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Atlantic Geoscience Society

ABSTRACTS

47th Colloquium & Annual General Meeting 2021

Virtual

Due to current Pandemic circumstances, the 2021 Colloquium & Annual General Meeting was held for the first time using a virtual venue (Zoom) on February 5th and 6th. Although not ideal from the networking and social point of view, not travelling in the unpredictable winter weather of Atlantic Canada was a bonus. On behalf of the society, we thank Colloquium organizers Donnelly Archibald, Rob Raeside, and Chris White, as well the numerous session chairs and judges, for facilitating an excellent meeting with about 200 registrants. AGS acknowledges support from the corporate sponsors and partners for the meeting: Nova Scotia Department of Energy and Mines (Geological Survey and Petroleum Resources), New Brunswick Department Natural Resources and Energy Development, Prospectors & Developers Association of Canada, and Acadia University (Department of Earth and Environmental Science).

In the following pages, we are pleased to publish the abstracts of oral and poster presentations from the meeting on a variety of topics. Best undergraduate and graduate student presentations are recognized and indicated by an asterisk in the authorship. The meeting included five special sessions: (1) Defining the controls on onshore and offshore Pliocene-Quaternary processes; (2) Sedimentological and paleontological investigations from the onshore and offshore realms; (3) Developments in geoscience education; (4) Developments in mineral resources research in the northern Appalachians; (5) Karst research in Atlantic Canada; and a general session on mineralogy, igneous and metamorphic geology, and structural geology.

Also included with the conference was a day-long, short course on "Applications of GIS (Geographical Information Systems) to Earth Science" delivered by Robin Adair (University of New Brunswick). In addition, a Workshop was held on "Looking to the Future; Equity, Diversity, and Inclusion as a way of being in our discipline" chaired by Anne-Marie Ryan (Dalhousie University) and Deanne van Rooyen (Cape Breton University). The traditional Saturday evening banquet and social were replaced by a virtual Awards Banquet at which society awards were announced, as well as student prizes for best poster and oral presentation. The student award winners are noted at the end of the appropriate abstract.

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

THE EDITORS

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Insights into complex titanian andradite crystal growth using micrometre GIS and 3D GIS applied to EPMA, μXRF, and petrography

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Crystal growth mechanisms are investigated using EPMA, μXRF, and petrography on a euhedral andradite crystal from the Crowsnest Formation in southwestern Alberta. A micrometre scale, non-earth geographical reference system is used to combine these datasets. In two dimensions, this approach enhances interpretation of chemical, physical, and crystallo-stratigraphic relationships that are demonstrated by crystal growth patterns and that define growth domains of unique character. Using an idealized three-dimensional model of a euhedral garnet exhibiting {110} faces, a 3D-GIS analysis can also be performed to investigate these various characteristics in 3D space within the crystal. A basal section created in the plane of two crystallographic axes was cut in a sample garnet measuring 0.44 centimetres across. This plane cuts at or near the nucleation point of the crystal. Datasets from the above analyses that include graphic as well as numerical point data were combined to map the growth history of the garnet.

Three domains of crystal growth are defined. An initially formed core crystal, a first regrowth rim (RR1) and a second regrowth rim (RR2) with a coupled dissolution-reprecipitation (CDRP) boundary between RR1 and RR2. The core and the second regrowth domains exhibit rhythmic zonation in Ti, Fe, V, Al, Mn, and Zr. All three domains can be defined on mean weight percent TiO_2 as follows: (1) core-4.58%, (2) RR1-3.31%, and (3) RR2-4.10%. The core garnet exhibits marked titanium enrichment towards its original rim, culminating in a symmetrical spike high in the 6.6 weight percent TiO_2 range. Initial multivariant analyses demonstrate positive correlation between MgO and TiO_2 and negative correlation between TiO_2 and SiO_2 in all domains. Calculated garnet compositions (mol%) from EPMA are andradite (mean = 68.1%), morimotoite (mean = 16.6%), grossular (mean = 5.6%), and schorlomite-*Al* (mean = 5.15%). Titanium content can be shown to dictate the relative andradite versus morimotoite/schorlomite-*Al* compositions with negative and positive correlations, respectively. This suggests a proxy for silica saturation.

Demonstrated is that a euhedral garnet was initially formed with sharply increased TiO_2 content towards its rim and it did not undergo resorption. Regrowth followed by a somewhat TiO_2-depleted magma that was interrupted by a period of resorption (CDRP). Continued regrowth followed to form the final euhedral crystal shape. The later period of regrowth on the original garnet occurred in a crystallographic orientation that was both tilted and rotated, each at roughly 45°, from the original, and initially formed, core crystal.

Environmental lipidomic baseline survey of the Scotian Margin, Canada

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The natural microbial community composition of ocean floor sediments for the Scotian Margin has yet to be fully resolved. Such an environmental baseline study can be conducted by genomic and lipidomic surveys of sediments collected from the ocean floor. For this investigation, we are applying lipidomic techniques to resolve the microbial cellular membranes of bacteria and archaea that are hosted in the upper 10 m of ocean floor sediments across the Scotian Margin. The Scotian Margin off the coast of Nova Scotia is ~500 km in length and descends to 4000 m water depth. It is dominated by a series of anastomosing sub-basins that are themselves stratigraphically disrupted by salt tectonic features. Some of the basin sedimentation has resulted in active petroleum systems, which are expressed at the ocean seafloor as active hydrocarbon seeps. These seeps may host unique microbial communities that will be offset from the background microbiological ecology. We are extracting the intact polar lipids and core lipids using high resolution, ultra-high performance liquid chromatography-quadrupole time of flight mass spectrometry (UHPLC-qToF-MS). It is hypothesized that seep associated microbes may be dependent on the natural occurrence of hydrocarbon thus having a distinct lipid diversity. We therefore aim to use this environmental baseline survey to help differentiate the microbial community composition of ambient sediments from those that have been impacted by hydrocarbon seepage. Thus far, we have processed ~50 samples from various gravity and piston core samples that were collected across the Scotian Margin. Ultimately, the

results of this study will provide a lipid diversity map of the Scotian Margin, which contains information about the geochemical environmental conditions of the subsurface sediments, taxonomy and metabolism of microorganisms, and improves the resolution of their activities.

Study of silica-undersaturated dykes of the Bermuda basement, Bermuda

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The Bermuda Islands are comprised of 181 carbonate islands on volcanic basement rocks of the Bermuda Rise. Two deep drill cores show the islands are capped with thick limestone concealing the igneous basement rocks. The Bermuda Rise is significantly above sea-level indicating smaller rates of subsidence in comparison to other Atlantic seamounts, due to further magmatic activity after its original formation. It has been determined from the drill cores that the basement consists of two distinct igneous rock types that are chemically and texturally distinct. The volcanic flows (100 Ma) show classic mid-ocean ridge (MOR) basalt textures and mineralogy of pyroxene, plagioclase and altered olivine and have been determined to have erupted at the MOR. The plutonic rocks observed in the two cores are silica-undersaturated ultramafic sheeted dykes (30 Ma) and are metasomatized. The intrusions are characterized by phenocrysts of olivine altered to hydrous iron-magnesium silicates, chemically and optically zoned clinopyroxene with smaller phenocrysts of melilite, phlogopite, and secondary minerals. The groundmass consists of clinopyroxene, biotite, melilite, oxides, and apatite. The groundmass is more altered than the phenocrysts. The preliminary petrography and mineral chemistry suggest that the intrusions are ultramafic lamprophyres. The clinopyroxenes in the ultramafic lamprophyres have chemical zoning with areas of high Mg, Al, and Ti concentrations. Therefore, analyzing the pyroxene chemistry will allow an understanding of the emplacement and origin of melt.

The temporal relationship between two LCT pegmatites and the Streaked Mountain pegmatitic granite, Oxford County, Maine, USA

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Precise age constraints on magmatic and regional tectono-thermal events are essential for elucidating the petrogenesis of mineralized granitic pegmatites. Geochronological studies of granitic rocks in southwestern Maine reported ages of 267.6 ± 7.9 Ma and 270.4 ± 8.1 Ma (U–Pb apatite) for the Mount Mica and Emmons pegmatites, respectively, 283 ± 32 Ma (U-Pb zircon) for the Streak Mountain pegmatitic granite, and 293 ± 2 Ma (U–Pb monazite) for the Sebago granite pluton. Previous workers have suggested that lithium-cesium-tantalum (LCT) type pegmatites in the region were derived from spatially associated pegmatitic leucogranite stocks, such as the beryl-bearing Streaked Mountain granite. However, large uncertainty in the U-rich zircon age of the Streaked Mountain granite does not provide unambiguous support for this hypothesis.

To better constrain the temporal relationship between the Streak Mountain pegmatitic granite and the spatially associated LCT pegmatites, we determined the age of the granite by the Sm–Nd isochron method using garnet and tourmaline separates. Our new Sm–Nd age of 287.9 ± 5.5 Ma indicates that crystallization occurred between 10 and 20 Ma before emplacement of the Mount Mica and Emmons pegmatites. It is therefore improbable that the Mount Mica pegmatite is the product a residual liquid derived from the Streaked Mountain stock. This result demonstrates the need for more widespread Sm–Nd dating of simple and geochemically evolved granites and pegmatites in the region to better understand the derivation and evolution of LCT pegmatite groups.

Karst hydrogeology of the basal Windsor Group limestone at Glen Morrison, Cape Breton Island, Nova Scotia, Canada: preliminary findings

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Quarrying of the basal Windsor limestone 18 km southwest of Sydney, Cape Breton Island, has been on-going since 1993, exposing 10 hectares along 750 m of strike. This basal limestone has been referred to as either the Glen Morrison or Macumber Brook formation. It dips to the northeast at 5 to 10 degrees with an apparent thickness up to 15 m. It is underlain by conglomerate of the Grantmire Formation of the Horton Group and overlain by shale of the Sydney River Formation of the Windsor Group. Geological

assessments, visual observations, and environmental monitoring over 27 years of operation have identified a wide variety of micro and macro karst features exposed over 250 m of subcrop width, in up to 20 m high quarry walls. They include paleo epikarst features over the top 1 to 5 m of the subcrop surface, including a variety of, as well as rapid transition between, karren features including pit and tunnel, clint-and-grike, splitkarren, rundkarren, dolines, and possible Carboniferous paleokarst. At depth features include schlottenkarren chimneys, solution walls following vertical jointing, solution along sub-horizontal exfoliation planes, and horizontal caves along the contact with the conglomeratic beds of the Horton Group. However, these have been rendered essentially hydraulically inactive, having been infilled with glacial till, which forms a cap up to 8 m thick over the subcrop. This till cap suggests well developed karst prior to Wisconsinan glaciation and perhaps earlier. Glacial overburden becomes thin and discontinuous along strike to both the east and west of the quarry. The resultant exposed karst pavement exhibits boulder fields, hydraulically active runnels, clint and grike, and nine springs ranging in Meinzer flow categories from 4 to 8. Also present are three 5 to 8 m deep trenches carved into the limestone outcrop, trending northeast-southwest at right angles to strike. Ground surface water interaction within the trenches create influent streams, periodically dry riverbeds, a blind valley and swallet. The swallet can accept flows up to at least 3400 USgpm. Dye testing noted groundwater flow did not follow the northeast trend of the trenches but instead was directed north along the master joint set, down both structural dip and topographic gradient. Velocities of 120 m per hour were recorded during a 40 mm rainfall event.

Constraints on the emplacement of the South Mountain Batholith using zircon petrochronology and implications for Sn-W metallogeny in the northern Appalachian orogen*

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A variety of sources have been proposed for the causative magmas related to Sn-W deposits, including deep metasomatized mantle and enriched supracrustal sequences, the latter relating to anatexis or contamination. Such magmas typically form multi-stage intrusive complexes and the associated Sn deposits form in multiples. Here we explore aspects of Sn metallogeny in the northern Appalachian orogen through a study of the South Mountain Batholith (SMB), Nova Scotia. This multi-phase batholith hosts numerous polymetallic (Sn, W, Mo, Cu, Ta, Nb, Zn) occurrences; however, the only known significant Sn (Zn-Cu-Ag-In) deposit is at East Kemptville (EK) in the Davis Lake pluton (DLP). Timing of emplacement and the nature of magma sources is assessed via U–Pb dating, REE chemistry and isotopic (Lu-Hf, $\delta^{18}O$) characterisation of zircon samples from across the SMB.

Zircon dates using CA-TIMS indicate a transition from less-evolved granodiorite (378.7 ± 1.2 to 375.4 ± 0.8 Ma) to more evolved leucogranite (375.4 to 370.8 ± 0.8 Ma), reflecting ~10–15 m.y. of magmatic activity. In situ SHRIMP, LA-MC-ICP-MS, and SIMS analyses of distinct CL-defined zircon domains reveal: (1) autocrysts with ages coincident with the CA-TIMS results and $\delta^{18}O$ between +7.3 and +9.1 ‰ (V-SMOW), but the DLP is distinctly younger (365.3 ± 2.3 to 362.2 ± 3.4 Ma); (2) the $\delta^{18}O$ for antecrystic domains (+7.1 and +8.9 ‰) are similar to autocrystic rims, but generally record crystallization ages 3–15 Ma older than the autocrysts; (3) abundant xenocrystic cores of varied ages (~420 Ma to 2.2 Ga) with distinct chemical and isotopic signatures; (4) zircon REE patterns and derived fO_2 values are similar across the SMB; and (5) the εHf signature in zircon autocrysts from the EK host pluton is higher (+1.74 to +4.38) than from the rest of the SMB (-2.99 to +1.68).

These new data suggest the following regarding the SMB: (1) its construction occurred over a protracted interval spanning 15–20 m.y.; (2) variation in its zircon $\delta^{18}O$ and εHf values suggests that a mantle source with elevated $\delta^{18}O$ and εHf values influenced its original melt; (3) contamination of the melt via assimilation of the Meguma Supergroup country rocks was widespread; and (4) the DLP represents a separate magmatic phase distinct petrogenetically from the rest of the SMB. These data strongly suggest that Sn in the DLP and thus the EK deposit was likely introduced during a magmatic process distinct from that which formed the rest of the SMB.

**Winner: AGS Sandra Barr Award for best graduate student oral presentation*

Investigating the relationship between the elemental composition of coprolites and trophic level: a brief digest of Late Carboniferous coprolites from the Joggins Formation, Nova Scotia, Canada

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Coprolites offer insights into the diets of the animals that produced them, and thereby also provide a unique perspective of the paleoenvironments and paleoecosystems that existed during their deposition. Late Carboniferous fish coprolites are abundant in the Joggins Formation at the Joggins Fossil Cliffs UNESCO World Heritage Site (Joggins, Nova Scotia, Canada) and offer an opportunity to study the lesser-understood aquatic realm. The research presented here builds on a previous study that used hand samples and thin sections to classify coprolites into six morphotypes (conical, cylindrical, irregular, large, small, and spiral). Collectively, these morphotypes were interpreted to represent four trophic levels, and used to create a theoretical trophic pyramid for the Late Carboniferous aquatic realm at Joggins. This study hypothesizes that coprolites of differing trophic levels should show discrepancies in elemental composition due to dissimilar dietary requirements. If this hypothesis proves correct, chemical analyses of coprolites and the substrates in which they are found could provide valuable paleoenvironmental information and assist with the reconstruction of paleoecosystems and food webs throughout geological history.

Scanning electron microscopy – energy dispersive X-ray spectroscopy (SEM–EDS) was conducted on 42 coprolites, with representatives of each morphotype, to test whether elemental variation occurs between morphotypes reflecting variations in dietary requirements of the different trophic levels. SEM–EDS analysis detected the presence of three main compounds in both the coprolites and the surrounding substrate: FeS_2, $BaSO_4$, and ZnS. Of these, FeS_2 and $BaSO_4$ were detected more frequently than ZnS, and the sulphates/sulphides are not mutually exclusive of one another, with the rare sample containing all three and some samples being barren of any of these compounds. The sulphates/sulphides occur commonly (but not exclusively) near the boundaries of the coprolites, which could suggest a possible sulphur-based diagenetic crust. Furthermore, rare occurrences of zircon (substrate) and TiO_2 (substrate and coprolite) were identified in some samples during the analysis.

