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ABSTRACTS

2022 Technical Meeting

Virtual

The Annual Technical Meeting was held virtually on February 21 and 22, 2022, from various home offices, dens, and bedrooms across St. John's, Newfoundland and Labrador, and beyond.

This year the meeting kicked off on Monday with introductory remarks from the GAC-NL President, Anne Westhues, followed by a tribute to Dave Liverman who passed away earlier this year. The rest of the conference was taken up by presentations on a wide range of geoscience topics. Monday afternoon featured a Special Session on New Developments in Mineral and Petroleum Exploration. In the following pages, we are pleased to publish the abstract from the oral presentations. The best student presentations are recognized and receive the "Outstanding Student Presentation Award" which consists of $100 and a certificate. The award winners are indicated by an asterisk in the title.

As always, this meeting was brought to participants by volunteer efforts and would not have been possible without the time and energy of the executive and other members of the section such as Anne Westhues, Jared Butler, James Conliffe, Shawn Duquet, Sarah Hashmi, Zsuzsanna Magyarosi, Annie Parrell, and Karen Waterman. We are also indebted to our partners in this venture, particularly the Geological Association of Canada, Department of Earth Sciences (Memorial University of Newfoundland), and the Geological Survey of Newfoundland and Labrador, Department of Energy, Industry, and Technology. We are equally pleased to see the abstracts published in Atlantic Geoscience. Our thanks are extended to all the speakers and the editorial staff of the journal.

Although the abstracts are modified and edited as necessary for clarity and to conform to Atlantic Geoscience format and standards, the journal editors do not take responsibility for their content or quality.

THE EDITORS

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Combining high resolution seismic sub-bottom imagery with magnetometer data to identify potential UXOs: a case study off the Danish coast

Stephanie M. Abbott, Maria Kotsi, Ryan Laidley, and Jacques Y. Guigne

PanGeo Subsea, A Kraken Robotics Company, St. John's, Newfoundland and Labrador A1G 1A1, Canada

The aim of this project was to acquire Sub-Bottom Imager (SBI) and magnetometer data to identify shallow sub-surface geohazards, particularly potential Unexploded Ordinances (pUXOs). The Sub-Bottom Imager, developed by PanGeo Subsea, is a novel system that provides high-resolution near-surface investigations with real-time 3D imaging. Its novelty relies on the combination of near-field beamforming with synthetic aperture sonar (SAS) processing tools, and the use of an Inertial Navigation System (INS) that allows for accurate source and receiver positioning and orientation. PanGeo's SeaKite deployment method was used to equip and acquire the SBI and magnetic data simultaneously. The survey area was 2480 m by 150 m, and the geological composition was primarily fine-grained sand or silt. Initial processing involved identification and interpretation of acoustic anomalies suggestive of pUXOs. This interpretation included associated attributes such as location, depth of burial, shape, and size meeting the minimum criteria of 0.60 m by 0.30 m. The magnetic processing was completed using the UXO Marine extension of Oasis Montaj, and targets were picked using the analytical signal (nT/m) grid. A target list was compiled with the information of target_ID, easting, northing, altitude, anomaly amplitude, and depth to target. Together with the target list, the residual field (nT) maps of magnetic anomalies displaying their shape and amplitude were used to correlate with the acoustic anomalies. Specifically, the SBI data was assessed for the presence of acoustic anomalies at the provided magnetic anomaly locations, and these correlations were delivered to the offshore renewable energy developer. Utilizing our results, the energy developer was able to assess the risk associated with these pUXOs and plan to safely remove them as deemed necessary.

Geophysics over a vulnerable cliff-side road, Bay Bulls, Newfoundland, Canada

Marzieh Arshian and Alison Leitch

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

Coastal erosion can be a serious issue requiring accurate observations in order to evaluate vulnerable areas and determine the subsequent actions to address this problem. The Town of Bay Bulls, about 29 km south of St. John's, Newfoundland, has coastal areas prone to erosion, and an important aim for the Town municipality is to reinforce these areas to avoid future road collapse. The Cliff site is over Northside Road, near the northwest end of the bay on the side of a steep incline, facing the marine terminal. The road here was widened in the 1960s, involving the construction of a wooden retaining wall infilled with earth materials. Slumping of the road surface and outward displacement of some parts of the wall are observed today.

Two geophysical methods were employed to image the surface and subsurface of the vulnerable stretch of road 140 m long. The methods were ground penetrating radar (GPR) and direct current resistivity/induced polarization (DCR/IP). A GPR investigation was carried out to examine about a 5-metre depth of subsurface. The GPR survey used 250 antennae, providing useful information about the shallow underground structure. GPR results of the Cliff area depict the subsurface wooden braces for the wall, culverts, and bedrock.

To thoroughly assess an area's vulnerability, it is essential to evaluate the deeper subsurface using DCR method. Combining two different DCR configurations, Schlumberger-Wenner and Dipole-Dipole, helped us achieve a two-dimensional model to a depth of about 17 m. Two overlapped DCR profiles were performed along the north side of Northside Road in the Cliff area.

St. John's urban flooding – The Rennies River experience: can we or should we try to tease modern global change phenomena from city-orchestrated urbanization (building and paving)?

