounts and FI wafers offer an alternative, reliable means of generating quantifiable provenance, depositional environment, and oil charge data from such material.