Initial examination of the results has produced no obvious relationship between the presence of FeS_2, $BaSO_4$, and ZnS and morphotype/trophic level. Additional analyses (e.g., X-ray diffraction, carbon isotope analysis, ICPMS etc.) are needed to further delineate the elemental composition of coprolites, determine the origin of the various compounds detected, to establish the significance of the compounds, and to investigate how they are related, if at all, to morphotype and, by extension, trophic level.

Geochemical evaluation of mineralization and igneous activity in the vicinity of the Elmtree deposit, northeastern New Brunswick, Canada

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The Elmtree deposit is situated approximately 5 km west of Petit Rocher and hosts a resource of over 300 000 ounces of gold and subordinate polymetallic (Ag, Zn, Pb, Sb) mineralization in three zones: West Gabbro, South Gold, and Discovery. Ongoing work aims to identify controls on mineralization and the potential for additional deposits in the region. Lithogeochemical data were collected for several intrusive units: felsic and mafic dykes from the South Gold Zone, the Nigadoo porphyry (located 6 km to the south-southeast), and dykes from the Nigadoo Gold property (approximately 5 km to the west). Mafic dykes at the South Gold Zone are locally mineralized, fine to medium grained, and locally feldspar phyric. The mafic dykes have Zr/Y (4.4–5.4, n = 3) and Ti/V (38.4–41.3) ratios consistent with within-plate basalts, with some similarities to volcanic arc basalts, and are more geochemically similar to basalts of the Dickie Cove, Dalhousie, and Tobique groups than to the Quinn Point Group. Felsic dykes at the South Gold Zone are aphanitic, feldspar to quartz phyric, post-date gold mineralization, and have crustal A-type compositions unlike those of the major intrusions in the area (e.g., Antinouri Lake Granite, Nicholas Denys Granodiorite) and known felsic volcanic units (e.g., Benjamin and Madisco Brook formations). To the west, at the Nigadoo Gold property, unmineralized, unfoliated dacitic porphyry dykes that intrude the Melanson Brook Fault/Ordovician-Silurian

angular unconformity have chemistry comparable to the Nicholas Denys Granodiorite. These observations indicate that the Melanson Brook Fault was the site of multiple episodes of magmatic activity. Geochronological work is ongoing to identify the temporal, and possibly genetic, relationship between magmatism and gold mineralization.

Comparison of mineralized and least-altered pairs of sedimentary and mafic dyke host rocks from the South Gold and Discovery zones, and gabbro from the West Gabbro Zone reveal several systematic lithogeochemical variations. Specifically, enrichments of Au, As, W, S, Sb, Rb, and K_2O are recognized in mineralized intervals across all host rock types, whereas depletions of Na_2O in mineralized zones are observed in all but the medium- to coarse-grained gabbro. These trends are consistent with observed pervasive sericite alteration and are compatible with fluids derived from either a metamorphic or magmatic source. Although the South Gold and Discovery zones are also host to base-metal mineralization, the lack of base-metal enrichment with gold mineralization provides further evidence that polymetallic mineralization was emplaced during a separate, later event.

Seabed evidence for a paleo-ice shelf along the Newfoundland and Labrador continental margins, Canada

Gordon D.M. Cameron and Edward L. King

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A regionally coherent suite of erosional lineations along the outer Newfoundland and Labrador continental shelves is imaged with Olex bathymetric rendering, supplemented locally with higher resolution multibeam bathymetric and 3D seismic-generated seabed imagery and seismic profile data. They reveal a primarily erosive character of expansive lineations and broad planar ramps, cutting into both till and Cretaceous-Cenozoic strata, found shallower than ~450 m water depth. Lineation fields cover at least 25 000 km^2, in each area across NE Grand Bank, Flemish Cap and Makkovik Bank. These lineations are flat-bottomed or V-shaped and range from ~5 to ~60 km long, up to 8 km wide, with a maximum depth of 28 m. Orientations are strongly coherent, trend N-S, both parallel and across bathymetric trends. Deep cuts on west Flemish Cap occur on a north-tilted erosional plane developed across the Cenozoic strata. Branching and asymmetric pin-wheel-like eroded bedrock lineations are found in the eastern and southern areas of Flemish Cap. These sometimes sinuous and irregular features shallow northeast to southwest, are up to 40 km long, 13 m high and are found between 230–330 m water depth. These lineations developed when glacial ice differentially eroding up-dipping Cretaceous-Cenozoic beds that rap around Flemish Cap, creating the pin-wheel appearance. These lineations have a different orientation than the mega-scale glacial lineations (MSGLs) where they intersect and may be from an earlier glaciation. A moraine identified for the first time on Flemish Cap is found at the terminal end of bedrock and till gouging MSGLs, forming a moraine up to 40 m high, 7.5 km wide and nearly 50 km long. We submit that an expansive ice shelf generated the lineations, erosion ramps and moraine. It skirted the entire Labrador Shelf, sourced strongly from Hudson Strait and recently recognized pathways across NE Newfoundland Shelf, splayed eastward as it rode 150 km across a strongly buttressing Grand Bank, overriding much of Flemish Cap which also provided crucial pinning. We cannot yet develop strong arguments for the timing or duration of such an ice shelf, but published work favors both a penultimate or younger glaciation. Multiple-age feature inheritance is possible. Many of the morphologic details require further explanation in an ice shelf context, including the role of sub-ice water and deforming sediment. The implications for a fundamental shift in understanding ice shelf integrity, extent, flow pattern, dampened ocean calving, and deep ocean sediment proxies like Heinrich events are strong, warranting further discussion and investigation.

Gold mineralization at the Cape Spencer area, New Brunswick, Canada – project update*

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The Cape Spencer area is located 15 km southeast of Saint John in southern New Brunswick, Canada. Gold mineralization has been identified in illitized (illite-carbonate ± quartz ± pyrite ± chlorite ± specularite), pyrite-rich rocks of the Millican Lake Granite and the Cape Spencer Formation, along thrust faults and folds, and in quartz ± carbonate veins with sulphides (pyrite ± chalcopyrite ± galena ± arsenopyrite ± sphalerite). These styles of gold deposition related to major accretion-related faults and/or reactivation of faults are consistent with the orogenic class of gold deposits; the gold system is associated with the accretion of the Meguma terrane to southern New Brunswick.

Gold occurs in both the intensely illitized host rocks and the associated quartz-carbonate veins, mainly parallel to the S_2 cleavage. It is closely related with pyrite grains, present for the most part as particles along fractures in grains or along grain margins, and to a lesser extent in particles within quartz and carbonate in the vicinity of gold-bearing pyrite that commonly contains inclusions of chalcopyrite, galena and arsenopyrite. These features were identified by detailed μXRF-EDS mapping and reflected light microscopy of pyrite grains, following a paragenetic evaluation that resulted in the selection of different pyrite-bearing assemblages with high Au grades, according to previous assays from drill core. The presence of inclusions from host rocks in pyrite grains as well as the development of "pressure shadows" point to pyrite growing contemporaneously with the alteration and strain.

Through the geochronological assessment of various parts of the area, including both the host rock system and the mineralization system, a better understanding of the distribution of gold mineralization in the region will be obtained, by constraining the source of the metals and chronologic information related to ore deposition. The project goals are to identify the local to regional controls on mineralization, source of fluids and gold, and determine its relative timing with respect to the tectonic evolution of the region. Therefore U–Pb (zircon, apatite, rutile) and $^{40}Ar/^{39}Ar$ (illite) geochronology of the different fabric elements and vein systems have been applied to constrain the timing of the mineralizing events. Both μXRF-EDS mapping of thin sections and XRD have been used to help identify phases for in situ dating. Additionally, LA-ICP-MS analysis of pyrite will ascertain the presence of refractory gold, and sulphur and lead isotope geochemistry studies will assist in the characterization of the mineralizing fluids.

**Honourable Mention: AGS Graham Williams Award for the best graduate student poster*

Is methane clumped isotopologue the future offshore exploration tool?*

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In sedimentary basins, methane is produced by thermogenic cracking of deeply buried organic-rich source rocks and through the reduction of CO_2 or H_2 and acetate by microbial methanogenesis. Comparative gas speciation and stable isotopic compositional ($\delta^{13}C$ and δD) analyses are traditionally used to distinguish the origin and formation mechanism of methane gas. Recent advances in the measurement of 'clumped' isotopologues of methane ($\Delta^{13}CH_3D$ and $\Delta^{12}CH_2D_2$) enables the determination of the thermodynamic isotopic equilibrium of the gas from various sedimentary environments. We therefore hypothesize a 'clumped' isotopologues study of the methane collected from the Scotian Margin sediments and a reference sample from an abandoned gas well. These can be used to determine the burial depths of methane producing source rock intervals. To do this, we are analyzing headspace-gas samples obtained from piston and gravity core sediments collected on the Scotian Margin for cruises conducted from 2015–2018. We have also analyzed a gas sample from the ExxonMobil Alma 4, an abandoned well operated off Sable Island located on the Scotian Shelf. The extracted hydrocarbon gas from the 15 cores (n = 83 samples) all contain methane and in 3 cores ethane and propane (n = 18 samples), which is consistent with previous published reports studying gas collected from the bottom core rounds. The methane concentration of 7 cores collected in 2015 and 2016 cruises have an average of 0.05 ppm (n = 26 samples), whereas 8 cores sampled in 2018 is average to 0.003 ppm (n = 57 samples). Methane core profiling shows a putative concentration dip at 3.5–4.5 meters below sea floor, which may relate to the presence of a sulfate-methane transition zone (SMTZ) at this depth. This study is expected to provide a better understanding of the depth of gas formation, and therefore better constrain the maturity of underlying source rocks across the margin. It may also further test the efficacy of using this isotope technique as a tool for offshore gas exploration activities.

**Winner: AGS Graham Williams Award for best graduate student poster*

An integrated paleoenvironmental study of Lower Cretaceous to lower Cenozoic strata of the Labrador margin, offshore eastern Canada

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Rifting and opening of the Labrador Sea began in the Early Cretaceous and ceased in the latest Eocene as the Greenland plate separated from the paleo-North American plate. A record of this tectonism is preserved in the stratigraphic successions of the Hopedale and Saglek basins, respectively to the south and north along the Labrador margin. Previous paleoenvironmental studies of these strata have primarily focused on a single methodology using cuttings samples, typically microfossils or sedimentological observations, to define paleoenvironments. In this study, we use conventional core intervals to combine macroscopic observations of the sedimentology and ichnology with quantitative microscopic palynological analyses of bisaccates, other miospores, dinoflagellate cysts (dinocysts), acritarchs, and other palynomorphs to provide robust paleoenvironmental interpretations. The results are reported for 23 core intervals from 14 wells representing key intervals from the Early Cretaceous to basal Ypresian, with palynological counts from a total of 64 samples. The sedimentological and ichnological observations generally provide well defined interpretations of the paleoenvironment, while the palynomorph ratios indicate an approximate distance from the shoreline. Lower Cretaceous mudstones are typically devoid of dinocysts and acritarchs but contain bisaccates and other miospores: the palynological assemblages combined with low diversity and low abundance trace fossil suites indicate a restricted (brackish) marine embayment. Upper Cretaceous mudstones deposited in slope-equivalent and shelfal-equivalent water depths show high proportions of dinocysts and acritarchs relative to miospores, as expected. The slope strata are devoid of trace fossil suggesting reduced oxygenation, but fully marine *Cruziana* Ichnofacies characterize bioturbated shelfal strata. The Upper Cretaceous and Selandian–basal Ypresian deposits are mostly deltaic, reflecting various depositional conditions. Storm- or wave-influenced deposits are characterized by low dinocyst and acritarch abundances and weakly stressed expressions of the *Cruziana* Ichnofacies. River-influenced deltaic strata mostly contain limited dinocyst and acritarch abundances with sedimentary structures prevalent and highly stressed expressions of the *Cruziana* Ichnofacies are present. River-dominated and tide-dominated (channel) strata lack marine palynomorph indicators, with sedimentary structures predominating. Dinocyst and acritarch results tend to parallel trace fossil diversity and abundance but can be misleading in highly brackish settings where these marine indicators may not be present. Palynomorph counts can, however, help to refine paleoenvironments from strata that contain non-ubiquitous sedimentary features and can provide evidence of mixing of shallow and deeper water settings, such as progradation of a delta into deeper water. Overall, integration of the two methodologies, operating at very different scales, provides more robust paleoenvironmental interpretations.

Structural, petrographic, and lithogeochemical analysis of the vein-hosted Williams Brook South gold occurrence, north-central New Brunswick, Canada

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The Williams Brook South occurrence is situated approximately 90 km west of Bathurst in north-central New Brunswick. The occurrence consists of a series of gold bearing quartz veins cutting rhyolite host rocks exposed semi-continuously for approximately 150 m. Current work takes advantage of bedrock exposure created during recent mineral exploration in order to elucidate the structural controls on mineralization and other characteristics to assist with exploration in the region.

Mineralized quartz veins at Williams Brook South are hosted predominantly in porphyritic to locally fragmental rhyolite and to a lesser extent in adjacent siltstone and tuff which are all assigned to the Wapske Formation (Tobique Group). Veins occur in several apparently cogenetic sets. Quartz veins are up to 2 m wide, typically vuggy, locally contain millimetre- to centimetre-scale fragments of brecciated wall-rock, and contain minor syn-quartz sphalerite, chalcopyrite, and galena. Lithogeochemical data from rhyolite samples indicate that host rocks are post-orogenic (A-type), compositionally homogeneous, and similar to rhyolite host-rocks at the Williams Brook Au occurrence located 5 km to the north-northwest. Preliminary analysis of primary aqueous-carbonic fluid inclusions in quartz indicates the minimum temperatures of formation are between 300 and 314°C, pressures of at least 400–900 bar (2000–3500 m depth; lithostatic P), and salinities between 4.2–5.6 wt% NaCl equivalent.

Structural analysis of the vein and fracture sets at Williams Brook South indicate that all these structural elements can be explained by a single deformational event characterized by sub-horizontal, northwest-southeast-directed shortening. This deformation manifests itself as ductile deformation in the enclosing sedimentary units and as brittle deformation in the rhyolite. Veins within the rhyolite generally correspond with extensional or shear planes, whereas fractures are

related to compressional or shear planes. The tectonic forces responsible for the generation of these features are attributed to regional dextral transpression resulting from collision between the Ganderia and Avalonia during the Acadian orogeny. Mineralized veins also appear to be most common near the northern siltstone-rhyolite contact indicating that contrast in host rock competencies may be an important for focusing strain and/or fluid flow. These results indicate that host rock rheology is an important factor in the formation of gold mineralization in the region, and that rhyolite units near regional structures (e.g., Rocky Brook-Millstream, McCormack Brook, and Ramsay Brook faults) are prospective for gold mineralization.

Empowering citizen science and earth science literacy

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Citizen science and earth science literacy are important for the welfare of humankind due to the increasing stresses resulting from the global climate crisis and rapid population growth. Citizen science has a long and well-established history in the earth sciences. A meteorologist, Alfred Wegener, consolidated the evidence for continental drift and publicized his thoughts. His insightful view of the world was not accepted until a revolution in earth science thought occurred in the 1960s. Although trained in scientific principles, Wegener applied this ability outside his field of knowledge and specialization. Mary Anning was considered "the greatest fossilist the world ever knew" and yet she was an avocational paleontologist with no formal training. She was the foremost expert on Jurassic marine reptile anatomy during her lifetime and is responsible for countless specimens that have shaped the field of paleontology. A local earth science enthusiast, Eldon George, became a self-taught citizen scientist. His work added to our knowledge of the Paleozoic and Mesozoic flora and fauna in the Parrsboro, Nova Scotia, region. These three people from entirely different backgrounds are examples of citizen scientists who developed their own sense of earth science literacy We continue the work of earth science literacy through geology courses in university, the Atlantic Geoscience Society's EdGeo Program, Geology 12 in Nova Scotia public schools, and in the numerous outreach initiatives that promote an understanding of earth science like those found in science museums all over Nova Scotia. For over twenty-five years, the former Nova Scotia Department of Natural Resources encouraged geoscientists to lead walks in provincial parks to interpret, explain, and connect geological processes with modern human activity. Likewise, the Fundy Geological Museum in its 28 years of operation has encouraged people to be more aware of geological processes and their effect on humans. All these outreach activities have a common thread of developing earth science literacy to be relevant for current audiences. As the world becomes more populous, we need more people to become aware of geological processes and potential hazards as well as resources. This literacy may well encourage an increased number of citizen scientists who may then help with hazard and resource identification and development and enforcement of public policies that benefit the planet and its inhabitants for generations to come.