Elliott Burden

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

The Rennies River watershed, a small network of streams and ponds draining a little more than 30 km^2 in St. John's, Newfoundland, has a history and prehistory extending back to end of the last ice age. Throughout most of that time the river has behaved as a misfit stream fed from a marshy landscape perfectly adapted to our boreal oceanic climate. Late 19th and early 20th century agriculture had a modest impact on improving river fitness with much more sediment entering Quidi Vidi Lake, but air photo coverage from the mid 20th century indicates that the large marshlands of the Ken Brook and Yellow Marsh Brook tributaries basically remained intact until more recent times. The city's own poster board displayed on the Rennies River trail shows a river flood in 1948. In 1986, and now some years after Ken Brook and Yellowmarsh Brook wetlands were being developed a significant late fall rainfall event led to flooding of many downstream homes and the "Mall". By the early 2000s, when hurricanes Gabrielle and Igor indeed touched upon Newfoundland shores, climate researchers were beginning to sound the alarm about global change. And so too, development of the upland marshlands continued. During our most recent event – a rainfall/snow melt upon frozen ground, can we really blame climate change, or is this a function of our growing lack of wetlands to absorb precipitation? I am not a lawyer, and there may yet be other issues at play if flooding is not simply explained as a random act of nature. Solutions are possible, but none are without costs to people and governments.

Using fluoride analysis in till to assist in identifying the bedrock potential for critical minerals in central Newfoundland, Canada

Heather Campbell[1], Steve Amor[2], Zsuzsanna Magyarosi[1], Chris Finch[1], and Rosauro Roldan[1]

1. Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada; 2. Geological Consultant, St. John's, Newfoundland and Labrador A1A 3C5, Canada

Fluoride analysis has successfully located previously unrecognized mineralization associated with Li-Cs-Ta (LCT) pegmatites in sandy, bouldery, variably eroded, and dispersed till overlying granite and metasedimentary rocks in the Snowshoe Pond region of the Meelpaeg Subzone in central Newfoundland. Fluoride, measured by Ion Selective Electrode (ISE) analysis, is a component of the analytical suite for till-geochemical samples in the province of Newfoundland and Labrador. In central Newfoundland, fluoride in till is thought to be derived from apatite that typically occurs in LCT pegmatites (up to 5%). Fluoride anomalies in till samples are more effective in defining the extent and locale of the underlying pegmatites than other geochemical indicators associated with mineralization (e.g., Cs, Li, Nb), as the fluorine-bearing apatites are: (1) relatively abundant in the source rocks, and (2) sufficiently resistant to reside in dispersed and eroded tills. Based on this study, the use of fluoride analysis in till is highly recommended in other areas with potential for rare element mineralization. More studies are being conducted to assess the potential of fluoride in till in exploring for other types of deposits, such as rare earth elements (REE) that are also typically associated with F-rich rocks.

A review of the structural controls on mineralization at the Valentine Gold Project, Central Newfoundland, Canada

Nic Capps

Marathon Gold Corporation, 36 Lombard Street, Toronto, Ontario M5C 2X3, Canada

The Valentine Gold Project, located in central Newfoundland, is a structurally-controlled orogenic gold deposit consisting of quartz-tourmaline-pyrite-Au (QTP-Au) veining hosted in the Valentine Lake Intrusive Suite (VLIS; 575–565 Ma). The VLIS lies in unconformable contact with the Silurian-aged Rogerson Lake Conglomerate (RLC) along the NE-SW trending Valentine Lake Shear Zone (VLSZ). Five phases of Acadian-aged deformation have been identified on the property, with gold mineralization associated with up to four orientations of QTP-Au veining, the dominant set being SW-dipping, and infilling extensional brittle fractures. Individual extensional fractures, as exposed at surface, can have a lateral extent of up to 50m.

The project currently hosts five deposits with mineral resource estimates, two of which, Leprechaun and Marathon, form the basis of an open-pit mining proposal currently undergoing provincial and federal environmental assessment. Once operational, the Valentine Gold Project is expected to produce approximately 2 million ounces of gold over a 13-year life, with an average gold production of 173 000 ounces a year for the first 9 years. This makes it the largest undeveloped gold project in Atlantic Canada.

Current exploration is focused on the newly discovered Berry Deposit. At Berry, as well as at Leprechaun, gold mineralization within the QTP veins appears controlled by large-scale (>20 m) mafic dykes which run sub-parallel to the VLSZ, causing the mineralization to accrete in a concentrated band between these dykes and the Rogerson Lake Conglomerate to the SE. The Marathon deposit, which is the largest deposit currently on the property, hosts much more irregular, discontinuous mafic dykes. This appears to dictate a broader distribution of brittle deformation and QTP-Au veining, at a modestly lower average grade.

The Valentine Gold Project is a large scale, bulk-mineable gold deposit of a type generally new to Newfoundland. Understanding the genesis of the project's multiple mineral deposits, the detailed structural and geological controls on mineralization, and the similarities and differences of one deposit to the next,

is key to the further discovery and development of additional large scale gold projects across the island.

Predictive lithology mapping using machine learning: practical insights

Michael W. Dunham[1,2], Alison Malcolm[1], and J. Kim Welford[1]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada;
2. Goldspot Discoveries Corporation, Toronto, Ontario M5E 1K3, Canada

A popular use for machine learning in the mineral exploration industry is predictive mapping, where remote sensing data are combined with our limited observations on the ground to make lithology predictions for an entire region of interest. These machine learning predictions can produce a starting geologic map or enhance existing geologic maps. Over the past decade, supervised learning (SL) methods have become the common approach for predictive lithology mapping. In essence, SL methods learn a relationship between the co-located remote sensing observations and training targets (e.g., lithologies from outcrops, grab samples, etc.) in order to make predictions for where the lithology is unknown. Arguably, the biggest challenge with these problems is that the amount of training data is inherently limited (e.g., minimal outcrop exposure), which can lead to a phenomenon called overfitting; this translates to the SL model generalizing poorly to the data where the lithology is unknown (i.e., the unlabeled data). Semi-supervised learning (SSL) is a different machine learning approach that is better designed for these minimal training data situations. The advantage of SSL techniques is that they incorporate all the information (i.e., the training data and all the unlabeled data) during the learning process, which can provide improved predictions compared to SL methods.

