

GAC-MAC 2026



St. John's
Newfoundland & Labrador

May 25-28

JOINT ANNUAL MEETING



ABSTRACT COMPILATION



GEOLOGICAL
ASSOCIATION OF CANADA
ASSOCIATION
GÉOLOGIQUE DU CANADA



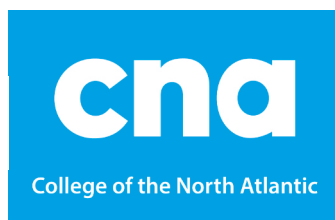
MINERALOGICAL
ASSOCIATION OF CANADA
ASSOCIATION
MINÉRALOGIQUE DU CANADA

THANK YOU TO OUR SPONSORS

PLATINUM



DIAMOND



GOLD



SILVER



CIBC PRIVATE WEALTH
WOOD GUNDY



BRONZE



Chronology, kinematics, and thermal conditions of the Saint-Fulgence Shear Zone, central Grenville Province, Quebec, Canada

Brahim Aajli¹, Renaud Soucy La Roche¹, Abdelali Moukhsil², Francis Talla Takam², Jim Crowley³, Kyle Larson⁴

¹Institut National de la Recherche Scientifique, ²Ministère des Ressources naturelles et des Forêts, ³Boise State University, ⁴University of British Columbia Okanagan.

E-mail: brahim.aajli@inrs.ca

The ~400 km long, 8–10 km thick Saint-Fulgence Shear Zone in the Saguenay-Lac-Saint-Jean region of Quebec, Canada, records multiple deformation phases related to the Grenvillian orogeny. It dips moderately to the SE or E and records dextral ($\pm$ reverse) displacement. Mylonitic fabrics developed in paragneiss are defined by high-temperature mineral assemblages including garnet, sillimanite and K-feldspar. Sillimanite commonly occurs as fibrous to acicular crystals forming C-S-C' fabrics or sigmoidal aggregates. Chessboard extinction and grain boundary migration in quartz and diffusion creep in monomineralic K-feldspar fish indicate deformation temperatures exceeding 630°C, consistent with quartz crystallographic <c>-axis preferred orientation opening angle thermometry from asymmetric (dextral) distributions (650–800°C). Lower temperature microstructures, including quartz subgrain rotation (400–500°C), are associated with sinistral shearing along rare narrow planes that overprint and are parallel to dextral mylonites. U–Pb zircon dating from an asymmetric (dextral), foliation-parallel leucosome pod within a metapelite yields a crystallization age of 1061 ± 7 Ma. Ti-in-zircon thermometry from zircon autocrysts indicates that crystallization took place at ~690°C. This value is consistent with high-temperature deformation microstructures (grain boundary migration, chessboard extinction) developed at the leucosome margins, indicating that shearing occurred during or shortly after leucosome crystallization, providing a pre- to syn-shearing time constraint. In the host metapelite, monazite grains are restricted to the margins of sigmoidal sillimanite aggregates and biotite-rich asymmetric pressure shadows around them. All three minerals are interpreted to have formed during shearing, and ongoing in situ U–Pb dating of monazite grains is expected to provide a direct chronological constraint on the timing of shearing.

Revisiting the uranium metallogensis of the eastern Appalachians: New perspectives on old data from Nova Scotia, Canada

Erin Adlakha, Shawna White, Jacob Hanley

Saint Mary's University.

E-mail: erin.adlakha@smu.ca

In 1975, a regional geochemical survey of well water within Carboniferous sedimentary rocks in Nova Scotia revealed significant U anomalies, triggering a period of intensive mineral exploration from 1976 to 1981. This activity was halted in 1981 by a provincial moratorium on the exploration and mining of materials exceeding 0.01 wt.% U — a ban later codified into legislation in 2009. For over four decades, this restriction stifled research and limited access to samples. However, in March 2025, the Government of Nova Scotia lifted the ban to stimulate the exploration of critical minerals. This study re-examines historical datasets through the lens of modern ore-system models to provide fresh insights into the U metallogensis of the Avalon and Meguma terranes, as well as the overlying Maritimes Basin. We categorize and discuss three primary occurrence types: (i) vein-hosted U–Cu occurrences associated with late-stage peraluminous leucogranites of the South Mountain Batholith. These occurrences likely resulted from a combination of magmatic–hydrothermal and supergene processes within the Paleozoic metasedimentary rocks of the Meguma terrane. (ii) So-called “volcanic-associated” occurrences located within the Avalon terrane of the Cobequid Highlands. Elevated alkali and copper concentrations in historical assay data suggest these may have affinities with albitite-hosted U or iron oxide copper–gold (IOCG) systems. (iii) Sandstone-hosted U–Cu occurrences situated within the Pictou Formation of the upper Maritimes Basin. We evaluate competing genetic models, ranging from supergene weathering to the migration of evolved marine brines expelled from the lower Windsor Group during salt tectonics.

Evaluating possible basement structural controls on the Dundas Buried Valley (Hamilton, Ontario) using land-based gravity surveys and 2-D modelling

Keeley A. Aird¹, Joseph I. Boyce¹, Alexander L. Peace¹, Hernan Ugalde^{1,2}, William A. Morris^{1,3}, Ethan T. Davies¹, Benjamin Michalchuck¹

¹McMaster University, ²DIP Geosciences, ³Morris Magnetics Inc.