Hydrocarbon fingerprinting of Cambrian-Ordovician sedimentary rocks in eastern Laurentia (western Newfoundland, Canada): organic geochemical approach to palaeo-environmental investigation

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This study investigates marine carbonates and shales deposited as rhythmites from the lower Shallow Bay Formation and upper Green Point Formation of the Cow Head Group, which marks a type-locality for the Cambrian-Ordovician boundary. Due to the lack of molecular evidence to characterize the ancient geochemical environment of western Newfoundland, 24 samples were collected and processed for their hydrocarbon biological markers. However, carbonate samples from the Lower and Upper Cambrian contained relatively high extract yields that were not in accordance with the low total organic carbon values (n = 8; 0.04–0.54 wt.%). These organic-lean samples were most likely contaminated by secondary addition of organic matter and/or sample storage. Hydrocarbon biomarkers were measured for the remaining 16 samples from lower to upper Cambrian carbonates and the Cambrian-Ordovician shales. The sample location further records the SPICE, post-SPICE, and HERB global carbon isotope excursions that are strongly linked to eustatic sea-level fluctuations. The Ph/*n*-C_{18} and Pr/*n*-C_{17} ratios indicate the organic matter (OM) for most of the samples was derived from mixed Type II/Type III kerogens common to marginal marine settings. C_{27}, C_{28}, C_{29} αββ- and αα-steranes were dominated by C_{29} stigmastanes

implying the sedimentary organic matter was deposited in an open marine setting consistent with sediment lithology and expected basin palaeo-geography. Pr/Ph ratios mostly record dysoxic conditions with low gammacerane index values (avg. 2.0) suggesting minimal levels water column stratification. However, a carbonate sample from the lower Cambrian, global $\delta^{13}C$ excursion SPICE event recorded an exceptionally high value suggesting at least one temporal interval where oceanographic conditions markedly changed. Periodic intervals of anoxia may have existed at the end of the HERB event, during the transition into the Ordovician, and across a discrete interval of the Early Ordovician as evidenced by low Pr/Ph values (<3). These events also record distinctive steranes/hopanes and Pr/Ph ratios displaying a pronounced inverse relationship that implies systematic changes in organic matter input and redox conditions that are similarly linked to oxygen drawdown from increased productivity in the water column. V/Ni and V/Cr trace metal palaeo-redox and the Ni/Co palaeo-productivity parameter support these findings. There is a narrow interval of anoxia in the Early Ordovician accompanied with increased microbially-induced methane and sulfate oxidation shown by 3β-MHI and BNH/(30αβ + BNH). These changes are likely the result of tectonic configuration of the Early Ordovician Taconic orogeny, which allowed the full opening of the basin to the ocean.

An experimental study of the effect of pressure on the formation of chromite deposits

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Despite extensive research on the Bushveld Complex chromite deposits, the mechanism(s) that form such anomalous chromite segregations remains uncertain. A recent study using the MELTS thermodynamic model proposed that reduction of pressure upon magma ascent shifts the silicate-in temperature to lower values, with the chromite-in temperature remaining unchanged, resulting in chromite-alone crystallization and the formation of massive chromitite. This project aims to evaluate this hypothesis through laboratory phase equilibrium experiments conducted at 0.1 MPa and 1 GPa employing two bulk compositions. Composition 1 (C1) corresponds to the widely accepted parental magma of the Bushveld chromitites, termed B1, and composition 2 (C2) is the same used in the recent MELTS modeling study, which contrasts with C1 most significantly in Al_2O_3 (17.4 wt.% vs 11.8 wt.% in C1) and MgO (6.7 wt.% vs 11.9 wt.% in C1) contents. Starting materials are synthesized from reagent grade oxides and carbonates which were fused into a homogeneous glass, and contain ~970 and ~700 ppm Cr, for C1 and C2, respectively. Thus far, experiments have been done at 0.1 MPa over the temperature interval of 1170–1340°C and at the FMQ buffer. Samples were mounted on Fe-pre-saturated Ir wire loops and equilibrated in a vertical tube, gas-mixing furnace for run durations of 24–48 hours. Results show that the Cr# (Cr/(Cr+Al) in the C1 experimental chromite (0.7–0.75) is within the range of the most primitive chromitites (~0.65–0.76) located in the Lower Critical Zone of the Bushveld. However, Cr# of experimental chromite in C2 (0.6–0.63) is more consistent with the chromitites located in the Upper Critical Zone (~0.59–0.76). The Fe# (Fe/(Fe+Mg) for experimental chromite in C1 (0.39–0.41) and C2 (0.44–0.48) are on the lower end of natural Bushveld chromitites (0.45–0.75) but slightly higher than MELTS predictions (0.39–0.42). Experiments show that C1 agrees with the crystallization sequence observed in the Lower Critical Zone with chromite + orthopyroxene on the liquidus at 1280°C. Composition C2 crystallizes chromite-alone at 1280°C, followed by plagioclase + chromite at 1200°C and plagioclase + chromite + orthopyroxene at 1170°C. Again, this composition is more reflective of the Upper Critical Zone which is dominantly noritic. This sequence is also in agreement with the MELTS modelling study, with the exception that chromite-alone crystallization in experiments begins at a higher temperature (1280°C) than predicted (1230°C). Further experiments at high pressure will allow a more complete evaluation of the pressure reduction model and the effect of pressure on chromite crystallization.

Reviewing 200 years of Nova Scotia geology: gypsum caves and mastodon sinkholes

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Solomon Thayer, from Lubec, Maine, wrote to Professor Cleaveland at Bowdoin College in October 1819, noting that around the Windsor gypsum quarries there were holes in the earth like tunnels or an amphitheatre and these were formed by dissolution of the gypsum by water. As part of the first detailed survey of Nova Scotia geology in 1833, Jackson and Alger noted that gypsum in the vicinity of Windsor abounds in conical or inverted funnel-shaped cavities. They also mentioned that human remains had been found associated with indigenous points in one of the local gypsum caves. The skeleton and artefacts were likely later

lost during the fire at King's College. When Charles Lyell visited in 1842, he drew attention to the fossil shells from the Windsor limestones along the Avon River, and much later, the International Geological Congress fieldtrip to Atlantic Canada in 1913 provided important research contributions from Jennison, Bell, and others, on the Windsor area gypsum and limestone. In the late 1950s, William Take, the Curator of Geology at the Nova Scotia Museum, excavated beaver-chewed wood and beaver bones from a sinkhole structure in the gypsum fields at Milford. In the late 1980s workers at the Bailey Quarry near Windsor discovered a Mastodon tusk, but the largest discovery of Mastodons was made by Bob Grantham in the early 1990s back at the Milford quarry. In 1992 and 1993, as Curator of Geology at the Nova Scotia Museum, Grantham oversaw field work to collect the skull and large portions of the postcranial skeletons of an adult and portions of a juvenile Mastodon, along with fossil turtles, insects, wood, and dung. Most recently, other Mastodon bones have been recovered from gypsum sinkhole deposits from Little Narrows, Cape Breton Island, and Falcon-Lang and others described Cretaceous fill in the Windsor area gypsum that included the oldest pine fossils in the world. By providing an overview of the history of geology research involving karst and sinkholes in Nova Scotia, this report highlights the key topics of interest for engaging public and allowing discussion of fossils and evidence of risk that demonstrates millions of years of karst terrain in Nova Scotia.

The Canadian Society of Exploration Geophysicists Foundation Outreach Program: another approach to enhancing effective learning

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On April 30, 1949 eleven geophysicists met for an "informal" lunch in Calgary. From this the Canadian Society of Exploration Geophysicists (CSEG) was born, formed to "increase (the) skill, knowledge and experience in the field of exploration geophysics. In 1956 the CSEG Foundation established a scholarship program, joined the Calgary Technical Library Advisory Committee and contributed financial resources to the cause. In 1973 the Society's University Liaison Committee became active, marking the start of a long history of outreach. In 2009 the CSEG established the Mentorship Program as part of its University Student Outreach initiative. In 2014 the Emerging Professionals Program was established to help young professionals transition into the industry by creating community, and opportunity for technical and soft skill development.

Wikipedia defines mentorship as "a relationship in which a more experienced or more knowledgeable person helps to guide a less experienced or less knowledgeable person." Traditionally, Oil and Gas entities employed professionals that ranged in levels of experience from new graduates to 30+ years. As the industry evolved to a larger number of small entities, aggravated by business cycle downturns and resulting in staff reductions, the number of senior staff in many organizations has decreased dramatically. Training budget constraints have reduced or eliminated another source of knowledge for young professionals to access. Professional and industry bodies have developed both Continuous Professional Development requirements and mentorship programs to ensure all members have professional growth opportunities.

While not perhaps considered to be teaching/learning in the classical or classroom sense, the CSEG mentorship program nevertheless provides additional learning resources to its participants. Coupled with the Emerging Professionals program, they represent a unique extension of the learning experience. This session will outline the goals and approaches used by the CSEG to expand the total skills package of those who avail themselves of the mentor programs.

Finding fault in a shear zone*

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Marathon Gold Corporation's Valentine Gold Property is located in west-central Newfoundland. The property has four known gold deposits in early exploration stages along 20 km of northeast to southwest trend. It is a future site for an open-pit gold mine, which upon completion will be the largest gold mine in Atlantic Canada. The Valentine Lake property contains orogenic-type quartz-tourmaline-pyrite veins which are gold-bearing. These veins are structurally controlled, occurring along or proximal to the Valentine Lake Shear Zone. The mineralization is found only on one side of the shear zone in intrusive rocks and is rare in the conglomerate on the other side. The area has considerable

basaltic dykes, which show up well when conducting a magnetic survey due to their proportions of magnetite. Though their relationship to the mineralogy is uncertain, these dykes can help indicate structure. To further constrain the location of the shear zone (and hence the mineralized region), a detailed magnetics survey was conducted over a 200 m × 300 m section of a larger-scale magnetics study completed in 2014 using a GPS-enabled Overhauser magnetometer. Sixteen lines were traversed through a heavily wooded area with thick soil and moss cover. The survey area also contained two roads and several anthropogenic objects such as trucks, fuel tanks, and culverts. Magnetic susceptibility measurements of surrounding rock types were taken to supplement data provided by Marathon Gold. With the collected data, total magnetic intensity maps were created and further processed using pole reduction and first vertical derivative computation. This helped identity a zone where the pattern of linear magnetic highs is offset, with lesser magnetic intensity near the offset. This zone has been identified as a fault offset to the shear zone, as the loss in magnetic intensity could be due to alteration or thinning of the basaltic dykes at the fault boundary.

**Honourable Mention: AGS Rupert MacNeill Award for best undergraduate student oral presentation*

3D modelling and synthesis of geophysical data in Nash Creek, New Brunswick, Canada

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Since the development of the Bathurst Mining Camp (BMC) in the 1950s, New Brunswick has been characterized by its volcanogenic massive sulphide deposits. Early electromagnetic surveys had success detecting 'hotspot' anomalies that lead to the development of mines such as Brunswick No. 6. Of the 45 known deposits within the BMC, only 4 have been discovered since 1989. The decrease in exploration can be attributed to several factors: fewer easy-to-detect geophysical targets, changing prices of base metals, less economic incentive, and most importantly, lack of subsurface knowledge. As exploration efforts expand and geophysical methods improve, regions such as Nash Creek show potential to revitalize the mining industry of New Brunswick. Located within the Chaleur Bay Synclinorium, Nash Creek plays host to Zn-Pb-Ag deposits. Like Bathurst, a plethora of airborne and ground-based geophysical surveys have been conducted. Some 3D modeling has been completed but lacks geologic control and was restricted in the number of datasets used. A true synthesis of all available geophysical data has yet to be conducted. Thus, the purpose of this study is to construct a 3D geological model of the Nash Creek exploration area using a multidisciplinary approach that can provide new exploration insights. New software and more powerful computers make the construction of multiparameter 3D models highly accessible; however, adding proper geological constraints to mitigate non-uniqueness is a problem that cannot be solved by the many semi-automatic tools that have become popular over the past few years. In this study we used borehole logs, petrophysical data and the limited mapping information available in the area. By integrating all the data, we generated an initial geological model, which was then optimized to fit the available geophysical information (EM, IP, magnetics, LiDAR).

The geological setting and Pb- and S-isotopic signature of base-metal mineralization at the Lumsden polymetallic deposit, southeastern New Brunswick, Canada

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The Lumsden Zn-Cu-Pb deposit, situated in the eastern Caledonia Highlands of the Avalon Zone in southeastern New Brunswick, is hosted by the highly deformed Crooked Creek Formation of the Neoproterozoic Broad River Group. Major- and trace-element geochemical signatures of this volcano-sedimentary sequence is consistent with an island arc convergent plate margin, which have been intruded by several plutons ranging in age from ca. 693 to 564 Ma.

The epigenetic polymetallic mineralization is structurally bound and most likely controlled by Devonian to post-Devonian fault systems. Mineralization is hosted by impure dolomite and chloritized felsic rocks, and predominantly consists of pyrite and sphalerite with lesser galena and chalcopyrite. Field relations and petrographic observations suggest two main stages of mineralization: (1) sphalerite and iron sulphide precipitated in the wall rocks during an early brittle-ductile shearing event, and (2) emplacement of dolomite veins followed by subsequent fracturing and precipitation of pyrite, sphalerite, chalcopyrite, and galena.

Dolomitic rocks in the mineralized zone are enriched in Mg (7.55–13.5%), Ca (13.5–18.5%) and Ba (7–1220 ppm) and have relatively low abundances of Si (1.58–7.23%),

Al (0.08–0.475%), Fe (1.45–4.97%), Mn (1.4–5.99 %), Ti (<0.01%),Na (< 0.01%), K (<0.01%), and P (0.01–0.03%). The Zn-Cu-Pb mineralization is associated with anomalous Ag, As, Bi, Cd, In, Mo, Se, Sn, Sb, and Te. Galena mineralization controls the amount of Bi and Ag mobilized in the system, whereas sphalerite controls that of Cd and to a lesser extent In. Strong correlation between Zn and Cu indicates that the two elements may have mobilized together in the system. Alteration of the felsic host rocks is characterized by strong leaching of Na and K.

Secondary Ion Mass Spectrometry analysis of galena yielded lead isotope ratios of 17.495–17.972 $^{206}Pb/^{204}Pb$, 15.431–15.625 $^{207}Pb/^{204}Pb$, and 37.215–37.887 $^{208}Pb/^{204}Pb$. Galena from dolomitic rocks yielded Pb–Pb model ages of 518 and 471 Ma. Sulphur isotope analysis of pyrite and galena yielded mean values of $^{34}S_{V\text{-}CDT}$ 23.2.and 25.8‰, respectively thus suggesting crustal sources for the sulphur. The mineralization style, structural control, and sulphur isotope signature indicate that the sulphur source for the mineralization may have been largely mobilized from the Carboniferous Windsor Group evaporite. Lead isotope signatures indicate the recycling of Pb into the mineralizing systems from an older orogenic belt, most likely mafic volcanic rocks of the Broad River Group or Coldbrook Group. This newly recognized polymetallic system has genetic similarities to Mississippi Valley-type mineralization.

Advances in the chronostratigraphy of the Beaufort Formation, Arctic Canada

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The late Miocene and Pliocene Beaufort Formation and equivalent units throughout the Canadian Arctic Archipelago captured a rich record of landscape evolution, Arctic paleoclimatology, and paleo-ecosystem changes caused by a polar-amplification of global climate change and the opening of the Northwest Passage. We provide new insights into the age, sedimentology, erosion rates, and range of depositional environments through the Archipelago, with emphasis on new and previously investigated sites with key paleoclimate and sedimentology data. Interpretation of previous and new cosmogenic nuclide measurements in combination with previous lithospheric flexure modeling we can estimate the paleo-erosion history throughout the region and suggest that the modern limited distribution of the Beaufort Formation to the western archipelago is not only some 200 m thinner than it was, but that equivalent age sediments once covered much of the entire Canadian Arctic region before it was an archipelago.