We explore the effectiveness of SSL methods using a dataset from New South Wales, Australia, where the geologic map, and radiometric and magnetic data are provided. We simulate multiple exploration scenarios where the *a priori* knowledge of lithology is limited, and the task is to predict the lithology for the remaining majority of the map. Our results show that SSL can be 5–10% more accurate than SL, which means that lithology predictions from SSL can further reduce our risk when identifying exploration targets.

Ground penetrating radar observes forest hillslope soil trends in Pynn's Brook, Newfoundland, Canada

Zachary X. Gates[1], Lakshman Galagedara[2], and Susan Ziegler[1]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada;
2. School of Science and the Environment, Memorial University of Newfoundland, Corner Brook, Newfoundland and Labrador A2H 5G4, Canada

Soil property measurements to determine carbon (C) stocks are traditionally collected using physical samples or excavation practices which rely on small scale interpretations for sitewide averages. Such methods are limited in capturing soil distribution and landscape variance across heterogenous forests, as seen in estimates of 384 ± 214 Pg C in the top 1 m of Canadian forest soils and 1500–2400 Pg C globally at 30 cm deep.

Ground penetrating radar (GPR), a continuous, non-destructive geophysical tool for measuring subsurface reflection patterns, can expand boreal forest soil investigations past limited spatial scales. We have demonstrated through soil sampling and GPR surveying in Pynn's Brook, Newfoundland, Canada, at small pit (<1000 m^2) and large plot (>1000 m^2) scales that GPR measurements of soil horizon thickness, bulk density, and C stocks observe landscape trends across a hillslope site not previously captured by soil sampling methods.

GPR measurements across landscape scales suggest variable mineral soil horizon thickness sitewide (±4 cm) with thicker horizons accumulating downslope, following expected sediment transport and deposition mechanics. Soil bulk density measurements by GPR were consistently lower than soil estimates which suggests that traditional methods may overestimate soil content due to sampling bias. These differences in soil horizon thickness and bulk density measurements contributed to lower soil C stock calculations by the GPR method across scales. Overall, analogous GPR measurements for sitewide soil C stocks showed that increasing spatial data capture across gradients like a hillslope can significantly impact interpretations of sitewide soil and thus C content. As such, GPR's high resolution spatial sampling (5 cm sampling interval) and sitewide data collection capabilities expanded previous soil and C estimates to incorporate measurements across the full slope for a better understanding of landscape soil trends.

Natural CO_2 sequestration and mineralization in the Bay of Islands Ophiolite Complex, Newfoundland, Canada

Matthew J. Gill and Penny L. Morrill

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

The high reactivity and unique chemistry of ophiolites make them ideal sites for carbon mineralization. At elevated pH values, dissolved CO_2 in the water can dissociate to form CO_3^{2-} ions which readily bonds with Mg^{2+} and Ca^{2+} which are present in ophiolite groundwater. While this process has been proposed as a unique method to combat climate change the kinetics of these reactions and the impact that they could have on the atmosphere has not been quantified experimentally.

Experiments reported here were performed on rocks from the Bay of Islands Complex (BOIC) an ophiolite in Western Newfoundland. Crushed rock (<7 mm) was combined with simulated basic and ultra-basic groundwaters in a closed-batch chamber. A CO_2 analyzer was connected to the chamber headspace which monitored CO_2 concentrations over a 4-hour period. Conductivity, pH, ion concentrations, and total inorganic carbon (TIC) were measured before and after each observation. A total of 6 experiments were completed (in triplicate), one for each water type with and without the addition of crushed peridotite.

In all experiments, except for the control group, the CO_2 concentration decreased in the chamber headspace over the four-hour period. The addition of crushed ultramafic rock to deionized water had a CO_2 flux of -1.26×10^{-5} mol/m^{2}min ($\pm 4.5 \times 10^{-6}$ mol/m^{2}min, 1σ, $n = 3$). Basic waters and deionized water with rock had similar CO_2 fluxes while ultra-basic waters had the greatest CO_2 flux of all experiments at -7.05×10^{-5} mol/m^{2}min ($\pm 1.4 \times 10^{-6}$ mol/m^{2}min, 1σ, $n = 3$). The data here suggest that ultramafic rock in the presence of H_2O can sequester carbon dioxide. At a greatly elevated pH (>12), some of the CO_2 removed from the headspace precipitates out of solution as solid carbonate minerals. Our results indicate that this process could have a substantial impact on the Earth's atmosphere.

Volcanism associated with edge-driven convection preserved in the Deer Lake Basin, Newfoundland, Canada

Alana M. Hinchey, Ian Knight, Hamish A. Sandeman, and John G. Hinchey

Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada

During the Carboniferous, the assembly of the supercontinent Pangea periodically reactivated strike-slip faults and shear zones that transect the northern Appalachian orogen. These strike-slip deformation zones represent crustal-scale tectonic boundaries that likely originated in association with Paleoproterozoic rifting of the paleo-Laurentian margin and have long-lived and complex kinematic histories. Their periodic reactivation controlled the evolution of the transtensional sedimentary basins of the region. The continuous interplay between the lithospheric plates, their subcontinental lithospheric mantle, and surficial processes (i.e., oceanic/riverine, biological, atmospheric, gravitational, erosional) controlled the development of the Deer Lake Basin (DLB) in western Newfoundland. The Saltwater Cove Formation of the DLB is a late Tournaisian deltaic succession where sedimentation was interrupted by minor intervals of basalt flows and pyroclastic deposits. The basalt samples have E-MORB (enriched mid-ocean ridge basalt) to OIB (ocean island basalt) chemical affinities, i.e., enriched LREE to HREE, and have $\varepsilon Nd_{(t=345\ Ma)}$ values between +2.8 and +6.4. Pyroclastic deposits include mafic lapilli tuff and intermediate tuff, and have compositions similar to CAB (continental arc basalt), with steep LREE relative to HREE patterns, negative Nb and Ti anomalies, and have $\varepsilon Nd_{(t=345\ Ma)}$ ranging from -6.1 to -1.0. Geochemical variation within the mafic rocks is explained by an E-MORB source variably influenced by crustal contamination processes. Coupled with field evidence, the geochemical and isotopic data support their emplacement in a transtensional, intra-orogenic basin setting that formed during the assembly of Pangea. Their m oderately primitive chemistry supports the interpretation that faulting associated with transtensional basin development facilitated asthenosphere upwelling via edge-driven convection.