E-mail: airdk@mcmaster.ca

The Dundas Buried Valley (DBV) is a deeply incised buried bedrock valley located at the western end of Lake Ontario in the Hamilton–Wentworth region. Previous studies have identified thick (> 210 m) Quaternary infill sediments and evidence for faulting of the Paleozoic bedrock valley floor. The aim of this study is to better define the extent and subsurface geology of the DBV and to evaluate possible Precambrian basement structural controls using gravity surveys and geophysical modelling. The project database includes Bouguer gravity (> 580 stations), multi-channel seismic reflection profiles and LiDAR digital topographic data (0.5 m). The preliminary Bouguer gravity map identifies a west–east-trending Bouguer gravity low defining the valley thalweg, which aligns with a broad aeromagnetic lineament (Hamilton-Presqu'île Fault) in western Lake Ontario. Seismic reflection profiles show faulting of the Ordovician bedrock surface with apparent vertical offsets of up to 50 m. Mapping and 2.5-D forward gravity profile models are being employed to determine the valley form and depth, and to assess spatial relations between Paleozoic bedrock faults and basement magnetic lineaments. The Hamilton region is one of several earthquake clusters in south-central Ontario that have been linked to neotectonic reactivation of basement fault structures. Evaluation of bedrock faulting and structural controls on the DBV is key to understanding intraplate tectonic processes and seismic risk within the region.

Composition isotopique et géochimique des sulfures du gisement de VMS Boundary, Terre-Neuve

Rayan Alam¹, Crystal LaFlamme¹, Stephen Piercey²

¹Université Laval, ²Memorial University of Newfoundland.

E-mail: raala15@ulaval.ca

Malgré une lithostratigraphie, une lithogéochimie et un cadre tectonique bien documentés, le gisement VMS Boundary (0,45 Mt @ 3,5% Cu, 4% Zn, 1% Pb, 34,0 g/t Ag) possède des lacunes quant aux sources des métaux et des fluides hydrothermaux. Conséquemment, ce projet vise à déterminer la paragenèse des sulfures et leur composition chimique et isotopique au sein de l'horizon minéralisé, afin d'identifier la source du soufre et des métaux, et déterminer les processus de minéralisation. Les observations pétrographiques montrent trois générations de pyrite : 1) pyrite framboïdale précoce, 2) pyrite colloforme avec des agrégats de framboïdes soudé arrivée en même temps que sphalérite et chalcopryrite, 3) pyrite idiomorphe tardive. La cartographie géochimique montre que la pyrite framboïdale est enrichie en Te (≈ 800 ppm), Bi (≈ 1000 ppm), Ni (≈ 100 ppm), As (≈ 1000 ppm) et Ag (≈ 750 ppm), que la pyrite colloforme est enrichie en W (≈ 200 ppm), Cu (≈ 3000 ppm), Mn (≈ 8000 ppm) et As (≈ 800 ppm) et que la pyrite idiomorphe est appauvrie en ces éléments. L'isotopie du soufre ($\delta^{34}\text{S}$) montre des valeurs moyennes de +2,3‰ pour la pyrite framboïdale ($n = 18$), +12,4‰ pour la pyrite colloforme ($n = 8$), +16,6‰ pour la pyrite idiomorphe ($n = 8$) et finalement de +7,1‰ ($n = 9$) pour la chalcopryrite. La faible valeur de $\delta^{34}\text{S}$ mesurée dans la pyrite framboïdale suggère une source de soufre reliée à la réduction bactérienne du sulfate (BSR) et leur enrichissement en métaux en fait également un réservoir significatif de métaux. L'enrichissement en ^{34}S observé entre les textures framboïdales vers les pyrites colloformes + chalcopryrite suggère une contribution majeure du sulfate de l'eau de mer lors du processus de formation de VMS. Ceci indique que l'eau de mer et les sédiments environnants ont pu constituer des réservoirs importants de soufre et de métaux associés à la minéralisation.

The Cadomian accretionary orogen in the Iberian Peninsula

J. Javier Álvaro¹, Josep Maria Casas², Cecilio Quesada³

¹Instituto de Geociencias-Universidad Complutense de Madrid, ²Universitat de Barcelona, ³Instituto Geológico y Minero de España.

E-mail: jj.alvaro@csic.es

The Cadomian accretionary orogen in Iberia constitutes the basement of the Variscan Iberian Massif and the neighbouring Alpine mountain ranges, such as the Pyrenees. Subduction of the Mirovoi Ocean beneath NW Gondwana led to the onset of an arc system that was finally accreted to the continental margin. In the Iberian Massif, a complex Cryogenian–Fortunian arc/back-arc system is preserved in the Ossa-Morena Zone, whereas a thick Ediacaran–Fortunian infill of a vast retro-arc basin, developed as a result of arc accretion, is exposed in the Central Iberian, West Asturian-Leonese and Cantabrian zones, defining a proximal (hinterland) to distal (foreland) transect. Wedge-top, foredeep and forebulge basin domains may be recognized in the foreland basin. The Cadomian suture zone is currently exposed along the Variscan-age Badajoz-Córdoba shear zone lining the Ossa-Morena/Central Iberian zonal contact. The suture materialized by an accretionary unit consisting of high-pressure metamorphic rocks and dismembered ophiolites, which is sandwiched between an underlying Gondwana margin parautochthon (lower plate) and an overlying Ossa-Morena-like arc/back-arc unit (upper plate). This geometric superposition implies a southward polarity of the subduction responsible for the accretion, i.e. antithetic to the main subduction beneath Gondwana responsible for the development of the Cadomian arc. In contrast, the uppermost Ediacaran volcano-sedimentary complexes recorded in the eastern Pyrenees and the neighbouring northern Montagne Noire (French Occitanie) represent a different distal retro-arc basin. It should be linked to the Brioverian successions recognized in the Armorican Massif, assigned variously to intra-arc, forearc and continental margin settings depending upon the selected tectonic model.