Petrological and U–Pb zircon age constraints for metamorphic rocks of the northeastern Cape Breton Highlands, Nova Scotia, Canada: new insights into the geological history of the Aspy terrane

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Geological mapping, petrological studies, and U–Pb (zircon) dating were done to better characterize metasedimentary and metaigneous rock units in the northeastern Aspy terrane, Cape Breton Highlands, Nova Scotia. Foliated biotite monzogranite of the newly recognized South Aspy River pluton has a Silurian age (440.3 ± 2.1 Ma or 421.6 ± 4.0 Ma). An early Devonian age for the Glasgow Brook granodiorite pluton was confirmed at 415.7 ± 2.7 Ma, consistent with a previously reported age of 416.0 ± 1.9 Ma. U–Pb (zircon) ages from the Cheticamp Lake Gneiss of 416.9 ± 1.3 Ma and 415.9 ± 1.9 Ma, combined with mineralogical and textural similarities, suggest that the Cheticamp Lake orthogneiss and Glasgow Brook pluton may be related. Both the South Aspy River pluton and Glasgow Brook pluton were emplaced in a volcanic-arc tectonic setting and combined with ages of volcanic and plutonic rocks from other parts of the Aspy terrane indicate an extended history of arc magmatism from the early Silurian through the early Devonian. The plutonic units intruded metasedimentary rocks previously assigned to the Money Point Group but now named the Little Southwest Brook formation. The youngest detrital zircon population in a semi-pelitic schist sample provides a maximum depositional age of 441.2 ± 2.5 Ma. Mineral assemblages, lack of evidence for melting, and thermobarometry constrain peak prograde metamorphic conditions to <650°C at 5.5–7.0 kbar. Based on similar lithologies, including characteristic pelitic rocks interlayered with amphibolite and marble as well as similar detrital zircon signatures, the Little Southwest Brook formation is interpreted to be part of the Cape North

Group and correlative with high-grade metamorphic rocks elsewhere in the northern, western, and central Aspy terrane. The igneous, metamorphic, and deformational history of the area records the Salinic and Acadian orogenies and the Silurian-Devonian collision between the Aspy and Bras d'Or terranes within Ganderia.

One city's trash is a geophysics student's treasure

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The Robin Hood Bay landfill is located in the northeastern part of the City of St. John's, Newfoundland. It is the solid waste management facility for the city and the greater Avalon region. It has been in use since the 1940s, first by the American military before it was turned over to the City of St. John's in 1963. In the past, there have been concerns of leachate penetrating groundwater at the site and draining into the ocean and adjacent streams. In 2009, the landfill underwent a large-scale renovation, which included adding a geosynthetic cover, creating regulations to residential dumping and adding gas and groundwater monitoring wells to the site to counteract leachate seepage. The southeast corner of the landfill, an area that has not been infilled with new waste since the 2009 renovations, was chosen as a site for geophysics surveys. This is the first geophysical study that has been performed over the landfill, despite being common practice in other landfills. It is the first step in the process of monitoring long-term changes to the subsurface of Robin Hood Bay. The area studied is flat and grassy with an underlying layer of cobblestone. Magnetic and DCR surveys were performed among other techniques. They are non-invasive geophysical studies that provide a method in which to interpret the subsurface environment for ground structure, water flow patterns, and environmentally concerning anomalies such as past improper disposal of large metal objects and iron debris. The magnetic surveys used a GEMGSM-19GW Overhauser Magnetometer in a grid formation to identify localized magnetic materials. The DCR surveys were conducted with both a Schlumberger Vertical Electrical Sounding and Wenner Constant Separation Transverse array in a southwest to northeast colinear manner in the study area.

Characterizing the mineral domains of Li-(Rb-Cs) enrichment at the East Kemptville Sn-(Cu-Zn-Ag) deposit, Nova Scotia, Canada

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The ca. 385–368 Ma South Mountain Batholith comprises eleven plutonic centers, including the Davis Lake Pluton that hosts the East Kemptville Sn-Cu-Zn-Ag deposit (mined 1985–1992). In addition to Sn, other strategic elements of interest (e.g., group I alkali metals Li, Rb, and Cs) have been the focus of recent exploration. This study of the mineralized topaz-muscovite leucogranite intrusion and locally, and its host metasedimentary rocks, describes the mineralogy and chemistry of Li-Rb-Cs characterized by optical and scanning electron microscopy, IR and Raman spectroscopy, and laser ablation ICP-MS.

Bulk rock Li (up to ~3000 ppm) is controlled by mica abundance, highest in the metasedimentary country rocks in the contact zone near the leucogranite, and comparable to low grade Li stockpiles in producing deposits in Canada (NA Lithium), Germany (Banacora), and the Czech Republic (Cinovac). High bulk rock Sn concentrations (up to ~1 wt% Sn) are always associated with low Li concentrations (<1500 ppm). Bulk rock Li-Rb-Cs correlate strongly and two trends are noted: (i) for the leucogranite fractional crystallization led to increasing Li (up to ~1000 ppm), whereas (ii) in the metasediments/contact zone, Li concentrations do not follow normal fractionation trends. In the leucogranite, zinnwaldite-annite-phlogopite solid solution ("zap-ss") is the main Li-Rb-Cs carrier (up to ~9500 ppm Rb and 1.4 wt.% Li; >70% of bulk rock Li) in contrast metasediments in the contact zone where muscovite-trilithionite solid solution ("mt-ss"; up to ~9500 ppm Rb, and 1.4 wt.% Li) hosts >90% of Li-Rb-Cs. The mt-ss replaces earlier zap-ss in the contact zone. Li-bearing micas in the contact zone likely grew during contact metamorphism, augmented by the infiltration of early granite-derived fluids, and later by fluids released during the chloritization of earlier zap-ss in the leucogranite.

Ternary Rb-Sn-Li and Nb-Li-Ta diagrams discriminate different Li domains by assay, clearly separating metasedimentary, contact zone metasedimentary, and leucogranite/greisen. However, mineralogical hosts for Li-Rb-Cs can only be differentiated using spectroscopy. In particular, IR spectroscopy may offer a cheap and portable technique to quickly screen samples for their Li content

without assay. Elevated mt-ss abundance is recognized through key absorption features near 1411 cm^{-1} (O-H bending) and 2200 cm^{-1} (Al-OH vibration) that shift to higher wavenumbers due to replacement of octahedral Al by Li. Notably, the wavenumbers of diagnostic absorption features are insensitive to orientation/grain size, suggesting that the method can be applied to drill core samples and does not require preconcentration/grain orientation before analysis.

U–Pb geochronologic and mineral-chemical results from apatite and titanite in the Clarence Stream gold-antimony deposit, southwestern New Brunswick, Canada

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The Clarence Stream deposit in southwestern New Brunswick consists of several antimony-bearing gold mineralized zones hosted within large-scale structures in metasedimentary and metavolcanic sequences of the Cookson and Mascarene groups, as well as several younger magmatic intrusive rocks, consisting of gabbroic and intermediate dykes, and granitic pegmatite-aplite dykes. Mineral chemistry and U–Pb geochronology of apatite and titanite in the South, George Murphy, Richard, and Jubilee zones reveal details about the mineralizing fluids and timing of mineralization. Hydrothermal apatite and titanite hosted in mineralized quartz veins were analyzed by in situ methods including microX-ray Fluorescence Spectrometry (μXRF) followed by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS).

The apatite chondrite-normalized REE plots illustrate LREEN and HREEN enrichment (0.95, 2.08) and depletion (0.61, 1.94) patterns, pronounced negative $((Eu/Eu^*)_N$, <0.80) and positive Eu anomalies $((Eu/Eu^*)_N$, >0.82), in the South (CS332-264.5), Richard (BL12-117.5), and one of the Jubilee zone samples (BL43-74.2). These different REE patterns show that the apatite formed during two different stages from hydrothermal fluids under reducing to oxidizing environments. Apatite within the George Murphy Zone sample (CL33-247.25) shows $(LREE/HREE)_N$ of 0.33 with negative Eu anomalies $((Eu/Eu^*)_N$, <0.65), corresponding to crystallization in a reduced environment. The second sample from the Jubilee Zone (BL19-44-303) shows $(LREE/HREE)_N$ of 0.73 with a positive Eu anomaly $((Eu/Eu^*)_N$, >0.98), which formed in an oxidized environment. As the George Murphy, Richard, and Jubilee zones are hosted within the same structure, their combined U–Pb age is 374 ± 24 Ma.

Two mafic intrusive rocks from the West (CS13-329-14.8) and South (CS17-353-127) subzones of the South Zone contain hydrothermal titanite. The chondrite-normalized REE plots in CS13-329-14.8 illustrate $LREE_N$-depletion ($(LREE/HREE)_N$, 0.18) with positive Eu anomalies ($(Eu/Eu^*)_N$, >1.29) reflecting crystallization from a low oxygen fugacity fluid. However, CS17-353-127 shows $LREE_N$-enrichment ($(LREE/HREE)_N$, 1.24) with positive to negative Eu anomalies ($(Eu/Eu^*)_N$, 2.40–0.61). These positive to negative Eu anomalies could be representative of fluctuations from low to high oxygen fugacity of the mineralizing fluid; combined U–Pb geochronology results from these two samples yielded an age of 396.9 ± 2.5 Ma.

Based on previous studies, the age of gold mineralization associated with the late phase of the Magaguadavic Granite is 396.0 ± 0.5 Ma at the South Zone, which is confirmed by U–Pb geochronologic data from hydrothermal titanite. The maximum age from apatite shows that the gold mineralization at the George Murphy, Richard, and Jubilee zones is no older than the mineralization at the South Zone.

Quartz-hosted fluid inclusions associated with polymetallic mineralization (Fe-Co-Ni-Cu-As-Ag-Sb-Au-Pb) of the Nictaux Falls Dam, Lansdowne, and Cape St. Marys occurrences in the Meguma terrane, Nova Scotia, Canada*

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This study is on quartz-hosted fluid inclusions (FI) from three metasedimentary rock-hosted polymetallic vein occurrences [Nictaux Falls (Co-Ni-As-Au-Bi), Lansdowne (Zn-As-Ag-Sb-Au-Pb), and Cape St. Marys (Co-Ni-Cu-Zn-Ag-Sb-Au-Pb-Bi)] in the southwestern Meguma terrane, Nova Scotia. Similarities in host rock-type, alteration, and metal association suggest a possible genetic link among these occurrences. This work aims to establish the P-T-X of fluids associated with all three sites to confirm their genesis.

Nictaux Falls FI are classified into three types: *type-1* are liquid-rich, two-phase ($L_{H2O\text{-}NaCl}+V_{H2O\pm CH4}$), *type-2* are liquid-rich, three-phase ($L_{H2O\text{-}CaCl2\text{-}NaCl}+V_{H2O\pm CH4}+S_{halite}$),

and *type-3* are single-phase ($L_{H2O\text{-}CaCl2\text{-}NaCl}$) inclusions. Textural observations indicate that *types-1* and *-2* inclusions are primary or pseudo-secondary in origin, while *type-3* inclusions are secondary. Most inclusions (all types) did not freeze at/before -180°C, suggesting high divalent cation contents (likely Ca^{2+}). Final ice-melting temperatures (T_m^{ice}) were -47.1°C (n = 1), -49.8°C (n = 1) and -40.1 to -51.1°C (n = 3), for the three respective fluid types, suggesting minimum salinities of 43.2 wt% $CaCl_{2equiv}$. Heating experiments yielded homogenization temperatures (T_h; to liquid) of 127–213°C (n = 6) and 194–202°C (n = 3) for *types-1* and *-2* fluids. Calculated isochore data for *type-1* inclusion assemblages combined with chlorite thermometry (~280°C) indicate a very low entrapment pressure (~110 bar).

Lansdowne FI are classified into four types: *type-1* inclusions are single-phase ($L_{H2O\text{-}CaCl2\text{-}NaCl\pm CH4}$) inclusions, *type-2a* are liquid-rich, two- or three-phase ($L_{H2O\text{-}NaCl}+V_{CH4\pm CO2}$ or $L_{H2O\text{-}NaCl}+L_{CO2}+V_{CH4}$), *type-2b* are two phase ($L_{H2O\text{-}NaCl}+V_{CH4\pm CO2}$) vapour-rich inclusions, and *type-2c* inclusions are one-phase ($V_{CH4\pm CO2\pm H2O}$). *Type-2* inclusions may occur in single assemblages. Crosscutting relationships show FI are primary or pseudosecondary in secondary quartz coeval with mineralization. *Type-1* inclusions show T_m^{ice} between -44.0°C and -20.4°C (n = 26), suggesting salinities of 23.4–47.1 wt% $CaCl_{2equiv.}$ Many *type-1* inclusions did not freeze, suggesting high Ca^{2+}. *Type-2a* inclusions show T_m^{ice} between -8.3 and -3.9°C (n = 54), suggesting moderate to low-salinity (6 to 12 wt% $NaCl_{equiv}$). Only CH_4-poor, *type-2a* inclusions homogenized before decrepitation between 148-173°C (n = 7). *Type-3* inclusions homogenized to vapour between -110 and -92°C (n = 10), indicating a very low entrapment pressure of ~150 bar.

The results of this study show that ore fluids at both Lansdowne and Nictaux Falls were variably Ca-rich and highly saline in a near-surface epigenetic environment. The co-entrapment of low salinity brines and CH_4 is unique to Lansdowne, where mingling between the two fluids is preserved in *type-2* assemblages showing variable brine-hydrocarbon phase ratios. The characterization of Cape St. Marys samples is under way.

**Honourable Mention: AGS Rupert MacNeill Award for best undergraduate student oral presentation*

Application of bulk fluid volatile chemistry to exploration for metasedimentary rock-hosted orogenic gold deposits: an example from the Meguma terrane, Nova Scotia, Canada

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Disseminated Au deposits hosted in metasedimentary rocks present unique exploration challenges because the Au is generally very fine-grained or refractory, and not vein-hosted. Exploration programs in such settings rely on extensive lithogeochemical surveys, lesser structural analysis, and little emphasis on ore-fluid geochemistry. The Moose River anticline (MRA) in the Lower Paleozoic Meguma terrane, Nova Scotia, hosts several high-tonnage (~10–20 Mt), low-grade (≤1–4 g/t Au) Au deposits comprised of disseminated ± quartz vein-hosted mineralization in metamudstones. In this study, the Touquoy deposit is used to evaluate a new approach to geochemical exploration by examining if the volatile chemistry of host rocks preserves a signature related to Au mineralization, using a gas chromatographic (GC) technique that analyzes bulk volatiles released from crushed rock. Since GC is a bulk analytical technique, the volatile compositions of fluid inclusions were also investigated using laser Raman microspectroscopy to reconcile bulk analyses with the composition and abundance of different inclusion types. Inclusions in quartz pressure shadows associated with porphyroblasts host $N_2\pm CH_4$-dominant vapor phases and represent wall rock-equilibrated fluids. In comparison, fluid inclusion vapor phases in quartz veinlets crosscutting the metamudstones are more complex in composition and show a continuum between CO_2-dominant and $N_2\pm CH_4$-dominant compositions; the former is interpreted as the fluid responsible for Au mineralization in the Meguma terrane (e.g., $H_2O\text{-}CO_2\pm CH_4\pm N_2$ fluids). GC shows statistically significant differences between the bulk volatiles released from crushed metamudstones from the Touquoy deposit (n = 21) and barren (n = 24) settings. Whereas the former commonly contain detectable CO_2 (50% of samples), only ~4% of metamudstones from barren settings along the MRA contain CO_2, yielding a t-test p-value of 0.0103 between the two sample populations. Additionally, anomalous differences in abundances of released C3 (t-test p-value = 0.043) and C4 (t-test p-value = 0.03) hydrocarbons (HC) are recognized between the two populations, with Touquoy metamudstones having higher $\Sigma(C3)/CH_4$ and $\Sigma(C4)/CH_4$ ratios compared to barren equivalents. The compositional differences suggest that more aqueous-carbonic fluids infiltrated metamudstone units where locally favourable physical and/or chemical conditions were present, resulting in increased Au endowment. The relative increase in fluid flux, and thus Au grade, resulted in more trapped CO_2 and modification to hydrocarbon signatures through homologation and/or degradation reactions.