Critical minerals in Newfoundland and Labrador: a review of concepts and a preliminary inventory of potential resources

Andrew Kerr

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

Critical Minerals is now a widely used phrase in the Minerals Industry, but it is hardly a new concept. During the Cold War, critical minerals were initially defined as materials important to national objectives that might encounter

supply disruptions by military or political conflicts, but the term is now much broader. Canada has a list of 31 critical minerals, but this includes several with widespread global production and some (e.g., nickel, uranium, and potash) that we produce ourselves. There is limited supply risk for these, but they are important to the economy.

All present lists of critical minerals feature commodities linked to the much-heralded *Energy Transition*. These include cobalt, lithium, manganese, nickel, graphite, and vanadium (for batteries in electric vehicles and energy-storage systems), the Rare Earth Elements (REE: for high-strength magnets in EV motors and wind-turbines) and some truly rare elements (e.g., cadmium, germanium, gallium, indium and tellurium) used in high-efficiency photovoltaic (solar) energy systems. Some of these (e.g., cobalt and the REE) are important in more than one sector or have other diverse applications in modern technology. Although some are primary commodities, many critical minerals (e.g., cobalt and "photovoltaic" elements) are by-products.

Exploration and development for many critical minerals will likely be very different from what we are used to. Future trends are hard to predict because end-use technology evolves on a scale of years, but exploration and development typically takes decades. There is much research aimed at material substitutions, which can quickly change requirements. Conversely, optimistic projections predicated on new research may be derailed if such innovations cannot be commercialized. Forecasts of demand growth made on a percentage basis often obscure the reality that global production of some commodities will remain small in *absolute* terms, which limits options for new producers. The geometallurgy of some such deposits (notably for REE) is complex, so custom process development adds another layer of cost and risk to any new project. Valuable by-product commodities are commonly extracted during smelting or refining, which may be in another jurisdiction. Finally, if such new operations are claimed to have climate mitigation benefits, their own environmental and energy footprints will require careful auditing.

Setting aside these multiple uncertainties, Newfoundland and Labrador has a promising inventory of known and potential critical minerals resources, including nearly half of the entries on Canada's current list. In Labrador, nickel and copper are produced at Voisey's Bay, and its by-product cobalt will be increasingly important. Significant manganese and uranium resources exist elsewhere in Labrador, and the Strange Lake Deposit is a world-class undeveloped resource of REE and associated elements. Other smaller REE and Be resources may also have future importance. Newfoundland hosts important antimony and fluorite producers, and also undeveloped resources of molybdenum and tungsten. Our knowledge of the abundance of other critical minerals such as graphite, lithium and vanadium is more limited, but our varied geology implies that potential exploration environments exist in both regions of the Province.

Reconstructing the southern North Atlantic Ocean back through time using deformable plate tectonic models*

Michael King and J. Kim Welford

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

The offshore rifted margins of the southern North Atlantic Ocean have been demonstrated to have a complex present-day crustal structure comprised of sedimentary basins, inherited structures, variable basement affinities, and continental blocks. Consequently, this has led to challenges when studying the crustal evolution of the southern North Atlantic. In particular, the kinematic history of continental blocks (e.g., Flemish Cap) and micro-plates (e.g., Iberia) and their subsequent impact on strain-partitioning during poly-phase rifting experienced along the Newfoundland, Irish, and West Iberian margins. Recently, deformable plate tectonic models, built using the GPlates software, have proven to be an advantageous method for investigating the interplay between plate kinematics and deformation experienced throughout the North Atlantic. Furthermore, their ability to calculate temporal variations in strain rate and crustal thickness provides a quantitative method of comparison with present day crustal thickness estimates calculated by gravity inversion and interpretations made from offshore seismic and well data. However, previous deformable plate models of the North Atlantic have included assumptions that are geologically problematic. Examples of assumptions include, but are not limited to, the rigid nature of continental blocks and model boundaries, and the specification of uniform crustal thicknesses within pre-rift templates.

In this study, we present a new deformable plate modelling approach using GPlates and its python programming module, pyGPlates, which aims to address these limitations by reconstructing present-day crustal thicknesses back through time. Using previously published and newly presented models, our results demonstrate the pre-rift crustal thickness template of the southern North Atlantic and the crustal thickness evolution of continental blocks and sedimentary basins within. In addition, this study highlights the potential impact of Appalachian and Caledonian terrane boundaries on the crustal segmentation observed within pre-rift templates and subsequent rift events.