The Avalonian arc-to-rift transition hidden in Fortune Bay, Newfoundland

J. Javier Álvaro¹, Andrea J. Mills²

¹Instituto de Geociencias-Universidad Complutense de Madrid, ²Geological Survey of Newfoundland and Labrador.

E-mail: jj.alvaro@csic.es

Understanding the arc-to-rift transition in the aftermath of accretionary orogens is difficult because it involves overlapping processes that operate on different timescales and depths, including changes in stress regimes, magmatism and lithospheric strength. These signals often overprint earlier subduction-related structures, effectively masking when and how a convergent margin reorganizes into an extensional system. The case study recorded in the Avalon Zone of SE Newfoundland is not an exception. There, the Avalonian basement rocks are dominated by voluminous upper Neoproterozoic (ca. 640–570 Ma), arc-related volcano-sedimentary successions and granitoid units. Before the widespread establishment of Cambrian rifting conditions, the 570–550 Ma interval in Fortune Bay reflects an arc-to-rift transition characterized by bimodal igneous rocks and continental (mainly alluvial and lacustrine) to marine deposition. The sea cliffs and rocky foreshore areas along northern Fortune Bay provide excellent, continuous exposure of the Long Harbour Group (Belle Bay, Andersons Cove and Mooring Cove formations) and the unconformably overlying Rencontre Formation. These units comprise subduction-related calc-alkaline basalts and rift-related tholeiitic to alkaline mafic and felsic igneous suites reflecting the development of extensional to transtensional, fault-bounded troughs. The steep paleo-relief was finally sealed by transgressive, open sea, shoreface to offshore strata (Rencontre–Chapel Island transition) allowing the immigration of burrowing soft-bodied and shelly metazoans characteristic of the Ediacaran–Cambrian boundary interval (GSSP at Fortune Head).

Two distinct events of pegmatite formation in the Lac Jacques pegmatite swarm, central Grenville Province (Lac-Saint-Jean region, Québec): Implications for rare metal mineralization (REE–Nb–Th–U) in Grenvillian anatectic pegmatites

Pedro Alves¹, Bertrand Rottier¹, Crystal LaFlamme¹, Abdelali Moukhsil², Joshua Davies³, Morgann Perrot⁴

¹Université Laval, ²Ministère des Ressources naturelles et des Forêts, ³Université du Québec à Montréal, ⁴McGill University.

E-mail: pedro.alves@ggl.ulaval.ca

Multiple rare metal (REE–Nb–Th–U) granitic pegmatite dykes are hosted in the hinterland of the central Grenville orogen. They were formed continuously between ~1060 and 970 Ma by differentiation of anatectic melts derived from multiple sources. The Lac Jacques pegmatite swarm, located in the Lac-Saint-Jean region (Québec), is a typical example of LREE–Nb–Th-rich pegmatites. It consists of > 100 undeformed granitic dykes intruding a deformed/migmatized metagabbro. Two main groups of pegmatites are recognized: syenogranitic and pink granitic dykes. Both are weakly peraluminous, high temperature (~700–800°C), and relatively oxidized ($\Delta_{\text{NNO}} = 1.2\text{--}2.5$), but only the pink pegmatites are mineralized. Leucosomes occur in situ along the foliation of the metagabbro and as mobilized melts crosscutting it. LA-ICP-MS zircon U–Pb dating coupled with Lu–Hf isotope and trace element analyses were conducted on the metagabbro, in situ and mobilized leucosomes, and both pegmatite types. The metagabbro ($\epsilon\text{Hf}(t) \approx +7.3$) yields a metamorphic age that overlaps, within uncertainty, the crystallization age of the in situ leucosome, both constrained at ~1100 Ma. This metamorphic age is interpreted to represent a late Shawinigan or early Ottawa orogenic phase. The mobilized leucosome yields a crystallization age of ~1060 Ma ($\epsilon\text{Hf}(t) \approx -0.4$), slightly older than the crystallization age obtained for the syenogranitic pegmatite of ~1050 Ma ($\epsilon\text{Hf}(t) \approx -1.7$). Their similar crystallization ages and $\epsilon\text{Hf}(t)$ signatures suggest that they were formed during the same anatectic event from similar sources, likely the ~1.6–1.3 Ga metaigneous rocks of the Allochthonous Belt. The pink pegmatite yields a crystallization age of ~1014 Ma and $\epsilon\text{Hf}(t) \approx -7.9$, consistent with partial melting of Archean–Paleoproterozoic rocks of the Parautochthonous Belt. The Lac Jacques swarm therefore records two distinct events of anatectic pegmatite formation, the first at ~1050 Ma (barren syenogranitic dykes) during the collisional stage, followed by the second at ~1014 Ma (LREE–Nb–Th-rich pink pegmatites) during the post-collisional stage of the Grenvillian orogeny.