Tentatively, the results suggest that bulk analysis of volatiles released from fluid inclusions in metamudstones may be a

useful vectoring tool for disseminated Au mineralization in Meguma-type gold systems and similar environments (e.g., Carlin-type).

Large-scale late Cenozoic to post-glacial growth faulting in the northern sector of the Banks-Beaufort- Basin, western Canadian Arctic

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The Cenozoic Banks-Beaufort Basin spans >1000 km from the Beaufort Shelf (SW) to M'Clure Strait (NE). Offshore seismic and exploratory hydrocarbon wells are numerous within the analogous Mackenzie Basin, beneath Beaufort Shelf in the southwest, yet no offshore well control exists in the north. A recently accessed industry multichannel seismic grid enables focus on the Neogene-Quaternary stratigraphy for the Banks-Beaufort Basin. Strong faulting persists along the Banks Island shelf-break between Amundsen Gulf and M'Clure Strait. Assessing the nature and timing of faulting is necessary to mitigate geohazard risk.

A series of deep-seated (>4 km) listric growth faults demonstrate periodic reactivation through differential offsets upward through the undated strata. A limited chronology was establishing though seismic ties to wells on Banks Island and correlation from the Mackenzie Basin. We subdivided the Plio-Pleistocene section of Banks Island Shelf into six seaward thickening, aggradational units bounded by planar, conformable horizons. The lowermost unit overlies a basin-wide unconformity previously assigned late-Miocene to early Pliocene age buried over 1 km at the shelf break. Two additional uppermost units are erosion bound and attributed to a glacial origin. The two glacial units (<200 m thick) attest to shelf-crossing glaciations on Banks Island Shelf. They are Shallow Bay Sequence equivalents as defined on the Beaufort Shelf, apparently stratigraphically equivalent to the earliest and latest of multiple glacial sequences preserved in nearby Amundsen Gulf.

Most faults dip steeply seaward, flattening at depth, with synthetic and antithetic components. They number over 20; the most prominent are correlated across >75 km. Offset measurements on 15 seismic transects across 12 traced horizons reveal >30% exceed 50 m while 60% exceed 25 m. The most recent fault activity is closest to the shelf break where the aggradational wedge is thickest; the more landward fault occurrences de-activated in the mid Pliocene. Maximum horizon offset through time decreases from >200 m near the Miocene-Pliocene unconformity to >75 m at the seabed, reflecting periodic re-activation. The older glacial deposits are slightly more commonly offset than the younger deposits. This observation contrasts with the Beaufort Shelf where no faults are observed to cut even the oldest glaciated surfaces. Bathymetric multibeam and ultra-high resolution sub-bottom profiler transects express >10 m throw across otherwise extremely planar glacial erosion surfaces, a late glacial age canyon, and seabed iceberg scours. All are attributed to the last glaciation. Seabed mud volcanoes and a ridge diaper, both with undiscernible sediment cover, suggest recent fluids flux. These observations all point to an active fault system.

Investigation of geological controls on radon concentration in surficial sediment in Whitehorse, Yukon, Canada

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Indoor concentrations of radon gas more than Health Canada guidelines have been reported throughout the Whitehorse area, yet only cursory measurements have been made to determine the concentration of radon in undisturbed near-surface settings. ^{222}Rn is a carcinogenic gas formed by the decay of uranium in rock and sediment and is the second-leading cause of lung cancer in Canada. Information about its occurrence is important for public health policy such as building codes. Prolonged inhalation of ^{222}Rn leads to radioactive daughter nuclides and heavy metals in lung tissue. While bedrock is often considered the source of radon, the combination of uranium-poor bedrock and thick sediment cover suggests that surficial sediment may be a primary source of radon around Whitehorse.

To evaluate radon sources and activity, we sampled 30 sites over summer 2020 representing a range of bedrock and surficial sediment types. The underlying bedrock types are granodiorite, limestone, clastic sedimentary, and basalt. The surficial sediment we classified genetically as till, glaciofluvial sand and gravel, glaciolacustrine sediment (fine sand and silt), fluvial sand and gravel, and eolian sand. To determine controlling factors, we then compared mean radon concentration at each site to bedrock lithology, thickness of surficial sediment, surficial sediment type, surficial sediment grain size distribution, sediment maturity,

and soil moisture.

We observed correlation between grain size distribution and radon concentration, with sediments containing more silt and clay in their matrix displaying higher radon concentration. We also observed that radon concentration is generally higher in less mature sediments (e.g., till) compared to more mature sediments (e.g., fluvial and eolian sand). We observed no significant correlation between radon concentration and bedrock lithology nor depth to bedrock. Our findings suggest that sediment maturity and grain size are first order controlling factors of radon concentration in surficial sediment, and that bedrock is neither the only nor the most important source of radon in the study area. We also observed pronounced interseasonal variation at three long-term monitoring sites, but little intraseasonal variation over the summer.

Microscopic insight into a Meguma gold deposit setting: nature of arsenopyrite beds at The Ovens, Nova Scotia, Canada

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The Meguma terrane of southern Nova Scotia is well-known and studied for its slate-belt type orogenic quartz-vein gold deposits (i.e., Meguma deposits). Of the numerous studies of these deposits, the majority have focused on the macro-scale with emphasis on the host lithologies, structure, alteration, and vein types with supporting fluid inclusion, isotopic, and dating studies which together suggest a hybrid metamorphic-magmatic model. In contrast, less attention has been given to micro-scale mineralogical features which have, in recent years, become the focus of attention for such settings globally due to the advent of LA-ICP-MS and related elemental mapping of sulfides. At the Ovens deposit, auriferous quartz veins are localized to the hinge of a tight fold closure and cut metasiltstone and metamudstone rocks which are locally inundated with arsenopyrite (aspy) and best referred to as aspy beds. Previous work (i.e., Re–Os aspy, $^{40}Ar/^{39}Ar$ whole rock, muscovite) constrains formation of the auriferous veins to ca. 405 Ma with a later overprinting event at ca. 375 Ma. To better understand the nature and relevance of the aspy to the Au event, a detailed SEM-EDS study was undertaken of these aspy-rich beds. Results indicate a complex paragenesis in a general sequence of: (1) an early framboid-like porous pyrite (py1) locally recrystallized to As-pyrite (py2) with cavities lined by zoned carbonate hosting Cu-Fe-Pb sulfides and monazite; (2) an early matrix muscovite-Fe carbonate-rutile-apatite-gal assemblage (EA) overgrown by later pyrite (py3) with inclusions of euhedral aspy (aspy1); (3) euhedral aspy (aspy2) overgrows and replaces py3, hosts tourmaline, Fe(Ca-Mg-Mn) carbonates and overgrowths the EA noted before; (4) the host rock contains resorbed detrital quartz with sub- to euhedral overgrowths that coexist with abundant neomorphic muscovite which together define a variably developed fabric; and (5) Fe-rich chlorite replaces the latter muscovite. Disseminated in the matrix and sulfides are hydrothermal monazite and xenotime. These observations reveal a complex paragenesis for these aspy beds which commenced with early diagenetic py (py1) followed by subsequent periods of fluid ingress and new mineral growth (py2, py3, aspy1, aspy2) accompanied by modification of earlier assembles. How this relates to the geotectonic evolution of the setting, previous dating and the implications for the Meguma Au event will also be addressed.

Public opportunities to discover geoscience in industry from historic and modern mining practices through the partnership of Atlantic Gold and the Moose River Gold Mines Museum in Middle Musquodoboit, Nova Scotia, Canada

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The best opportunities for learning geoscience and geoheritage are centred around "seeing and doing", often through field excursions that can cause barriers for people limited by travel and mobility. On the site of Atlantic Gold's Touquoy mine, accessible public infrastructure encourages visitors to not only closely park and behold the natural and engineered features of the pit but discover the history of mining in the area and the community built around it. The Touquoy mine is a 1–2-hour drive from most mainland cities and towns. From the public viewing point, visitors can view the deep, benched walls showing pristine examples of sedimentary layering, folds, faults, and mineralized veins exposed in the hinge of the Moose River Anticline. These features easily make visualizing geologic processes tangible to even novice geology enthusiasts, available freely without cost or appointment. From Mooseland Road, also visible are the ore and waste stockpiles, tailings management facility, and processing plant exhibiting the vast amount of geological and environmental engineering efforts involved in modern mining. Neighbouring the mine, is the Moose River Gold Mines Museum that was established in 1986 in the village's historic one-room schoolhouse. While

it holds the histories of early gold mining on the Eastern Shore and the community of Moose River Gold Mines, its largest collection is centred on the Cave-in of 1936, which trapped three men, and the rescue effort that ensued. The event was the first for 'on the spot' news coverage in history and gained millions of listeners around the world. The museum is open for the months of July and August, seven days a week from 10 am till 4 pm. In the off season it will open for tours by appointment. The preserved history is a critical reminder for the safety perspective of mining. The adits of those underground tunnels that trapped the three men for ten days are visible from the public observation point, along with the geotechnical structures contributing to the collapse. The same geotechnical predisposition affects the current pit and modern safety mechanisms are situated close to the collapse site. The viewing point and Moose River Gold Mines Museum will remain accessible after the inevitable closure of Touquoy, but visitors are encouraged to timely observe the mine in operation and see the contrast of modern mining methods, technology, and safety from the ways of history.

Survey of potential syngenetic occurrences of archaeal lipid biphytanes in lower greenschist facies, Late Archean (2.65 Ga) metamorphosed argillites of the Abitibi Subprovince, Timmins, Ontario, Canada*

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Molecular fossils (i.e., biomarkers) from ancient rocks are not expected to preserve if subsurface temperatures reach above 200°C over extended periods of time. This makes reconstruction of the microbial diversity of life using biomarkers highly problematic for rocks older than the Paleoproterozoic Era (i.e., 2.5 Ga) where to date all known rocks have undergone at least some degree of metamorphism. Nonetheless, biphytanes, which are archaeal lipid biomarker, were detected in lower greenschist-facies metamorphosed argillites (200–300 °C between 2669 and 2665 Ma) from the Abitibi province, Timmins, Ontario, Canada. This work is highly controversial with many researchers favoring alternative sources for the reported lipids that are significantly younger than their host rock. We hypothesize that by using different extraction techniques, the sources of organic matter contamination can be more clearly defined and an evaluation of biphytane- host-rock syngeneity better evaluated. For this study, all equipment was carefully solvent washed, combusted, or acid treated to remove laboratory sources of contamination. Initial results have shown that different core or hand samples may have different susceptibilities to secondary inputs of organic matter. Hand samples collected near surface are fissile along their foliation planes and absorb water readily through foliation planes. These samples were therefore removed from further study. For the drill core samples, which did not adsorb water, drill mud contamination was evaluated and screened from the samples by an initial solvent wash that was followed by grinding away ~1 cm of the exterior layer of the core sample. The powder was then collected and extracted for hydrocarbon biomarkers. These series of steps were then repeated until the core sample was completely ground to powder. This technique has been performed on two core samples. The first did not recover any biphytanes but did display bacterial hopane and eukaryotic sterane biomarkers. A second sample is still to be completed. It is hoped that these improved extraction methods can significantly reduce potential sources of contamination in the resulting extracts to further help to constrain the age and origin of the biphytane biomarkers.

**Honourable Mention: AGS Rob Raeside Award for best undergraduate student poster*

A tale of two ponds

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Bathymetric surveys of two small lakes in Newfoundland, in very different environments and separated by hundreds of kilometres, were carried out using two different survey methods – ground penetrating radar (GPR) and sonar. Tippings Pond, on the outskirts of the town of Corner Brook in western Newfoundland, is a popular recreation area. Grassy Pond, several kilometers inland from the Trans Canada Highway in eastern Newfoundland, is within an undeveloped area accessible by skidoo in the winter. Tippings Pond, roughly square with an area of 1.6 km^2, is slightly salty, making it largely impenetrable by radar. Sonar surveys revealed it to be bowl shaped and more than 26 m deep in the centre. Grassy Pond, with an elongated shape 1.2 km^2 in area, is very fresh, and GPR was able to image structure in the soft sediment as well as the bedrock

interface. The sediment interface is undulating and shallow (up to 2.8 m deep) while the bedrock features sub-basins up to 8.3 m deep. Apart from revealing the different structure of these two disparate ponds, the study outlined the strengths and limitations of the two survey methods.

Groundwater silcrete in the Potsdam Group, Ottawa Graben, Canada: a case example of shallow fault-controlled silicification and desilicification in a tectonically active basin

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Silcrete forms by silicification of sediment or bedrock at the Earth's surface due to soil-forming processes (pedogenic silcrete), or in the shallow subsurface (< 100 m) along the water table (groundwater silcrete). Unlike pedogenic silcretes, the origin of groundwater silcretes are poorly understood with existing case studies highlighting near-surface silica flux, whereas extrabasinal sources and/or migration of silica-bearing fluids along faults have not been demonstrated. Based on spatial and textural characteristics of a groundwater silcrete from the Cambrian-Ordovician Potsdam Group in the Ottawa Graben, however, a close association between the migration of silica-rich fluids and multiple northeast-trending faults is suggested. This ≤150 cm-thick silcrete horizon underlies an unconformity that caps a succession of fluvial quartz arenite along the flanks of fault-bounded ridges of Grenville basement. The silcrete horizon thickens toward these faults and shows a systematic change in morphology from nodular to massive to brecciated. Cathodoluminescence reveals an early luminescent zoned cement (C1) associated with silcrete formation, and a later massive non-luminescent cement (C2) that occurs as overgrows filling remaining porosity in these and adjacent Potsdam strata. Fracturing and autoclastic brecciation of silcrete occurs within tens of meters of faults and is characterized by jigsaw and collapse breccia made up of silcrete clasts in a massive sand, kaolinite, and Fe-oxide matrix. Here it is speculated that silica-rich fluids moved along faults and advected into adjacent Potsdam sediment where the effects of pH change and evaporation promoted C1 precipitation. Later fracturing and migration of high pH fluids near faults led to local C1 dissolution and autoclastic brecciation. Finally, C2 cements formed throughout Potsdam strata following burial and pressure solution of non-silcretized arenite. Although the source of silica and fluid reservoirs for C1 remains uncertain, the scarcity of remnant detrital feldspar or unstable silicates in Potsdam strata suggests that the Grenville basement was the most likely source. Ongoing fluid inclusion analyses of C1 cements aims to resolve fluid temperature and salinity conditions, and a meteoric versus hydrothermal origin.

Student acceptance of digital specimens as a substitute for the real thing in an introductory geology lab

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Over the past decade, there has been a dramatic expansion in the availability of digitized versions of materials typically used in teaching geology labs (e.g., rock and mineral samples, sediment, and thin sections). The shift to online delivery of courses and labs during the 2020 fall semester presented an opportunity to test the effectiveness of these materials for instruction. While some schools opted to deliver rock and mineral kits by mail, instructors at Cape Breton University shifted entirely to digital resources to support introductory geology labs (GEOL 2101: Engineering Geology), while leaving the overall content and structure of labs largely unchanged. Enrolled students were given an anonymous end of term survey about their experience with three technologies: virtual microscopes, 3D digital models of hand samples, and 360-degree panoramic photos of localities. 38 students responded (64% response rate). Feedback on all three technologies was very positive, with 86-90% at least somewhat agreeing—and 44-55% "strongly agreeing"—that these devices helped their learning. Additionally, 47–52% strongly agreed that these technologies "replicated the experience of interacting with physical specimens or environments," and only 6–8% disagreeing. Written comments were overall positive, with emphasis on their realism, variety, and interactivity, but several respondents noted missing the tactile aspect of physical specimens, limitations of digital quality (resolution, lighting, or contrast), or issues getting the models to load. This latter problem was likely exacerbated by the fact that 31% of students were accessing the course on a mobile device or tablet and/or had only low-speed Internet. While

students overall endorsed these technologies, they were split on whether they would have preferred to have access to mailed sample kits if given the option, with a moderate preference for mailed kits (42% mailed/34% digital/24% neutral). Taken together, these data suggest that digital specimens provide an acceptable alternative for delivering traditional introductory geology labs.