**Honourable Mention: Outstanding Student Presentation Award*

Lithological controls on freshwater dissolved ultra-trace element signatures: examples from small catchments in Northern Ireland and Newfoundland and Labrador, Canada

Gabrielle M. Ledesma[1], Michael G. Babechuk[1], and Saskia E. Ryan[2]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3R5, Canada;
2. Archéozoologie, Archéobotanique: Sociétés, Pratiques et Environnements (AASPE, UMR 7209), Muséum national d'Histoire naturelle, CNRS, 75005 Paris, France

The global cycling of dissolved elements from land to sea is broadly controlled by relative element solubility and bulk crustal element abundance, as reflected in the geochemical signatures of major rivers. However, smaller rivers and streams within a catchment that contain predominantly one lithological rock type can provide a more detailed reconstruction of the biogeochemical factors governing the soil-to-aquatic transport of elements. Dissolved low abundance trace and ultra-trace elements (UTEs) within the freshwaters draining these smaller, monolithological catchments are especially powerful tools that can be used as indicators to link anomalous signatures to geological (e.g., mineralization, rock provenance) or anthropogenic point sources. Due to analytical challenges in quantifying UTEs in natural water, studies that contain full UTE characterization in monolithological catchments are rare, consequently resulting in poor understanding of the abundance and biogeochemical cycles of many element groups such as rare earth elements (REE), Zr, Nb, Mo, W, and Tl.

This study aims to characterize UTEs in rivers/streams in three areas, each with a different predominant bedrock lithology: Northern Ireland, UK (mafic volcanic rock); Bay of Islands, Newfoundland and Labrador (NL) (mafic-ultramafic plutonic rock); and St. Lawrence, NL (evolved felsic plutonic rock). Selected geochemical signatures of the Northern Ireland samples that cover standalone streams and a freshwater-to-seawater estuary transect will be the focus of this presentation. These results demonstrate that freshwaters draining mafic volcanic rock, despite being low in UTE abundance, develop consistent and geologically controlled signatures that diverge from major river patterns, with some signatures (e.g., REE patterns) being unexpectedly coherent, for particle-reactive elements, across wide salinity gradients. The NL study sites are part of a planned sampling excursion in 2022, with samples to be measured in the new low-metal clean laboratory facility at Memorial University and resulting in a dataset, the first of its kind, for NL freshwaters.

The Signal Hill Group: a record of fluvio-deltaic response to progressive Neoproterozoic deformation during the Avalonian Orogeny

David G. Lowe[1], Santiago Serna Ortiz[1], Andrea Mills[2], Benjamin F. Stanley[1], and Grace Khatrine[1]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X7, Canada;
2. Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada

The Signal Hill Group consists of the youngest Neoproterozoic strata in the Newfoundland Avalon Zone. It records sedimentation coeval with the ca. 560–555 Ma Avalonian orogeny, defined by local deformation of West Avalonia, including metamorphism, faulting, and folding coinciding with the shutdown of arc magmatism and initiation of local extensional magmatism. The Signal Hill Group provides a record of clastic progradation during the Avalonian Orogeny, details of which can resolve the near-surface effects and kinematics of deformation. At the base of Signal Hill, the Gibbet Hill Formation and overlying Quidi Vidi Formation record southward progradation of a sandy delta front environment dominated by mouth bars and distributary channel networks. Structural and stratigraphic evidence suggests blind faulting, folding, unconformity development, and basin reconfiguration between these units, supported by locally intense soft-sediment deformation along their contact. Conformably overlying the Quidi Vidi Formation are gravelly braided fluvial deposits of the Cuckhold Formation, recording amalgamation of alluvial channel belts with overall coarsening-up to pebble-cobble conglomerate followed by fining-up to pebbly sandstone. In the northern (proximal) Signal Hill basin, subsequent folding of the Signal Hill Group coincided with erosion that locally removed the Cuckhold Formation, with subsequent onlap of gravelly braded fluvial growth strata of the Flatrock Cove Formation. Here, progressive fault propagation then resulted in a change from braided channel belt to alluvial fan floodplain conditions. Conversely, in the southern (distal) part of the Signal Hill basin, the Cuckhold Formation is conformably overlain by the Blackhead Formation, recording anomalous overbank mudstone preservation under conditions of high sediment accommodation. It is not understood if or how these post-Cuckhold proximal and distal events were related; however, it is possible that renewed thrust propagation and orogenic loading led to proximal deformation and growth stratification coincided with reciprocal foredeep subsidence and preservation of overbank strata farther south.

Computer modelling of electromagnetic and direct-current resistivity data for mineral exploration

Xushan Lu[1,2], Colin Farquharson[2], and Peter Lelièvre[1]

1. Department of Mathematics and Computer Science, Mount Allison University, Sackville, New Brunswick E4L 1E4, Canada; 2. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada

Three-dimensional (3D) computer geological models created by integrating various types of geological, geophysical, and geochemical datasets are widely used in mineral exploration projects to help find and delineate ore deposits. Electromagnetic (EM) and direct-current resistivity (DCR) methods are extensively used geophysical methods in mineral exploration, and they are becoming increasingly more important as exploration requires more accurate imaging at depth. Forward and inverse modelling of EM and DCR data can help refine the 3D geological model which is then used for drill targeting. Consequently, it is of vital importance to be able to perform the modelling accurately and efficiently. Realistic geological models can be complex, with topography and irregular geometric interfaces between distinct geological units. Traditional modelling algorithms which use structured rectilinear meshes to discretize realistic geological models can be inaccurate unless extremely small cells are used to discretize the model, which inevitably leads to poor modelling efficiency.

We have developed numerical algorithms for the forward and inverse modelling of various types of geophysical data including EM and DCR data using unstructured tetrahedral meshes. Compared with rectilinear meshes, unstructured meshes can more faithfully conform to complex geometric features in the geologic model and topography. The modelling efficiency is also significantly better because local refinements in key regions of the geological model can be easily introduced while keeping the total number of cells small. To facilitate the process of mesh creation, we have also developed software (FacetModeller) to create wireframe models representing arbitrarily complex geological models within a graphical user interface environment.