Harmonizing rift domain terminology in the northeast Atlantic

Fenna Ammerlaan¹, Gwenn Peron-Pinvidic¹, J. Kim Welford²

¹Norwegian University of Science and Technology, ²Memorial University of Newfoundland.

E-mail: fenna.ammerlaan@ntnu.no

Rifted margins are formed as the continental lithosphere is stretched and thinned through rifting and replaced by oceanic lithosphere when break-up is complete. It is commonly accepted that rifted margins can be partitioned into distinct structural domains based on their tectono-magmatic architecture – namely the proximal, necking, distal, outer and oceanic domains. However, consensus on how to define the boundaries between these different domains is currently lacking. This results in inconsistent terminology, limiting cross-margin comparison and hindering the application of a unified framework. A major obstacle linked to this terminology ambiguity is the dependence of the domain boundary on its underlying data type. Geophysical, seismic or field data will inherently lead to different boundary locations. To address this issue, we compile and synthesize previously published boundaries with the aim of constructing unifying definitions. The Northeast Atlantic region is the focus of our study, encompassing the NE Greenland and Norway and the SE Greenland and Faroe–Hatton–Rockall systems. This area is an ideal test laboratory as 1) it captures a complete extensional evolution cycle, from orogenic collapse to continental breakup, and 2) it benefits from extensive data coverage from previous hydrocarbon exploration, providing useful data constraints. Additional complexities such as microcontinents (e.g. Jan Mayen), failed rift basins (e.g. North Sea) and anomalous ridges (e.g. Faroe–Greenland) ensure that our framework is tested across a wide range of rift features. We filter the existing boundaries based on their uniqueness, data availability, objectivity and usefulness, to obtain broadly applicable definitions which will help in unifying the rifting terminology.

Covert signatures, missing signatures and untested anomalies revealed by new analyses of Labrador lake sediments

Stephen Amor¹, Roger C Paulen², Alana Hinchey³, Jessey M Rice², Martin McCurdy², Heather Campbell³

¹Consultant, ²Natural Resources Canada, Geological Survey of Canada, ³Geological Survey of Newfoundland and Labrador.

E-mail: steve.amor2007@gmail.com

The Geological Survey of Canada (GSC) and of Newfoundland and Labrador (GSNL) have operated a comprehensive archival program of geochemical samples, collected over many decades. A suite of 6636 organic-rich lake sediment samples, collected from a large region of northern and northeastern Labrador from the 1970s to the 1990s, has been reanalyzed by ICP–MS after a modified aqua regia digestion and published as GSC Open Files 8017, 8026 and 8962. These new geochemical analyses have added value to the lake sediment samples through improved detection limits and the inclusion of elements not previously analyzed, such as suites of rare earth and other critical elements. A number of hitherto unknown or partly known anomalous features have been identified, and more detailed fingerprinting of dispersion patterns has been facilitated. Profiling, filtering and smoothing techniques have revealed that dispersion patterns of varying strength characterize some rock types of distinctive composition and many known mineral occurrences. The latter include the Voisey's Bay Ni–Cu–Co deposit, which lacks a distinctive surficial geochemical signature as indicated by other analytical methods. In contrast, the response to other well documented mineralized occurrences, such as the U occurrences at Kitts and Moran Lake, are weak to absent. Bedrock sources that account fully for other strong anomalies have not yet been identified, for example at Croteau Lake, at the west end of the Central Mineral Belt. It is important to take into account that the geochemical results were derived from glacial sediments formed from one or more erosional and depositional events; nevertheless, where responses can be confidently associated with bedrock of distinctive composition, displacement distances appear to be relatively short on a regional scale. These new analyses provide a broad geochemical footprint in eastern Canada and should find application in future exploration programs, as demand for critical elements continues.

Supporting municipal groundwater management through real-time telemetry groundwater monitoring systems

Kristina Anderson

Peel Region.

E-mail: kristina.anderson@peelregion.ca

The Region of Peel (the region) is an upper tier municipality in southern Ontario, located within the Greater Toronto area, and consists of three municipalities – the cities of Mississauga and Brampton as well as the town of Caledon. The region slopes from the high elevation areas of the Niagara Escarpment and the Oak Ridges Moraine in the north (Caledon) down to the shore of Lake Ontario in the south (Mississauga). While a lake-based municipal distribution system supplies the cities of Mississauga and Brampton, four groundwater-based municipal distribution systems supply Caledon. The four groundwater-based drinking water systems span across ten villages, hamlet and rural services centres within Caledon and are generally referred to by the largest communities each system serves (Alton–Caledon Village, Caledon East–Palgrave, Inglewood and Cheltenham). The Greenbelt, established in 2005, covers a significant portion of Caledon. The Greenbelt Plan works alongside the Oak Ridges Moraine Conservation Plan and the Niagara Escarpment Plan. Key purposes of the Greenbelt Plan include protection of agricultural land from urban encroachment and environmental protection including water resource security and biodiversity conservation. In addition to land use policy protection, the region operates a groundwater monitoring system to protect its water supply. The groundwater monitoring system provides an early warning detection of water quantity threats such as drought and water quality threats such as contamination. The region's groundwater level monitoring system comprises 160 monitoring stations. Historically, the region conducted groundwater monitoring in-house, but in the summer of 2023 the region launched the implementation of real time technology successfully at over 75 core monitoring stations across Caledon. The data are automatically corrected, compensated and sent to a web application via telemetry for real time analysis and with the automated production of time series hydrographs.