Epithermal gold mineralization and associated alteration at the Golden Ridge Deposit, Poplar Mountain Volcanic Complex, southwestern New Brunswick, Canada: analysis of the role of pyrite and arsenopyrite during mineralization

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The Middle Ordovician Poplar Mountain Volcanic Complex, southwestern New Brunswick, consists of three main volcanic phases: porphyritic rhyodacite, rhyodacitic volcaniclastic rocks, and basaltic volcanic rocks; previous U-Pb zircon dating indicates that these volcanic rocks formed at 459.0 ± 3.0 Ma. Gold mineralization is associated with veining and associated illitic alteration that was dated using $^{40}Ar/^{39}Ar$ methods to be 411.0 ± 3.7 Ma, thus suggesting it to be considerably younger than the volcanic sequence and possibly related to the Pokiok Batholith to the south. Based on gold assay data from archived assessment file reports and relogging available drill core, gold mineralized stockwork-like veining is mainly constrained to the porphyritic rhyodacite. The presence of gold appears to be restricted to areas containing arsenopyrite, and to a lesser extent pyrite, as well as in areas of multiple quartz-carbonate vein stockworks and areas of hydrothermal brecciation. Selected samples were analysed using Instrumental Neutron Activation Analysis and Inductively Coupled Plasma-Optical Emission Spectrometry and -Mass Spectrometry. Paragenetic examination of the complex veining helped select various pyrite- and arsenopyrite-bearing assemblages for microX-ray Fluorescence (μXRF) – Energy Dispersive Spectrometry mapping; certain pyrites were chosen based on their size and textures, as well as the Au grades of the corresponding samples. Using μXRF, two electrum grains were found within a sample containing 10.2 g/t Au. There is also evidence of some arsenic zoning in pyrite within a few samples, as well as S-As zoning in arsenopyrite overprinting some earlier pyrite that occurs as disseminations. The purpose of this research is to determine if gold is refractory within pyrite and arsenopyrite or if it is present as free gold or electrum. If gold was saturating during pyrite and/or arsenopyrite formation, there should be a geochemical association between As, S, and Au, which is evident in the bulk geochemical analyses. Laser Ablation Inductively Coupled Plasma – Mass Spectrometry (LA-ICP-MS) analysis has been conducted on pyrite in six of the samples, as well as elemental mapping of the six samples. From pyrite LA-ICP-MS analysis, samples contained values of up to 210 ppm Au in association with As substitution; a geometallurgical balancing is still needed to ascertain the relative forms of gold in this system. Future work includes Ar/Ar dating of illite from the NE zone discovered in 2011. Rare hydrothermal apatite has been identified in several stockwork veins, which may be dated by in situ LA-ICP-MS U-Pb methods to confirm the ages of mineralization.

Variation in the major and trace element geochemistry of biotite and apatite from the South Mountain Batholith, Nova Scotia, Canada

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The South Mountain Batholith (SMB) is a 7300 km^2, peraluminous, felsic intrusion that consists of 13 plutons that were emplaced in two different episodes between ~385 and ~368 Ma. Despite its large size, only one significant mineral deposit (East Kemptville) was mined. To aid in assessing magma metal fertility this study is characterizing biotite and apatite compositions with goals to (i) establish a geochemical "baseline" for these minerals; and (ii) determine if these minerals can highlight geochemical anomalies related to mineral deposits. We have analyzed 24 samples representing seven of the major plutons. Major elements (including F and Cl) were measured by electron microprobe and trace elements by LA-ICP-MS. The trace element suite includes transition metals, semi metals, high field strength elements and large ion lithophile elements. Key results are: (i) Biotite is close to the siderophyllite end-member with a composition of $K_{1.8\text{-}2.0}(Fe_{2.2\text{-}4.2}Mg_{0.201.8}Al_{0.582.2})(Si_{5.3\text{-}6.0}Al_{2.0\text{-}2.7}O_{20})(OH_{2.5\text{-}3.8}Cl_{0.00\text{-}0.06}F_{0.15\text{-}1.4})$; (ii) Both biotite and apatite are F-rich with F# (= F/[F+Cl]; wt.%

elements) ranging from 0.75 to 1.0 in biotite, and from 0.93 to 1.0. in apatite; (iii) The biotite F# shows a weak, positive correlation with Fe# (= Fe/[Fe+Mg]; wt.% elements), which ranges from 0.77 to 0.98. The F# and Fe# along with the Al content of biotite can be used to discriminate which pluton the sample originated from, although there is overlap between some plutons. Thus, biotite is a good reflection of individual pluton geochemistry and may reflect differences in pluton parental melts; (iv) The biotite Fe# also correlates with the whole-rock SiO_2 content (66 to 75 wt.%), indicating that Fe# of biotite can be used as a measure of SMB differentiation; (v) Cobalt, Cr, and Ni concentrations in biotite decrease from 40 to 5.9 µg/g, 155 to 1.7 µg/g, and 43 to 0.45 µg/g, respectively, as the Fe# increases. The biotite V concentration decreases linearly from 280 to 82 µg/g over the range of Fe# of 0.77 to 0.94 before dropping to 0.71 µg/g at an Fe# of 0.98. The whole-rock V concentration (2 to 64 µg/g) is lower than that of biotite but mimics the slope of the biotite V content from Fe# 0.77 to 0.84 and 0.86 to 0.94. These similar slopes suggest that biotite is exerting some control on the abundance of V; and (vi) Lithium (230 to 5800 µg/g) and Sn (10.0 to 120 µg/g) both correlate positively with the biotite Fe#, reflecting their incompatible behaviour during SMB differentiation.

Crestal faulting: a source of trap integrity loss and gas migration in the Migrant Structure, Sable Delta, Offshore Nova Scotia

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On the Scotian Shelf, rollover anticlines host most of the significant and commercial hydrocarbons. The size and commerciality of hydrocarbons trapped in their reservoirs may depend on the apparent crestal faulting of these structures. This study analyzes the Upper Jurassic to Lower Cretaceous age reservoirs contained in rollover targeted by the Migrant N-20 exploration well. The well was drilled on closure at the Missisauga Formation level based on sparsely intersecting 2D seismic data. However, a crestal fault below 2D seismic resolution that is visible in modern 3D seismic data is visible in the structure.

With commercial hydrocarbons produced from the Thebaud rollover structure faulted at its crest located downdip of Migrant, audited structural maps show that successful trapping was due to a combination of change in isochron thicknesses and favorable juxtaposition of strata on either side of key faults. Given that some rollover structures in the Sable Subbasin are commercially unsuccessful, this study integrates well data and 3D Sable MegaMerge seismic data to demonstrate the relationship between lithological variations and fault displacement (along a crestal fault). A combination of pressure and petrophysical analysis, and 3D geocellular models, populated with petrophysical parameters, were incorporated to demonstrate the mechanism and processes responsible for the failure of the Migrant Structure as a commercial trap.

Results indicate a low sand/shale ratio deep in the Migrant Structure with localized trapping of hydrocarbons. Furthermore, a corresponding increase in pressure deep in the structure coincides with zones containing hydrocarbons. The shallow and intermediate sections of the structure is characterized by increased crestal fault displacement with increased lithological juxtaposition. At this level, petrophysical analyses reveal sporadic gas shows suggesting some degree of hydrocarbon migration in that part of the system.

A fault plane profile of the crestal fault using 3D seismic data highlights the creation of juxtaposed leak points in the Migrant Structure from the fault displacement and variable lithological relationships that pose significant implications on the size, distribution, and estimates of hydrocarbon accumulations in these types of structures. The closure and fault relationship in deeper reservoirs in the Migrant Structure observed in this study indicates that most of the zones in the shallow and intermediate intervals at Migrant would likely have been filled to the structural saddle point in the absence of the crestal fault. These insights may be useful for predicting the trapping potential of untested rollover structures in the Sable Subbasin.

The relationship between selected metal content of soils in Nova Scotia, Canada, and the underlying geology: possible implications for public health (As, Cd, Cr, Cu, Hg, Pb, U, Zn)

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Toxic metals in soils can pose a threat to human and environmental health when elevated above health guidelines. The North American Soil Geochemical Landscapes Project (NASGLP) conducted in 2007–2010 provided soil geochemical data of the different horizons from 72 sites around the province. These data have yet to be thoroughly analyzed. All samples were taken from sites with no known direct anthropogenic sources. This study

aims to examine the relationship between the geochemistry and underlying geology with a focus on the toxic metal concentrations. Coordinates of the soil sample sites and field data descriptions were used to identify the bedrock and glacial geology underlying each soil sample. To assess both the relationship between soil and underlying material and any potential public health concerns, I studied geochemical data from the C horizon and public health layer (0–5 cm) of the following metals: As, Cu, Cd, Cr, Hg, Pb, U, and Zn. The preliminary results show some consistency within different bedrock lithologies and toxic metal content that is more evident in the C horizon than in the public health layer. Most metal data for the public health layer are within guidelines, although soil overlying Meguma Supergroup and, less commonly, Horton Group bedrock, show arsenic above guidelines locally. This initial exploration of the currently available soil data will allow further research on the geochemistry of Nova Scotia soils and their relationship to the province's complex geology, as well as provide important information related to the presence or absence of elevated toxic metals within the soils.

Experimental study of the formation conditions of trigonal etch pits on diamonds*

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Diamonds are a key material for providing information on our Earth's interior due to their ability to reflect and preserve chemical information. Diamonds form at high temperatures and pressure conditions and are brought to the surface by kimberlite magmas. Kimberlites originate from deep regions in the mantle and their composition can vary greatly due to a number of chemical and geological factors, making them difficult to understand. Diamonds commonly show dissolution (resorption) features on their surfaces, such as etch pits, that reflect the conditions of kimberlite magmas and can provide researchers with a stronger understanding of the deep regions of the mantle. Previous studies have shown that high temperature (T) and oxygen fugacity (fO_2) and low pressure promote diamond resorption. However, the limiting values of these parameters for the onset of diamond resorption are not well known. This experimental study determines minimal T and fO_2 for diamond etching at 0.1 MPa. Experiments were conducted with eight natural octahedra diamonds etched in a Na, Ca-carbonate melt in a gas-mixing furnace and in air using box furnace at 630–850°C for a duration of 60 minutes. FO_2 was controlled with mix of CO_2 and CO gases in gas-mixing furnace and using iron-wustite (IW), nickel-nickel oxide (NNO), and magnetite-hematite (MH), oxygen fugacity buffers in the box furnace were conducted using a silver capsule containing a layer of quartz between the diamond and buffer. Presence or absence of resorption was confirmed by imaging selected areas of diamond surface before and after experiments with Atomic Force Microscope (AFM) at resolution done to ~1 micron (horizontally) and ~20 nm (vertically). Experiments established minimal T required for diamond etching between 850°C and 800°C in IW buffer, between 800°C and 700°C in NNO buffer and in pure CO_2 gas, and below 630°C in air. The temperature and fO_2 levels can provide further information on the conditions in a kimberlite magma (such as CO_2, CO, and H_2O levels).

**Winner: AGS Rupert MacNeill Award for best undergraduate student oral presentation*

The elusive Continental Rise: insights from residual bathymetry analysis of the northwest Atlantic Margin, Canada

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The concept of the continental rise is engrained in our textbooks and consequently our perception of the 'Atlantic' passive margin morphology. But is it real? Heezen and others in 1959 were the first to identify the continental rise and derived the concept from bathymetric profiles off the eastern U.S.A. continental margin. These profiles crossed Chesapeake Drift and the Hatteras Outer Ridge; two massive submarine contourite drift deposits. Morphologies of continental margins are highly variable, as recognized even by Heezen and others, and they suggested that identification of the continental rise off Nova Scotia is difficult. Hydrogeologists have recognized for many decades that equilibrium stream dynamics result in a graded, concave-shaped profile along axis of the stream. This same graded shape has been recognized as an equilibrium condition in hydrocarbon exploration models. It is proposed in this study that a graded slope is the equilibrium condition for a margin that represents from long-term balance in processes of sediment input, transport, deposition, erosion, and output as a result of particle diffusion processes. The presence of a rise as identified by Heezen and others is, therefore, anomalous. This study further proposes that the

graded shape of a margin is mathematically predictable as an exponential decay curve with a constant exponent. To test this hypothesis, a graded surface model slope that extends from the shelf break to the abyssal plain was produced for the northwest Atlantic margin (NWAM). Subtraction of this model from measured bathymetry results in residual anomalies that highlight above grade and below grade segments of the margin. The majority of the margin is graded, i.e., in balance, but the margin is complex. Above grade segments are related to contourite deposition (e.g., Chesapeake Drift and Hatteras Outer Ridge) and submarine fan deposition (e.g., Laurentian Fan). Below grade segments are related to erosion (e.g., Blake Escarpment) or non-deposition (e.g., Flemish Cap). The complexity of the margin, highlighted by this residual bathymetry technique, emphasises the inadequacy of dividing a margin into long established components of slope, rise and abyssal plain. Classification of a passive margin based on grade is more informative in terms of understanding its geomorphology and its sedimentary history.

Quaternary glacial erosion: a global review of process, measurement, and rate

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Glacial erosion exerts a dominant control on the earth's terrestrial landscape. Through the excavation of material, glacial erosion plays a fundamental role in mountain range exhumation, isostatic processes, and biogeochemical fluxes. Yet, the factors that control the rate and spatial distribution of glacial erosion remain poorly understood. To address this problem, we present the first steps in a project that aims to synthesize and review glacial erosion by using a new global compilation of published Quaternary erosion rates (n = 955). We collate erosion rates from five different measurement techniques integrated over 10^{-1} to 10^{6} years: (i) instrumental measurements beneath active glaciers, (ii) sediment fluxes derived from streams or ice-marginal deposits, (iii) differential topographic incision of chronologically constrained surfaces, (iv) terrestrial cosmogenic nuclide (TCN), and (v) thermochronology dating. Collated erosion rates range over five orders of magnitude, between 10^{-5} and 10 mm yr^{-1}. This variability in rate supports the interpretation of glacial erosion as both episodic and nonuniform, a fact frequently explained by controls that modulate the efficiency of glacial processes at a variety of spatial and temporal scales. The most widely recognized controlling variables are ice velocity, mean annual temperature, precipitation, subglacial topography, lithology, geological structure, and glaciation duration. This glacial erosion compilation provides the foundation for the next step of the project. We will assess the dominant controls on these erosion rates and present (i) contemporary and (ii) long-term relationships between environmental and physical conditions.

Organic geochemical water column survey of the Labrador Sea, Canada

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The Labrador Sea has vital importance in the global ocean circulation system. However, it is characterized by difficult environmental conditions, which have led to limited understanding of the marine ecosystem and biogeochemical cycles. My project aims to survey a very specific area of the Newfoundland Labrador Shelf where the warm water masses of the Gulf Stream and the cold-water masses of the Labrador current mix via three transects that cross the Laurentian Channel, Flemish Cap, and Grand Banks This study aims to investigate nutrients variation and thermal water column stratification effects on particulate organic matter, microbial abundance, and community compositions. Microbial group identification is based on the quantification of intact polar lipids (IPLs) that represent the main building blocks of cellular membranes and an important biomarker in marine environments. IPLs have the potential to help delineate the taxonomic diversity and metabolic activity of organisms and can be used to resolve an organism's response to varying environmental conditions. This environmental lipidomic study focuses on the analysis of IPLs and their fossil counterparts, core lipids, which have lost their polar headgroups. Water column filtrate samples marking a series of transects extending out across the shelf margin of the Labrador Sea around Newfoundland were collected at different depths from 52 m to 1818 m. IPLs are being extracted using the Modified Bligh and Dyer technique

and will then be analyzed by ultra-high-performance liquid chromatography-mass spectrometry (UHPLC-MS). Lipids analyses will further involve the collection of structural information across various compound classes to identify the respective source organisms and their location of habitability within the water column. The molecular diversities of lipids give quantitative evidence of the living microbial community and their metabolic activity. This project will help to improve our understanding of the sources of input of organic matter that enters the Newfoundland Labrador Shelf and the productivity of upper water columns.