We have applied our modelling codes to real EM and DCR datasets, and to realistic, challenging test scenarios representing a range of ore deposit types and hosts. Our computer modelling algorithms have been shown to be accurate and efficient, and can greatly contribute to a better understanding of subsurface geology.

Li-Cs-Ta pegmatites in Newfoundland, Canada

Zsuzsanna Magyarosi and Heather Campbell

Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada

Pegmatites are a significant source of several critical elements including REE, Li, Cs, Ta, and Nb, and also a source of gemstones, high-quality feldspar, quartz and mica. Most economic pegmatites are derived from evolved granites with numerous magmatic phases representing varying degrees of fractionation. In the late stages of crystallization of the main granite, a residual melt enriched in incompatible elements, such as Li, Cs, REE, Nb, Ta and volatiles, separates and crystallizes as pegmatite dykes.

Based on their trace element enrichments, pegmatites are subdivided into Li-Cs-Ta (LCT) and Nb-Y-F (NYF) types. NYF pegmatites are associated with A-type granites, are enriched in REE and occur within their parent granite. LCT pegmatites are usually associated with S-type granites, having formed as a result of anatexis of metasedimentary rocks, and occur in the surrounding rocks up to ~10 km from the parent granite. The degree of fractionation is directly correlated with their economic potential and increases with increasing distance from the parent granite. LCT pegmatites are located along major tectonic boundaries, typically within metasedimentary dominated areas, where the grade of metamorphism ranges between greenschist and amphibolite facies. The host rocks are metasomatized around the pegmatite dikes with elevated Li, Rb, Cs, B and F contents and the occurrence of minerals such as tourmaline, holmquistite, muscovite and garnet.

In Newfoundland, the Gander Zone and surrounding areas represent an ideal geological setting for LCT pegmatites and show many similarities to the well-known pegmatite fields in the Superior Province. Pegmatites have been identified in central Newfoundland, but their economic potential has only recently been recognized. Further exploration should include till and bedrock sampling to identify fertile granites and metasomatic alteration associated with unexposed pegmatites, and mapping metamorphic grades to identify the contact metamorphic aureole from underlying intrusions. Once fertile granites or pegmatites are identified, further work should concentrate on determining fractionation trends with whole-rock and mineral chemistry.

Assessing the CO_2 sequestration potential of serpentinized ultramafic rocks of Baie Verte, Newfoundland, Canada*

Timilehin A. Oguntuyaki and Penny L. Morrill

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

The increasing need to mitigate the effects of climate change has necessitated CO_2 sequestration using ultramafic rocks. Despite numerous studies on the use of ultramafic rocks, highly altered forms of these rocks in Baie Verte have not been assessed for their potential to sequester CO_2. This study focused on using serpentinized ultramafic rocks of the Baie Verte Oceanic Tract (BVOT) to trap atmospheric CO_2 and potentially use it to mineralize carbonate.

Rocks from the BVOT, which primarily comprise peridotites with compositions ranging from serpentinized mantle harzburgite to dunite, were crushed into two sample groups of distinct grain sizes; crushed rock (CR) and powdered rock (PR), each of which was reacted with two water types; deionized (DI) water and magnesium-rich water, and a known concentration of CO_2 in a LiCor Flux Chamber and CO_2 Gas Analyzer for 4 hours. Water-only experiments were also conducted in the same manner for the two types of water. After the 4-hour experiments, observations were made for the change in concentration of CO_2 in the system, changes in dissolved ions (Mg^{2+}) concentration, and change in Total Inorganic Carbon (TIC).

Results showed that CO_2 concentration in the system decreased in all experiments; 300 g of CR + 300 mL of Mg-rich water had the most significant average CO_2 sequestration rate of $1.69 \times 10^{-7} \pm 1.40 \times 10^{-8}$ mole/min. The DI water + PR experiment also had the most significant increase in TIC (about 9.8 ppm of carbon) after 4 hours of reaction. The DI water-only experiments had the slightest decrease in CO_2 concentration and the lowest change in TIC.

The change in CO_2 concentration results suggests that serpentinized ultramafic rocks in BVOT could sequester CO_2, while the TIC and dissolved ion analyses showed that the rocks could convert the sequestered CO_2 into more stable carbonates.

**Winner: Outstanding Student Presentation Award*

Quaternary mapping and stratigraphy of northwest Gander, Newfoundland, Canada, and implications for regional ice dynamics and mineral exploration

Jennifer S. Organ[1], Daniela Mendoza-Marin[2] and Heather E. Campbell[1]

1. Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada; 2. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada

The northwest Gander region has a complex glacial history influenced by multiple ice flows including an ice streaming event, and marine incursion as ice retreated during deglaciation. This complexity is identified in landforms, surface morphology, and underlying stratigraphy. The regional ice-flow chronology is identified by relative age relationships found at multidirectional striation sites. It indicates that the region was influenced by three phases of ice flow: Phase (1) an early east-southeast flow; Phase (2) a pervasive north to northeast flow that is also recorded by streamlined landforms; and Phase (3) a local northwest flow observed in the northwestern part of the study region.

Surficial units include till, organic deposits, glaciofluvial sediments (particularly in the Gander River Valley and its tributaries), and sparse marine sediments near the coast and along the Gander River. Till is the most dominant surficial unit identified. It has a varying thickness (1–5 m) and is thinner towards the coast. It forms different morphologies, including veneers, blankets, ridges, and hummocky, eroded, lineated (streamlined) or glaciotectonized till. Subglacial till is typically more useful for delineating mineral dispersal than other till types.