A remote-predictive geological mapping approach to unraveling the recent tectono-magmatic evolution of the southern Reykjanes Ridge, North Atlantic

Melissa Anderson, Sofia Panasiuk

University of Toronto.

E-mail: melissao.anderson@utoronto.ca

Our understanding of the geological evolution of mid-ocean ridges in response to tectonic reconfigurations and associated mantle processes is hampered by a lack of exploration in off-axis areas. A notable exception is the Reykjanes Ridge, where multibeam bathymetry, magnetic and gravity surveys have been conducted up to ~150 km from the ridge axis. Previous work shows that the ridge has undergone a major reorganization following changes in spreading direction, resulting in the progressive formation and then elimination of transform faults from north to south under the influence of the regional mantle melting anomaly. Notably, this process is incomplete near the southern termination of the ridge, providing a window into processes of crustal accretion and segmentation prior to and immediately following this reorganization. Here, we employ remote-predictive geological and structural mapping methods linked to chrono-magnetic data to elucidate changes in segment morphology, magma supply and structural fabrics along the southern ~200 km of the ridge over the past ~11 m.y. We identify two new fracture zones and three new non-transform discontinuities, with elimination of transform motion occurring between ~9.7 and 4.2 Ma, which is later than previously thought. Transform elimination coincides with rift propagation and the emergence of a new magmatically robust segment at ~58°N at ~9.7–8.2 Ma. This transition is also associated with a reorientation of seafloor fabric from dominantly N-trending to NE-trending, associated with the dissection of axial volcanic ridges by the oblique (NE-trending) plate boundary, resulting in more crustal accretion to the North American plate overall. This work confirms previous models for episodic rift propagation and highlights the aftermath of the dynamic process of segment reorganization along a linear (oblique) plate boundary on the geology of the seafloor.

Mineral Exploration Team Project at the University of Saskatchewan: Successful student interactions with industry over the last 24 years

Kevin Ansdell

University of Saskatchewan.

E-mail: kevin.ansdell@usask.ca

Geoscience undergraduate students at the University of Saskatchewan can take a one-semester course in Mineral Deposits, during the latter stages of their program. The focus of the course is to provide an overview of models for magmatic and hydrothermal metalliferous deposits, but there is limited time to consider in detail the applicability of these deposits for exploration. In 2023, a new term project was initiated to allow students to use what they learn in the course, through summer work experience, and through discussion with industry personnel to develop an exploration strategy for a particular commodity. The aim was to allow the students to consider all aspects of the “real life” exploration industry, by targeting an unstaked area, and using a small budget to develop a one-year exploration program for their commodity. At the end of the semester, the teams present their ideas in front of about thirty members of the minerals community in Saskatoon, varying in seniority and experience, to decide the team that wins the “cheque” and trophy. The number of teams, and thus number of commodities explored for each year, depends on the size of the class, but over the last 24 years, the impact has been substantial. A total of 598 students distributed over 130 teams have outlined potential unstaked targets, at least at the time, across Canada and around the world. Graduates from the undergraduate program often consider this project to be the highlight of their university career, and alumni of the department, many of whom are working in the minerals industry in Saskatoon, now act as mentors for the teams and attend the final

presentations. The poster will highlight the locations of some of the targets identified by the teams and will emphasize that many of them are now staked by companies.

From rock to river: A luminescence-based approach using zircon and quartz to trace sediment provenance

Lily Rose Archambault, Magali Rizza, Joshua Davies

Université du Québec à Montréal.

E-mail: lilyrsearchambault@gmail.com

Tracing the pathway of sediments from their source to eventual sink in sedimentary basins is a key challenge in the geosciences and is crucial for understanding surface process dynamics. The minerals zircon and quartz are excellent tracers of sediment transport due to their high resistance to chemical and mechanical weathering and are often the target of sedimentary studies. Optically stimulated luminescence (OSL) is a key tool for characterizing sediment sources by linking luminescence properties to grain mineralogy (quartz, feldspar and zircon). Luminescence sensitivity is also strongly influenced by the processes involved in sediment transport and the trajectories of the grains within fluvial systems, an aspect that is explicitly exploited in this study. This project proposes an innovative, integrated approach that combines OSL analyses on quartz and zircon with U–Pb dating of the same zircon grains, to constrain variations in sediment provenance related to tectonic activity within a fluvial sedimentary succession. This methodology was tested on the Pakua fluvial terraces (Taiwan), where preliminary results suggest an abrupt shift in sediment sources, interpreted as a response to the emergence of the Pakua fold and associated local tectonic activity. The OSL measurements on quartz and thermoluminescence (TL) analyses on zircon were conducted to discriminate sediment sources within the different stratigraphic units. The results show a clear and consistent evolution of the quartz luminescence signal, confirming a significant change in sediment provenance. In contrast, although the zircon TL signal is reproducible across samples, it does not yet allow a clear discrimination of source variations. The U–Pb and geochemical analyses of zircon by LA-ICP-MS are currently ongoing and are expected also to provide important source information.