Combined soils and in situ ^{14}C approach to evaluate erosion of non-lithified landforms

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Reliable chronology of sediment landforms is required to establish rates for a wide range of pedogenic and geologic processes. Cosmogenic nuclide depth profile exposure dating provides a useful means of estimating the age of the upper meters of sediment by reducing uncertainty related to inheritance. However, surface erosion remains a largely unconstrained variable that together with other variables can contribute a significant uncertainty in the exposure ages. We use a novel approach to estimate erosion rates on five late Pleistocene landform surfaces in Panamint Valley, California, by measuring ^{14}C saturation concentrations in quartz sand from amalgamated sediment samples collected just below the soil mixing zone. The selection of specific sample locations was guided by optimal soils and geomorphic conditions. Erosion rate uncertainty improved by up to 50%, compared to soils geomorphology-based estimates, and previously computed ^{36}Cl and ^{10}Be depth profiles were recalculated. The ages re-calculated with the ^{14}C calculated erosion rates provided confirmation of previously calculated ages (for ^{10}Be profile data), with up to 50% improvement on uncertainty, as well as providing a corrected age (for ^{36}Cl data). While the approach improves uncertainty in the erosion rate, it is now apparent that previous field-based estimates of erosion rates may have significantly underestimated uncertainties.

The Belleisle Fault at Beaver Harbour, New Brunswick, Canada: where is it, what is it, and when (and how) did it move?

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Three Appalachian tectonostratigraphic terranes converge in the Beaver Harbour area of southern New Brunswick, overlain by two upper Paleozoic sedimentary sequences. The Ediacaran to Cambrian New River and Brookville terranes are separated by the Silurian Kingston terrane, and the cover sequences consist of the late Devonian red beds of the Perry Formation and the Lighthouse Cove, Cripps Stream and Beaver Harbour formations of more ambiguous affinity, but most probably Carboniferous age. Separating the New River terrane from the Kingston terrane is the Belleisle Fault, a major regional structure that moved as a right-lateral strike-slip fault during the late Devonian and Mississippian interval. Defining which of several faults between Letang Harbour and Beaver Harbour is the 'Belleisle Fault' is not straight-forward, nor is the continuation of the fault in Maine where the Lubec Fault is considered the best candidate. Fieldwork during summer 2020 examined critical relationships between the rocks of the upper Paleozoic cover sequences, the Cambrian rocks and two igneous bodies, the Blacks Harbour granodiorite and Beaver Harbour porphyry, and the various candidates for the Belleisle Fault itself. A major tectonic mélange at Beaver Harbour north of what has been thought of as 'the Belleisle Fault', and of Perry Formation beneath an angular unconformity below the Beaver Harbour Formation (and south of what was termed the 'Belleisle Fault') suggests this boundary has a more complex history and form. Instead of a single faulted boundary the fault appears to be a broader zone between the Kingston and New River terranes with enclaves of various sequences incorporated, including Blacks Harbour granodiorite, Cambrian Saint John Group, and Devonian Perry Formation.

Solving the structural puzzle: a 3D model of the Nash Creek deposit, New Brunswick, Canada

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The Nash Creek Deposit (NCD) is a zinc, lead, and silver deposit located within the northernmost segment of the Appalachians. This deposit is a Volcanogenic Massive Sulphide (VMS) that is contained within the Early Devonian rocks of the Jacquet River Syncline. The mineralization is bounded by the Nash Creek Graben, which was active at the time of deposition While the formations that host mineralization have been established, how, or if at all, the mineralization is structurally controlled is not yet well understood. The NCD has great economic potential but has not yet been modelled using modern software. Therefore, the development of an in-depth three-dimensional (3D) model could improve our understanding of the deposit. This study aims to make a 3D model of the NCD, which could help to better constrain the structural geology, and its interaction with late mafic intrusions. Such a model can be used to better understand the late mafic intrusions and could also provide insight as to areas in the NCD that have not been drilled and may potentially host an undiscovered deposit or mineralized extension to the known deposit.

Contrasting gold-bearing volcanogenic massive sulfide (VMS) and orogenic gold deposits in the Baie Verte Peninsula, Newfoundland Appalachian orogen

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The Baie Verte Peninsula has a history of Au (and Cu) mining (>100 years) and is one of the key gold-producing regions in the Canadian Appalachians. Gold mineralization was (and is) mined from both volcanogenic massive sulfide (VMS) deposits and orogenic Au deposits. Gold-enriched volcanogenic massive sulfides are associated with ophiolitic rocks in the peninsula, with most mineralization produced from bimodal mafic sequences in deposits hosted by Cambrian–Ordovician (~488–485 Ma) felsic volcanic and volcaniclastic rocks of the Rambler Rhyolite formation (e.g., Ming, Rambler). The mineralization is associated with typical VMS-related sericite-(chlorite-quartz) alteration and consists of (semi-)massive sulphide with epithermal suite element associations (Au, Ag, As, Hg, Sb, Bi, Te) and a complex mineral assemblage consisting of ~40 different sulfide, sulfosalt, and oxide minerals associated with Au mineralization. Although deformed and metamorphosed, Au mineralization in the VMS deposits is syngenetic and related to Cambrian–Ordovician seafloor hydrothermal and magmatic-hydrothermal activity. Orogenic Au deposits are spatially associated with the Baie Verte Line but hosted in subsidiary faults off this regional structure (e.g., Scrape thrust). Producing and past-producing orogenic deposits (e.g., Pine Cove, Nugget Pond, Stog'er Tight) are structurally controlled within the hanging walls of the thrust faults and predominantly restricted to chemically reactive units (e.g., Fe-Ti-rich mafic intrusive rocks, and iron formation) within the Ordovician Snooks Arm Group cover sequence that overlies the Cambrian–Ordovician ophiolitic rocks. Mineralization occurs as quartz vein arrays and/or as wall-rock hosted mineralization in chemical reactive units and has alteration assemblages typical of orogenic Au-mineralization (e.g., carbonate-chlorite-muscovite-albite-hematite-rutile). Further, the ore mineral assemblages are simple, with Au associated with disseminated pyrite in wall rock with few other sulfides; mineralization is not associated with massive sulfide. Stratigraphic and structural relationships coupled with U–Pb/Re–Os geochronology suggest that mineralization is likely Silurian (to Devonian) in age (~420 Ma and younger). Over 10 years of research on these deposits demonstrates two clear episodes of gold mineralization that represent two distinct pulses of mineralization that are spatially associated but genetically distinct.

Relating thick proglacial mud successions to processes at ice-stream margins: a tool for dating ice advances

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Thick red mud successions many metres thick of late Pleistocene age on Laurentian Fan have attracted attention since the 1950s. Recent studies have shown that they represent periods of high sediment supply on a centennial to millennial time scale, separated by intervals of hemipelagic sedimentation on a similar time scale. Comparison with independent evidence for ice margin positions suggests that the distinctive red muds with silt laminae are not restricted to times when ice reached the top of the continental slope but may also be deposited after retreat of the ice stream within Laurentian Channel. Most red mud successions are not accompanied by major plunging hyperpycnal flows of sand and gravel.

Seaward of Trinity Trough, muddy glacigenic debris flows (GDFs) are preserved on the low-gradient trough-mouth fan, providing evidence for the muddy composition of the basal deforming layer beneath the Trinity Trough ice stream. The GDFs are cut by three erosional horizons corresponding to plunging sand and gravel flows. Such observations suggest that some of the thick mud successions on Laurentian Fan are the result of breakup on the steep upper slope of GDFs derived from the basal deforming layer of the ice stream, involving rapid entrainment of ambient seawater.

Within Halibut Channel, a young erosional surface provides evidence for powerful meltwater flow seaward of the Younger Dryas ice margin and corresponding proximal turbidites in Halibut Canyon demonstrate that meltwater flow was sufficiently prolonged to deposit multiple turbidites. Sand transported by glacial meltwater was not restricted to a single catastrophic breaching event, but rather was a repetitive ice-margin process. "Normal" meltwater flows with low salinity, driven by a hydraulic head of water in the ice sheet, apparently filled the transverse trough and transported sediment to the shelf edge, where they probably evolved in a manner similar to that monitored in the Squamish Delta. Such a process provides an explanation for the youngest thick red mud successions on Laurentian Fan deposited after the ice stream had retreated from the shelf edge.

Seaward of the Hudson Strait ice stream, cores suggest that thick mud successions and GDFs accumulated at the time of Heinrich layer H3 and probably H4, whereas in H1 and H2 little sediment was supplied to deep water. Concepts developed at mid latitudes may be less applicable because the outer transverse trough is bounded by deeper water on either side, and there is less evidence for abundant meltwater.

Constraining the effect of a weakening Atlantic Meridional Overturning Circulation on ocean temperatures in the Gulf of St. Lawrence over the past 150 years*

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Ocean circulation is essential for transporting heat, dissolved CO_2, and nutrients all around the globe. The strength of the ocean circulation, therefore, has a major influence on climate and vice versa. Over time, ocean currents can change causing climate to vary on local, regional, and indeed global scales; in turn, changing climate can affect the strength and location of ocean currents. Recent studies suggest that freshwater addition to the western North Atlantic from melting Arctic and Greenland ice is causing the Atlantic Meridional Overturning Circulation (AMOC), which encompasses the northward flow of warm saline water of the Gulf Stream and the return flow of colder deep water of the Labrador Current, to weaken. This results in surface ocean temperatures offshore of Atlantic Canada to rise faster than in the rest of the global ocean. Ocean warming, in turn, is detrimental to a wide variety of marine species, thus impacting both the environment and the local economy. The objective of this study is to assess past changes in ocean currents in the western North Atlantic, based on sea surface temperature (SST) reconstructions from alkenones preserved in sediments on the Scotian Shelf. Alkenones are long-chain carbon molecules uniquely synthesized by a certain group of phytoplankton that change in composition depending on surface water temperatures. To improve the spatial and temporal resolution of previous studies investigating past SST variability in the open NW Atlantic, we analyzed a high-resolution sediment core from the central Gulf of the St. Lawrence that contains a detailed record of the last 150 years. From 1850 to present, our alkenone-derived SST estimates fluctuate between 6.5–7.0° C with a local error of estimation of 1.4°C. This absence of any significant trend in SST in the central Gulf of the St. Lawrence over the last 150 years implies that factors other than open ocean warming affect our study site. We will discuss how the hydrography of the St. Lawrence River itself, or variable admixture of colder waters from the Labrador Current could mask or offset any SST warming expected from the weakening AMOC. From such analyses, we can gain a better understanding of the changes we are seeing now and more reliably predict what is to come.

**Honourable Mention: AGS Rupert MacNeill Award for best undergraduate student oral presentation*

Conditions of pocket formation in the Zapot pegmatite, Gillis Range, Nevada, USA*

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We investigated the pressure and temperature conditions of pocket formation in the Zapot pegmatite, Gillis range, Nevada, using Raman spectroscopic and microthermometric data obtained from pseudo-secondary fluid inclusions in smoky quartz crystals. Thin sections of four quartz crystals reveal partially dissolved smoky quartz cores overgrown by colourless quartz. Randomly oriented planar arrays of negative crystal-shaped fluid inclusions cross-cut the smoky quartz core but do not extend into the colourless quartz rim. At room temperature, the fluid inclusions typically contain one or more solid phases, an aqueous fluid, and a vapour bubble. Raman spectroscopic analysis of solid phases show that topaz, sassolite (H_3BO_3) and stibioclaudetite ($AsSbO_3$) are common daughter minerals. The average homogenization temperature (T_h LV→L) for fluid inclusion assemblages (FIAs) varies between 122°C and 337°C, and the average fluid salinity ranges between 2.51 and 3.71 wt.% (NaCl equivalent). The presence of sassolite daughter minerals indicates that orthoboric acid is a dominant solute in the fluid involved in pocket formation. Orthoboric acid concentrations for different FIAs, as determined by the dissolution temperature of sassolite, varies between 4.5 and 7.5 wt.% H_3BO_3. We estimated the pressure and temperature of fluid inclusion trapping by extrapolating isochores in the system H_3BO_3-H_2O to the water-saturated solidus of a F-rich granite. Assuming near-solidus crystallization temperatures, the different fluid inclusion assemblages reveal large changes in fluid pressure (375 to 800 MPa) during pocket formation. Such high internal pressure during crystallization accounts for pocket rupture, which is evident in many gem-bearing miarolitic pegmatites.

**Winner: AGS Rob Raeside Award for best undergraduate student poster*

Investigating the controls of submarine landslides and associated hazards in Pangnirtung Fiord, Eastern Baffin Island, Nunavut, Canada

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High-latitude fiords are susceptible to hazardous subaerial and submarine slope failures. Recent investigations have shown that past slope failures in fiords of Greenland and Alaska have generated devastating landslide induced tsunamis. Since coastal communities inhabit these high-latitude fiords, it is critical to understand the slope failure recurrence time, their distribution, potential triggers, and ability to generate tsunamis. In this study, we identified >50 near-surface submarine landslides in Pangnirtung Fiord, eastern Baffin Island, Nunavut, using multibeam bathymetric and sub-bottom profiler data, along with sediment gravity-cores collected in 2019. Morphometric and morphological analyses, along with sedimentological analyses, were carried out on submarine landslide deposits to quantify their spatial and temporal distribution throughout the fiord and to evaluate the factors that may have triggered the slope failures.

Combining bathymetric with topographic data from unmanned aerial vehicle imagery, we found that most of these landslide deposits are relatively small (~ 0.08 km^2) and are associated with outwash fans and steep fiord sidewalls. However, since most slope failure head scarps lie between the intertidal zone and ~30 m water depth, they could not be mapped, which makes it challenging to determine the triggers of the submarine slope failures. Radiocarbon dating reveals that most of these surficial landslide deposits are younger than 500 years and that they were most likely triggered at different times. This finding highlights a high recurrence rate of slope failures within the fiord, suggesting that localised triggers are responsible for slope failures within the fiord, as opposed to widespread, seismically induced triggers which do not occur as frequently in the study area. In addition, the elongated morphology of the landslide deposits and the varying degrees of landslide deposit surface roughness supports localised point-source triggers. As most landslides are associated with subaerial outwash fans and deltas, we suggest that triggers of these relatively frequent submarine landslides within Pangnirtung Fiord include rapid floodwater input, subaerial debris flows, and sea-ice loading during low tide.

This research shows that slope failures in an Arctic fiord are affected by the interaction of numerous subaerial and submarine processes, leading us to speculate that a potential increase in the frequency of subaerial debris flows and river floods due to climate change may increase the recurrence of submarine landslides.

Pacing of Late Pliensbachian and Early Toarcian carbon cycle perturbations and environmental change in the westernmost Tethys (Betic Cordillera, Spain)

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Significant perturbations to the global carbon cycle from the Rhaetian (Triassic) to Toarcian (early Jurassic) time interval are recorded by short- and long-term, and smaller and larger amplitude positive and negative shifts in $\delta^{13}C$ from marine and terrestrial sedimentary archives. Two abrupt carbon cycle perturbations, reflected by negative carbon-isotope excursions (CIEs), occurred at the Triassic–Jurassic boundary (at ~201.5 Ma) and during the early Toarcian Oceanic Anoxic Event (T-OAE; at ~183 Ma).

The successions of positive and negative shifts in global $\delta^{13}C$ recorded in upper Pliensbachian and lower Toarcian sedimentary rocks worldwide are interpreted to reflect changes in the flux and source of carbon into the ocean-atmosphere system and sequestration of organic carbon into marine and continental sedimentary successions. These carbon cycling changes, directly affecting atmospheric pCO_2, are thought to have modulated contemporaneous climates and global temperatures. Despite the global nature of the late Pliensbachian and early Toarcian environmental changes, and the clear expression of these in marine and continental basins from both hemispheres, the interplay between global and local processes varies between sites, resulting in spatially different depositional conditions and, consequently, sedimentary records.

The low–mid latitude Jurassic basins of southern Iberia and the nearby northern Gondwana (e.g., Middle Atlas Basin) palaeomargins are thought to have been well connected to the western Tethys Ocean. Their palaeogeographical location and connection to the Tethys Ocean resulted in markedly different depositional conditions (organic-poor and without evidence of anoxia/euxinia) compared with the restricted to semi-restricted (generally organic-rich) northern European basins.