Preliminary investigations have exposed multiple till units (e.g., three till units were identified at one site in 2021) and provided insight into their stratigraphic relationships, although their lateral extent is unknown. The upper two tills were identified in 30% of sites visited during the 2021 field season, indicating that multiple-till preservation is more widespread than previously thought. The uppermost unit varies in thickness from 30–90 cm, which may have implications for mineral exploration using till geochemistry; knowledge of till units and their stratigraphic relationships are paramount when conducting sampling programs. Future work includes continued detailed mapping and examining the textural, mineralogical, and geochemical variation of each regional till unit through laboratory analyses, pebble counts, and mineral indicator studies. This future work will assist in providing constraints on material transport distances in a subglacial regime.

Topographic controls on soil organic carbon in moist boreal forest mineral soils*

Mackenzie Patrick, Zach Gates, and Susan Ziegler

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

Boreal forests contain ~30% of the global soil organic carbon (SOC) stock within a region vulnerable to climate change, yet detailed studies on the controls of this large reservoir are lacking. In these moist acidic soils, soil forming processes link C dynamics and chemical weathering via organo-metal complexes (OMC), which are important weathering products that stabilize C in the surface mineral soil. At the continental scale, climate and parent material control OMC abundance, but within a climate region, the influence of slope on hydrological and erosional processes may impact OMC formation and stability, and subsequently SOC content.

To investigate the role of topography on SOC, changes in particulate and dissolved organic carbon (POC and DOC, respectively) were measured experimentally using soil columns built from mineral horizon soils collected from different depth and slope positions within an experimental watershed in the Pynn's Brook region of Newfoundland. The gentle-sloped (6°) upslope soils had greater SOC and OMC, while the steeper (12°) downslope soils had higher bulk density and sand, consistent with a footslope depositional zone. Dissolved organic matter, a primary source of SOC to these mineral soils, was collected in passive pan lysimeters and applied to the experimental soil columns. Uptake of C was dependent on the degree to which OMC were saturated with SOC, where undersaturated deep horizons sequestered more C while saturated surface soils exhibited little change. The footslope had greater POC loss while upslope was relatively stable. Overall, vertical flow promoting OMC formation-controlled SOC content and C uptake in the gentle-sloped soils, while lateral flow and depositional processes of erosion dominated in steeper soils resulting in less OMC, easily mobilized POC, and consequently, lower SOC. These results highlight the importance of slope on SOC content through interacting hydrological and erosional processes, and the high potential for C uptake at depth in these forest landscapes.

**Winner: Outstanding Student Presentation Award*

Stable Isotope Precipitation Sampling (SIPS): determining the local meteoric water line using seasonal precipitation samples across the island of Newfoundland, Canada*

Kendra R. Revoy, Michael G. Babechuk, and Penny L. Morrill

Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X7, Canada

The aim of this study, known as the Stable Isotope Precipitation Sampling (SIPS) project, was to define a local meteoric water line (LMWL) for the island of Newfoundland using seasonal precipitation samples gathered during the 2021 calendar year. Meteoric water lines are linear relationships of the stable isotope values of hydrogen (H) and oxygen (O), derived empirically from isotopic measurements of precipitation in a defined region. Stable isotope values of H and O in meteoric waters vary with latitude, temperature, or any combination of these and other factors. This leads to variations in reported slope and intercept values for different geographic locations. While LMWLs have been calculated for the Corner Brook and the Bay d'Espoir regions, Newfoundland lacks a line that represents the whole island.

For this study, samples were collected through a community science network facilitated between Memorial University and the Newfoundland and Labrador English School District (NLESD). High school science students across Newfoundland's three primary regions (Eastern, Central, and Western) collected recent precipitation, recorded accompanying weather conditions, and applicable geographic information. The samples and field data were sent to Memorial University to arrange for isotopic analysis. While samples are still being received, to date, the H and O isotope data (n = 21) are well described by linear regression ($r^2 = 0.9864$) of $\delta^2H = 7.4919(\delta^{18}O) + 5.5348$.

The development of a unique slope and intercept for Newfoundland will allow for more accurate interpretations of water samples on the island, including those used for environmental, meteorological, or climatological studies. Unlike previous LMWLs from Corner Brook and Bay d'Espoir that address H-O isotopic variability in a specific area and/or over a long time period, the island-wide LMWL being reconstructed for this study allows for further evaluation of how factors such as latitude and temperature control variability on a wider spatial scale.

**Winner: Outstanding Student Presentation Award*

An overview of geochronological constraints on gold mineralization on the Island of Newfoundland, Canada, and their implications

Hamish Sandeman[1] and Ian Honsberger[2]

1. Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada; 2. Geological Survey of Canada, Ottawa, Ontario K1A 0E8, Canada

Although gold exploration on the island of Newfoundland started in the early 1900s, it did not gain significant momentum until the 1977 discovery of gold along the Cape Ray Fault Zone. Exploration in the late 1980s and 1990s led to many new discoveries; however, until the recent exploration boom only a select few gold-related projects had been episodically explored. These were largely restricted to the known auriferous areas of western Newfoundland and on the Avalon Peninsula.