Recent discoveries of lithium–cesium–tantalum (LCT) pegmatite dykes in the Canadian Appalachians

Donnelly B. Archibald¹, James Conliffe², Kiersty M. Malay^{1,3}, Deepyaman Saha^{1,4}, Allison C. Howes¹

¹Saint Francis Xavier University, ²Geological Survey of Newfoundland and Labrador, ³Memorial University of Newfoundland, ⁴University of Western Australia.

E-mail: darchiba@stfx.ca

Lithium–cesium–tantalum (LCT) pegmatite dykes occur throughout the ca. 4000 km Appalachian–Caledonian Orogen. Here, we summarize the characteristics of areas that host recently discovered LCT pegmatite dykes in Atlantic Canada. Spodumene-bearing pegmatite dykes were discovered in 2023 approximately 9 km north of St. Stephen, New Brunswick. Field mapping identified one main dyke and discontinuous outcrop of pegmatite near Hayman Hill with the mineral assemblage spodumene, albite, muscovite, quartz, garnet, schorl, columbite and Li-phosphate. Preliminary muscovite Rb–Sr dating indicates that the dykes are ca. 390 Ma. In 2021, LCT pegmatite dykes were discovered in southern Newfoundland in two separate areas approximately 30 km north of the town of Burgeo. The Killick pegmatite field consists of at least 10 spodumene-bearing pegmatite dykes up to 15 m thick that are exposed over an area of ~1 x 2 km. The dykes are poorly zoned and are classified as albite spodumene sub-type pegmatites, with some areas containing approximately 10–50% spodumene crystals up to 15 cm long. The Hydra pegmatite dyke crops out 10 km northeast of the Killick pegmatites, is 8–10 m thick with distinct textural and macroscopic mineralogical zoning with extremely evolved compositions as shown by the presence of pollucite (Cs-bearing). The Hydra dyke contains at least 23 minerals with elbaite and lepidolite hosting most of the lithium. Preliminary geochronological data indicate that the Killick pegmatite field and the Hydra pegmatite dyke were emplaced during a single event at ca. 374 Ma. Spodumene-bearing pegmatite dykes are well known in Nova Scotia and adjacent New England, USA; however, the Hayman Hill, Killick and Hydra pegmatite dykes are the first documented occurrences of spodumene in New Brunswick and Newfoundland. Given the global necessity for additional critical element discoveries to support the decarbonization of energy systems, these new LCT pegmatite occurrences may represent important future resources.

The Whisker Valley Au–Te prospect: An alkalic-type epithermal gold prospect in the Baie Verte Peninsula, Newfoundland, Canada

Gabriel Ariza-Benavides, Stephen Piercey

Memorial University of Newfoundland.

E-mail: garizabenavi@mun.ca

The Whisker Valley gold prospect, located on the Baie Verte Peninsula, Newfoundland, Canada, represents a well preserved alkalic-type epithermal Au–Ag–Te system developed in a post-collisional setting. Gold mineralization occurs in steeply south-dipping, high-grade quartz veins enriched in Au–Ag tellurides and base metal sulfides, spatially controlled by rheological contrasts at contacts between mafic dykes and calc-alkaline plutonic host rocks of the Burlington granodiorite. The deposit is temporally and genetically associated with Mid- to Late Silurian alkaline magmatism of the King's Point Complex and a related alkalic monzonite intrusion which are products of slab break-off following arc–continent collision. Lithogeochemical data distinguish two distinct magmatic suites: Late Ordovician–Early Silurian calc-alkaline arc magmatism and younger post-collisional A-type magmatism product of slab break-off. Despite contrasting tectonomagmatic affinities, these units share similar REE patterns and isotopic characteristics, suggesting partial inheritance from remelted arc crust. Hydrothermal alteration is dominated by sericitic and propylitic assemblages, with minor distal calc-potassic alteration. Alteration intensity and mineralogy are strongly controlled by host rock composition, with felsic rocks favouring quartz–

sericite assemblages and mafic rocks developing chlorite–epidote assemblages. Integration of whole rock geochemistry, SWIR spectroscopy and mineral chemistry reveal systematic proximal–distal alteration zoning, including phengitic muscovite (> 2210 nm) and Fe–Mg chlorite (> 2250 nm) proximal to mineralization, grading outward to more muscovitic white mica (< 2210 nm) and Mg-rich chlorite (< 2250 nm). Chlorite–illite geothermometry indicates alteration temperatures of ~ 200 – 350°C . The dominance of Au–Ag tellurides, isotopic data and presence of neutral proximal alteration assemblages indicate that mineralization came from magmatic-dominated, neutral to slightly alkaline hydrothermal fluids. These characteristics distinguish Whisker Valley from other epithermal systems and highlight the exploration significance of post-collisional magmatism in the Baie Verte Peninsula.

The enigmatic deep conductive layer in the Iceland crust, electromagnetics complementary to seismics

Knutur Arnason

Reykjavik Academy.