For this presentation, we use high-resolution elemental and isotopic geochemical datasets collected from marl–limestone alternations cropping out at La Cerradura (Subbetic domain, Betic Cordillera, Spain) to address the nature, and timing and pacing of (1) paleo-ocean chemistry and climate change and (2) global carbon cycle perturbations during the late Pliensbachian–early Toarcian on the south Iberian palaeomargin. We also compare and correlate the La Cerradura section with the reference Mochras borehole (Cardigan Bay Basin, UK).

Integrating coastal environments into our understanding of Early Cretaceous carbon cycle perturbations and oceanic anoxic events (OAEs)

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The late Aptian–early Albian oceanic anoxic event (OAE) 1b cluster is characterized by several carbon cycle perturbations and deposition of high TOC sediments in many locations worldwide. This OAE cluster was a significant event in the marine realm, associated with drastic changes in ecosystems and ocean chemistry. However, there is a wide gap in knowledge concerning the response of terrestrial and coastal areas to the environmental drivers of the OAE 1b cluster and the impact of changes in the flux of carbon in-and-out of these depositional environments on the global carbon cycle.

The Upper Aptian–Lower Albian in the Isle of Wight (Wessex Basin, United Kingdom) comprises a thick sedimentary succession of sands and mudstones (the Ferruginous Sands, Sandrock, and Monk's Bay Sandstone formations of the Lower Greensand Group) deposited in estuarine and shallow marine shelf environments. This study investigated the Upper Aptian–Lower Albian successions cropping out along the southwestern Isle of Wight, analyzed for total organic carbon (TOC), organic matter programmed pyrolysis, and $\delta^{13}C_{TOC}$.

In this presentation, we discuss potential implications of coastal environments on global organic matter storage and atmospheric carbon feedback during the OAE 1b cluster. We will draw some parallels with the Scotian sedimentary

successions. The integration of our findings from the Early Cretaceous coastal palaeoenvironments in both sides of the Atlantic margins with current modelling efforts will help to clarify the impact of estuaries and wetlands on climate change, carbon cycle perturbations, and OAEs and help elucidate the factors contributing to present-day issues of coastal anoxia expansion and tidal wetland loss.

Potential for critical mineral deposits in Maine with applications to the Maritime Provinces, Canada

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The increasing global emphasis on green technologies demands the mining of known critical mineral deposits and the exploration for undiscovered resources of these commodities. In Maine, known critical mineral deposits of significant size and/or grade are limited to the sediment-hosted Mn-Fe deposits of Silurian age in Aroostook County in the northeast part of the state (largest known Mn resource in the USA), and the pegmatite-hosted Li deposit of Permian(?) age at Plumbago Mountain in the southwest. Small deposits and occurrences of other critical minerals in Maine, long documented, include those of Cr, Co, Mo, Sb, W, and U. Importantly, however, potential exists for the discovery of larger—and potentially economic—resources of these critical minerals, including (1) Cr (and PGE) in the Ordovician Boil Mountain ophiolite; (2) Co in magmatic sulphide deposits associated with Devonian mafic intrusions (e.g., Moxie pluton); (3) Sb in tectonically controlled vein deposits within Silurian metasedimentary rocks (Bangor area); (4) W in skarns related to Devonian granites (western Maine); and (5) U (and Th) associated with two-mica granites of Carboniferous age in southwestern Maine; these granites, and other small alkaline to peralkaline plutons in southern Maine, also have potential for deposits of Sn, REE, Nb, nd/or Ta. A potential for V may exist in some Ordovician black shales such as those of the Penobscot Formation near the coast; volcanic-hosted Be deposits might occur in Devonian rhyolitic tuffs along the coast. Successful exploration programs for these critical minerals, and others, should carefully integrate geological, geochemical, and geophysical data with those for known deposits, prospects, and mineral occurrences—the last including even those of interest mainly to specimen collectors. Very important are relevant descriptive and genetic models for giant deposits occurring in analogous geologic settings, regardless of location; e.g., the largest Sb orebody in the world is a tectonically controlled vein deposit in South China, for which detailed information in the western literature has only been published recently.

Metallogenic implications for Maine derived from the Maritimes include those of significant deposits in western New Brunswick such as Battery Hill Mn-Fe, Lake George Sb-Au-W-Mo, and Mount Pleasant W-Mo-Bi-Sn. In turn, the metallogeny of Maine offers insights into potential for these and other critical minerals in the Maritimes. Selected applications will be presented for diverse deposit types with a focus on those containing generally under-emphasized critical minerals including Be, Sb, and V.

Wallrock alteration and gold-bearing vein paragenesis of a Meguma-hosted gold deposit: Goldboro, Nova Scotia, Canada

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Sediment-hosted orogenic Au deposits are some of the largest orogenic Au systems in the Phanerozoic (e.g., Victorian Gold Belt, Sukhoi Log). Despite their importance, the understanding of the lithogeochemical and mineralogical footprint of such hydrothermal systems is not well understood, particularly so for Meguma-type Au deposits. Here, we present results from an ongoing lithogeochemical study of the Goldboro Deposit in Nova Scotia.

At Goldboro, mineralization is associated with quartz veins in the crests and limbs of upright anticlinal domes, along greywacke-mudstone contacts of the Upper Seal Harbour anticline. Hydrothermal alteration of the vein-proximal mudstones includes biotite, chlorite, albite, muscovite arsenopyrite, and trace carbonates and mass change calculations illustrate that the wall rocks exhibit enrichments in K_2O, Fe_2O_3, Na_2O, and As proximal to mineralization. Additionally, unlike other Meguma-type deposits, there are four distinct quartz vein generations at Goldboro: two syn-deformational, reef-type veins, and two younger vein stages that infill cleavage fractures and crosscut pre-existing veins. The two younger veins consist of an initial stage of stringer-type veinlets of ankerite, pyrite, and quartz, and fracture-filling chlorite, biotite, K-feldspar, albite, ilmenite, tourmaline, and gold. Thus, the relative timing of these veins raises questions regarding the source(s) of K, Na, REE, Ti, and Au, and perhaps provides evidence for gold deposition late in the paragenetic history of gold mineralization in Goldboro, as has been suggested by previous workers in the Meguma zone.

The disappearance of Slade Lake, Cumberland County, Nova Scotia, Canada

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Slade Lake is a 1.5 km-long, 200 m wide body of water situated adjacent to the TransCanada Highway 104 between exits 5 and 6 in Cumberland County, Nova Scotia. The lake resides within a well-defined belt of Windsor Group karst topography that extends approximately 5 km southwest from the Town of Oxford. In early May 2020, it was reported that the water level within Slade Lake had dropped significantly. The area was subsequently surveyed in late May using a DJI Phantom 4 RTK Remotely Piloted Aerial System (RPAS), more commonly known as a drone. The RPAS survey data were used to produce a 0.25 m contour surface of the recently exposed lakebed. This new surface model was compared to a provincial LiDAR-derived digital elevation model that correlated to a time when maximum water levels were observed in the fall of 2019. A volumetric analysis was then completed using the two surfaces with a resultant total draw down of 783 280 m^3 of water between October 10, 2019 and May 27, 2020. Water levels continued to drop for the remainder of 2020 exposing a number of karst features such as sinkholes and vertical solution pipes that likely served as natural drainage outlets for Slade Lake. A review of Landsat imagery dating back to 1984 indicates the lake is subject to periodic fluctuations of water levels. Future monitoring of the karst belt will be used to examine the frequency of change, physical characteristics, and associated risk of karst activity to the surrounding area.

Analysis of Vertical Electrical Sounding (VES) data over a prospective geothermal area in Turkey

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Geophysical methods are one of the important disciplines to delineate geothermal resources. Among the geophysical methods, geophysical electrical methods play a vital role by determining the resistivity, which depends on temperature and fluid content and is therefore a key variable in geothermal systems. In this study, data from 384 Vertical Electrical Soundings (VES) were analysed, to determine heat sources and structure of the geothermal area in the Afyon-Sandikli graben, Turkey.

This study applied 1D and 2D inversion techniques in an effort to generate resistivity models of geothermal system. Prior to inversion, the raw resistivity data was characterized in terms of elevation changes in the study area, smoothness of the resistivity sounding curves, consistency between neighbouring sounding curves and their nearness to faults. Considering all these criteria, 1D resistivity models were obtained. Many of the soundings were arranged at even intervals along lines. Such linear arrangements of soundings were used for 2D inversion. The resulting models are compared and discussed in terms of resistivity distribution in the geothermal system.

Field and petrographic reports on mineral exploration at Castle Frederick, Nova Scotia, Canada

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Mineralization in the South Mountain Batholith (SMB) occurs near an unconformable contact with overlying sedimentary rocks of the Horton Group. Government reconnaissance (2006) discovered sulphide mineralization filling linear fractures in SMB monzogranite which is exposed in a quarry situated a few kilometres from Castle Frederick Road, near Windsor Junction. The Castle Frederick (CF) prospect is centred on the quarry. Vein orientation is dominantly flat-lying or vertical, and displacement is not easily measured. The average (n = 30) vein width is about two centimetres. Ground cover obscures the lateral extent of vertical veins and flat-lying veins extend a minimum of 10 m. In order of decreasing abundance, vein minerals include pyrite, quartz, galena, and barite. Mineral textures at CF range between unaltered hypidiomorphic granular to megacrystic (feldspar) porphyry. Vein quartz and primary SMB quartz in contact with vein selvages host fluid inclusions (FI). In the oral presentation, mineral textures and FI solute chemistry will be discussed. To characterize the CF geological setting, the granitoid facies exposed in the quarry headwall will be petrographically compared to a SMB-Meguma contact facies. Modal biotite in the porphyry significantly exceeds the compositional range of peraluminous felsic intrusions (e.g., SMB). Feldspar alteration ranges from minimal to

extreme and is clarified by examining polished sections. Results from core sample analysis will be presented. The objective of future exploration work is to grid survey the CF prospect and surrounding claim area using advanced geomagnetic techniques.

A Global Navigation Satellite System (GNSS) system for monitoring ground movement

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Global Navigation Satellite System (GNSS) receivers that monitor multiple satellite constellations (GPS, Glonass, Galileo) have become nearly ubiquitous in mobile applications such as phones and cars and in surveying applications. This mass market has resulted in the availability of small, low-power, and low-cost receivers. Real-time kinematic (RTK) positioning is a commonly used method to improve the positioning accuracy of GNSS receivers from what would normally be a few metres, down to centimetres. In applications where the receiver is stationary or normally moving slowly, multiple readings can be averaged on a daily timescale to achieve millimetre-level accuracy. Such a system is ideally suited for applications such as slope and dam monitoring, landmass deformation due to oil and gas extraction, or monitoring for sinkholes in karst topography. In the past such systems have required expensive solar panels and associated cabling to run each of the receiver nodes. We are developing a new ultra-low power node that can run from a single battery for a duration of several months. The system consists of a single base station that communicates with the outside world via satellite or internet and multiple, unwired nodes or monitoring stations. The nodes can be positioned up to 2 km from the base, allowing a large area to be monitored.

Kinematic models for the northern Appalachians and Caledonides

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Appalachian-Caledonide orogen development has been traditionally illustrated using cross-sections showing terrane accretion and collision over time. This approach is valuable but leads to implicit assumptions: subduction was initiated at passive continental margins; convergence was mainly orthogonal; terranes and zones had ribbon-like geometry parallel to continental margins; and present-day orogen geometry is a valid "end point" for reconstructions. Post-Pangea tectonic evolution provides little support for these assumptions. We will use GPlates software to display alternative, more actualistic kinematic models.

We will include in this analysis several previously under-utilized data sets: (1) Estimates of late Paleozoic and Mesozoic plate motions, to restore a valid mid-Devonian geometry from which to build back in time; (2) Reviews of legacy biostratigraphic data using calibrated time scales to place sedimentary units accurately relative to isotopically dated igneous units; (3) A review of paleomagnetic information including both declinations and inclinations, so as to evaluate systematic vertical-axis rotations as well as latitude changes; (4) A compilation of detrital zircon data using newly developed display techniques to show proximity of terranes to major continental blocks that are the best candidates for sedimentary provenance.

Preliminary results suggest that terranes attributed to Ganderia and associated Gondwana-derived arcs crossed the Iapetus in several pieces, arriving at the Laurentian margin at different times from Ordovician to Devonian. Portions of "Ganderian" and "Avalonian" continental crust may have been juxtaposed during Penobscottian convergence on the margin of Gondwana. The Taconian orogeny is explained as the result of a diachronous arc-continent collision that involved both Laurentia-derived and Gondwana-derived units. It was followed by subduction-polarity reversal at the Laurentian margin. Salinian deformation resulted from subduction-accretion of terranes at this margin, over a period of time lasting from the Late Ordovician nearly the end of the Silurian Period. Acadian deformation resulted from sinistral and convergent motions at an Early Devonian along-margin boundary that may have varied from transpressional in New England to ideal strike slip in Britain and Ireland.

Characterization of polymetallic vein-type Meguma Au deposits: Meguma's lesser-known Au deposit type

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This study focuses on three Au-bearing, polymetallic (Sb-Pb-Zn-Co-Ni-Cu-Bi-Ag-Au) vein occurrences in the western Meguma terrane with a suspected, but unproven, genetic link. The aim is to understand how the occurrences formed, including their timing, sources of metals, and relationship to other Meguma Au deposits and metasedimentary-hosted polymetallic vein deposits globally (e.g., Sb-Au deposits of the Bohemian Massif, Variscan Orogen, Europe).

At the Lansdowne and Cape St. Marys (CSM) occurrences in Digby County, Bear River Formation metapelites are intruded by gabbro (~440 Ma; apatite U–Pb) and crosscut by quartz ± carbonate veins, some of which host multi-stage, sulfide-sulfosalt mineralization. At Lansdowne, mineralization crosscuts the early quartz veins and consists of an early Fe-As stage (pyrite-arsenopyrite-pyrrhotite), a Zn-Cu stage [(Cd-rich) sphalerite-chalcopyrite], and a later Pb-Sb stage (boulangerite-jamesonite-galena) with multiple generations of quartz-calcite-chlorite gangue. Arsenopyrite thermometry indicates temperatures of 425–450°C, while chlorite of the Zn-Cu stage provides a lower temperature of 350–390°C. The latest chlorite provides a temperature of 120–160°C. Isocon diagrams generated using least- and most-altered samples from the mafic intrusions and metapelites indicate variable depletion in the above metals (except Sb, which was gained), potentially indicating these rocks as metal sources.

At the CSM stibnite occurrence, siderite infilled-breccia hosts mineralization and crosscuts earlier, brittle-ductile deformed quartz veins in Bear River Formation metapelite. Mineralization consists of an early As±Co-Ni stage [arsenopyrite-(Co-rich) gersdorffite], followed by a Cu-Sb-Ag stage [tetrahedrite-(Ag-rich) freibergite], a Cu-Sb-Bi stage (chalcopyrite, Bi-Sb alloy) and late REE-P alteration (florencite-pyrite). At the Mavillette Beach occurrence, Pb-Sb mineralization (boulangerite-jamesonite-galena) is observed in quartz-pyrite veins.

At the Nictaux Falls Dam occurrence, variably mineralized quartz veins and quartz-infilled breccia cut Kentville Formation metapelites, near their contact with the South Mountain Batholith (370 Ma), diabase dykes, and a gabbro intrusion (~380 Ma; apatite U–Pb). Mineralization consists of early pyrite, a zoned Fe-Co-Ni-As stage (arsenopyrite-cobaltite-gersdorffite) with chlorite (~280°C) and rutile, and late-stage electrum.

The mineralogy, paragenesis, metal associations, and ore textures are distinct from typical Meguma Au deposits. The occurrence of mineralization in breccias and mineral thermometry suggest their formation in relatively shallow crustal environments at moderate to high temperature. Striking similarities are noted between Lansdowne and CSM and the West Gore Sb-Au deposit (Hants Country, Nova Scotia) in terms of mineralogy and paragenesis. Future work includes Re–Os dating of arsenopyrite and trace element work on ore minerals to compare with similar deposit types.