The emerging Newfoundland gold district contains numerous gold occurrences spatially associated with Paleozoic crustal-scale fault zones and their subsidiaries. These encompass a number of mined deposits and developed prospects having variably developed resources, and include: (1) Pine Cove Mine (3.63 Mt at 1.3–2.0 g/t for 154 132 oz Au mined); (2) Valentine Lake (~86 Mt at 1.72 g/t Au for ~4.7 Moz Au, measured and indicated); (3) Cape Ray (3.5 Mt at 3.15 g/t for 0.918 Moz Au; measured and indicated); (4) Reid Zone (9.75 Mt at 0.56 g/t for 176 000 oz Au, indicated); (5) Nugget Pond Mine (0.43 Mt at 10.5 g/t, 168 748 oz mined); (6) Hammerdown Mine (291 400 t at 15.83 g/t Au for143 000 oz Au mined); (7) Rattling Brook (5.46 Mt at 1.45 g/t for 255 000 oz; indicated); (8) Mosquito Hill (4.47 Mt at 0.53 g/t for 75 600 oz Au, indicated); (9) Thor (0.357Mt at 3.19 g/t for 36 600 oz Au, indicated); (10) Argyle (0.529 Mt at 1.99 g/t for 33 850 oz Au, probable) and; (11) Stog'er Tight (191 500 oz at 2.39 g/t for 14 740 oz Au, probable). In addition to these deposits there are numerous other, in some cases newly discovered, gold discoveries in the central Newfoundland Appalachians including, for example, those associated with the Queensway, Moosehead, Kingsway and Toogood exploration projects; extensive drilling is underway on these targets.

This contribution summarizes current geochronological constraints on gold mineralization on the Island, evaluates their type and dependability and discusses their implications with respect to our current knowledge of the timing, and broad kinematics, of the geotectonic controls on orogenesis and mineralization. Future research must emphasize the integration of diverse datasets, including regional and local geological observations, ore parageneses, fluid inclusion analyses, stable and radiogenic isotopic analyses, sulphide trace element analyses, geochronological studies, and ore-host rock lithogeochemical investigations to better constrain the origin of the individual gold mineralized zones.

Application of ore deposit models for critical mineral assessments: examples from Maine, USA

John F. Slack

U.S. Geological Survey (Emeritus), National Center, MS 954, Reston, Virginia 20192, USA

This talk highlights the use of descriptive and genetic models, together with grade-tonnage data, in assessing the potential for undiscovered deposits that contain critical minerals and metals. Emphasis is on areas of known deposits having high potential, including sediment-hosted Mn, magmatic Ni-Cu(-Co-PGE), and pegmatitic Li-Cs-Ta. Also briefly discussed is the potential for other deposit types such as ophiolite-hosted PGE, orogenic Sb(-Au), and skarn W, and black shale-hosted V.

Seeking hot and cold water in the Sandıklı graben, Turkey

Fethi Tayfun Turanli and Alison Leitch

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

The country formerly known as Turkey has extensive geothermal and agricultural resources. It lies within the Alpine–Himalayan orogenic belt, and its interior is characterized by rugged mountainous terrain interspersed with cultivated valleys. It's generally high elevation, recent volcanism, and high heat flow is attributed to delamination of the mantle lithosphere about 10 Ma, and subsequent upwelling of the asthenosphere and crustal anatexis.

The Sandikli graben, west central Anatolia, is one of the largest agricultural areas in the region and features 1500 wells tapping fresh water from shallow aquifers for domestic and agricultural use. It is also the site of the Hudai-Sandikli geothermal field, which provides heat to spas and greenhouses from 23 deeper thermal wells.

We analyzed data from geophysical resistivity surveys covering an area of 36 km × 10 km and extending to 1 km depth in the Sandikli graben, including the geothermal field. The aim was to characterize the subsurface structure throughout the graben, looking for hot and

cold aquifers and for fault structures which may be related to the upward transfer of geothermal waters. Low resistivity values are generally associated with aquifers, and large changes with faults.

We found resistivity near the surface followed topography and drainage patterns, and that known faults produced varied results. Low resistivity layers, signifying aquifers, were common, although limited in horizontal extent to 1 or 2 km. Raw data in the geothermal field showed large jumps which may be a characterizing feature. We discovered the limitations of the data set: without additional data (e.g., well temperatures, heat flow) we could not determine the temperature of the aquifers.

Regional shear zones and faults in the Baie d'Espoir Group, south central Newfoundland Appalachian orogen, Canada

Anne Westhues

Geological Survey, Department of Industry, Energy and Technology, Government of Newfoundland and Labrador, St. John's, Newfoundland and Labrador A1B 4J6, Canada

The Bay d'Espoir area straddles the boundary between rocks traditionally assigned to the Dunnage (Exploits Subzone) and Gander zones in Newfoundland (equivalent to the Tetagouche-Exploits Backarc Basin (BAB) and the Gander margin of the microcontinent Ganderia, respectively). The contact between the Baie d'Espoir Group (Exploits–BAB) and the Little Passage Gneiss (Gander margin) was originally mapped as a thrust in early studies of the St. Alban's map area. However, wide mylonite zones and mylonitic fabrics reported along coastal outcrops of Bay d'Espoir indicate a ductile shear zone with a sinistral sense of shear. In the St. Alban's map area, the contact is often expressed as a topographic depression and a change in lithology and metamorphic grade over a relatively short distance. Rocks of both the Baie d'Espoir Group and the Little Passage Gneiss are mylonitized for several hundred metres or more, which supports the interpretation of a ductile shear zone. This zone is fairly well traceable in a detailed airborne geophysical survey.

Another prominent magnetic lineament relating to a potentially regional fault zone is the stark contrast between Salmon River Dam (low) and St. Joseph's Cove (high) formations of the Baie d'Espoir Group. In the northwest of the St. Alban's map area, part of this sharp contrast coincides with the Salmon River Dam Fault. However, this feature continues to the northeast for more than 50 km and connects with a fault in the Hungry Cove Pond map area, representing the contact between the North Steady Pond and St. Joseph's Cove formations of the Baie d'Espoir Group. Along this fault, small bodies of sheared serpentinizied peridotite are exposed. The lithological and tectonic relationships along this magnetic lineament require further examination, especially in the Twillick Brook map area, but it potentially represents a large-scale structure within in the Baie d'Espoir Group.