E-mail: knutur.arnason@outlook.com

Magneto-telluric (MT) surveys in Iceland have revealed a deep conductive layer (DCL) at ~ 10 km depth and ~ 10 km thick under most of Iceland. When first observed, the DCL was interpreted as partial melt below a thin and hot crust. Later studies have shown that the crust is abnormally thick and cold, with the DCL as an intra-crustal layer. The DCL domes up beneath central volcanoes where seismics indicate presence of melt. Outside volcanoes, the DCL is a solid-state conduction in a cold and fluid-free middle crust below the brittle-ductile transition and does not correlate with any known seismic features. It has been found to be electrically anisotropic and more conductive in the spreading direction. A detailed resistivity and seismic study on the Reykjanes Ridge, ~ 950 km SW of Iceland, showed a thin and ~ 5 km wide layer of very low resistivity and seismic velocities under the dykes at the ridge centre, interpreted as a melt lens. It is underlain by a little wider and thicker zone interpreted as crystal mush. No anomalies were observed beyond 10 km from the ridge axis. A sea-bottom survey across the Mohs Ridge in the North Atlantic shows irregular low resistivity in the uppermost ~ 2 km, a ~ 15 km wide low resistivity zone between 10 and 30 km depth under the ridge axis and an asymmetric low resistivity in the deep mantle below 50–100 km. Sea bottom surveys on the Vøring Plateau, west of Norway, and the Exmouth plateau, offshore SW Australia, show similar DCLs like under Iceland. They have been attributed to solidified intrusions or sills during continental break-up by mantle plumes. Seismics have been the dominant methods for crustal studies. The observation of the DCL under Iceland is a clear example of the importance and complementarity of electromagnetic methods in crustal studies. A burning question is: does the DCL extend along the Greenland–Iceland–Faroe Ridge?

Testing deep marine sequence stratigraphic models using the Neoproterozoic Windermere Supergroup turbidite system in western Canada

Bill Arnott

University of Ottawa.

E-mail: warnott@uottawa.ca

Deep marine rocks of the Windermere Supergroup record a several kilometre-thick sedimentary pile that accumulated along the passive continental margin of Neoproterozoic Laurentia. Observations along a several 100 km-long depositional transect that stretches from upper slope canyons to deep basin floor deposits show a number of systematic changes, and therein the opportunity for comparison with established stratigraphic models. Slope deposits are dominated by leveed–channel complexes up to > 250 m thick. The base of most complexes is marked by a thickly developed succession of mass wasting deposits commonly containing stromatolite and oolite fragments, in addition to abundant carbonate-cemented sandstone and mudstone clasts representing remobilized sediment from an upslope shallow water carbonate platform (highstand/falling relative sea level). This is then sharply overlain by a stack of channels filled aggradationally (i.e. bottom up) with poorly sorted siliciclastic sediment (lowstand), in turn overlain by laterally accreting channels filled with moderately well-sorted siliciclastic and minor carbonate sediment (transgressive/highstand). This upward change in channel architecture is related to changes in the state of the shelf and its influence through mechanical reworking on the texture of sediment supplied for downslope transport, which then influenced turbidity current structure, and ultimately slope channel type. Farther basinward, basin floor deposits consist of intercalated decametre-thick “sheet-like” sandstone and mudstone layers. Sandstone layers are composed mostly of terminal splay deposits with lesser tributary channel complexes and rare feeder channels composed of sediment texturally similar to that on the slope. Mudstone layers are dominated by thinly bedded, upper division turbidites. Unlike the slope, basin floor stratigraphy shows no systematic temporal change in architecture. This suggests that the effects of eustatically controlled changes on sediment supply became attenuated and apparently completely filtered as flows descended the slope, ultimately resulting in a basin floor stratigraphy largely unaffected by upslope conditions but instead controlled principally by local seabed topography.

Integrated magnetic interpretation for depth and geometry analysis of the Harp Lake Intrusive Suite, Labrador

Marzieh Arshian

Geological Survey of Newfoundland and Labrador.

E-mail: marzieharsbian@gov.nl.ca

The Harp Lake Intrusive Suite (HLIS) is a large Mesoproterozoic plutonic complex in central Labrador, exposed as a massive elliptical body covering approximately 10,000 km². The intrusion is situated along a major crustal-scale boundary where the Archean Nain Province to the east and the Archean–Paleoproterozoic Churchill Province to the west were juxtaposed during the Torngat orogeny. The HLIS is dominated by anorthositic rocks, which comprise almost 80% of the exposed area, while granitoid rocks are minor and occur along the margins. Unlike comparable intrusive complexes

in which granitoid rocks form a preserved felsic roof, deep erosion at Harp Lake has removed much of this upper shell, leaving the anorthositic interior exposed at the surface. Aeromagnetic data over the HLIS define alternating magnetic highs and lows and steeply dipping to vertically oriented magnetic patterns indicate significant variations in magnetic susceptibility. Highly magnetic, vertically oriented gneissic rocks are exposed outside the northwestern margin of the intrusion, whereas the exposed anorthositic rocks of the HLIS are comparatively uniform. As a result, parts of the observed magnetic signature may reflect contributions from underlying magnetic basement rocks rather than from the exposed intrusive rocks alone. These characteristics complicate definition of the intrusion geometry and depth. This study applies an integrated framework to investigate the depth and geometry of the Harp Lake intrusion using aeromagnetic data. The approach follows advances in geologically constrained and surface-based inversion strategies, in which geological hypotheses are developed and tested iteratively through modelling rather than imposed as fixed inputs. Euler deconvolution is used as an initial depth-to-source analysis tool to guide construction of simplified geological starting models, which are subsequently refined using three-dimensional VPMg inversion. This ongoing research aims to establish a geological model for the Harp Lake intrusion and to improve understanding of magnetic responses associated with deeply eroded intrusions.

Evaluation of the North Mountain Basalt for carbon mineralization in Atlantic Canada

Adedapo N. Awolayo¹, Benjamin M. Tutolo², Jianwei Tian¹, Bohyun Hwang², Naya Davidson-Lindfors¹, Julia Nelsen¹

¹McMaster University, ²University of Calgary.

E-mail: awolayo@mcmaster.ca

Geological carbon mineralization in basaltic formations offers a durable and scalable pathway for long-term CO₂ sequestration. The North Mountain Basalt (NMB), a laterally extensive tholeiitic basalt sequence underlying parts of Nova Scotia and New Brunswick, has emerged as a promising candidate for in situ CO₂ storage, adding to the effectively inexhaustible global capacity for CO₂ injection into basaltic rocks. This study evaluates the CO₂ sequestration potential of the NMB, with the target formation occurring at shallow to moderate depths beneath the Bay of Fundy. We integrate core-scale characterization, laboratory water-rock-CO₂ interaction experiments and reactive transport simulations to assess both storage capacity and mineralization behaviour. Core samples retrieved from the Stellarton Core Repository reveal generally low bulk porosity (< 10%), pronounced heterogeneity across flow units, and widespread pore-filling alteration phases. High-resolution porosity characterization using small-angle neutron scattering and X-ray microtomography constrains effective pore networks relevant for fluid flow and reaction. Laboratory experiments demonstrate contrasting reactivity, with less altered basalt releasing higher concentrations of Ca and Mg for carbonate formation, while altered units exhibit enhanced pH buffering. Reactive transport simulations show that mineralization rates and storage efficiency are strongly controlled by lithologic heterogeneity and alteration state, with an estimate of the target layers storing substantial quantities of CO₂, reaching hundreds of megatonnes. These results highlight both the promise and the limitations of basalt carbonation in Atlantic Canada's NMB, underscoring the need to explicitly account for heterogeneity, alteration and injection strategies when evaluating large-scale deployment feasibility.

Deep learning for seismic fault interpretation with uncertainty information

Ayda Azad, Alison Malcolm, J. Kim Welford

Memorial University of Newfoundland.

E-mail: aaazad@mun.ca

Accurate fault interpretation from seismic data is important for structural model building, understanding reservoir compartmentalization and identifying fluid migration pathways. In practice, fault mapping is still often performed manually, which is time-consuming, subjective and prone to interpreter-to-interpreter variability and human error. Automated approaches can reduce interpretation time, but many methods still deliver a single best guess result and provide limited information about where the prediction may be unreliable, which restricts their use for quality control and risk screening under domain shift or poor data quality. This limits their value for quality control and risk screening, particularly in settings where decisions depend on distinguishing genuine structural features from noise, acquisition footprints or processing artifacts. In this study, we present an uncertainty-aware workflow for seismic fault interpretation that produces both fault maps and accompanying uncertainty information so that interpreters can prioritize review and validation. The workflow uses a U-Net-style convolutional segmentation model with a lightweight encoder, designed to remain practical when labelled data are limited. We train it on 2D seismic sections extracted from a real 3D volume offshore Newfoundland, Canada, and evaluate performance on a held-out test set from the same volume to measure in-domain accuracy. To assess transferability beyond the training setting, we then apply the trained approach directly, without additional training or recalibration, to independent seismic datasets that differ in geology, acquisition design and processing characteristics. After training, uncertainty is estimated through repeated stochastic evaluations of the same inputs, allowing us to compute both an average prediction and spatially varying uncertainty measures. We quantified performance using several metrics to test the reliability of our uncertainty maps. These maps effectively flag noisy zones and complex fault intersections, providing a robust decision-support tool that allows interpreters to focus their efforts on the most challenging structural features.

Ocean acidification in the Canadian Arctic and northern Labrador Sea and implications for Arctic marine life in space and time

Kumiko Azetsu-Scott¹, Evan Edinger², Barbara de Moura Neves¹, John O'Brien¹, Tyler Fountain²

¹Fisheries and Oceans Canada, ²Memorial University of Newfoundland.

E-mail: eedinger@mun.ca

The Canadian Arctic Archipelago (CAA) is a critical gateway linking the high Arctic and the North Atlantic. Ocean acidification (OA) in this region is driven by both pan-Arctic changes and local processes. This study examines the spatial and temporal variability of OA across the CAA and the Baffin Bay–Davis Strait gateway, and the patterns in sessile benthic fauna along that spatial gradient. Arctic outflow through the CAA contains a large fraction of Pacific-origin water with high dissolved inorganic carbon and lower salinity, making it inherently more acidic than Atlantic water. During transit, carbonate chemistry is further modified by riverine inputs, sea ice and glacial melt, terrestrial carbon, biological processes and uptake of atmospheric CO₂. Large-scale variability in OA reflects the distribution and mixing of source waters – Arctic outflow, Atlantic water and terrestrially influenced coastal waters – where freshwater inputs drive low pH and reduced calcium carbonate saturation. Seafloor methane seeps in Baffin Bay and the northern Labrador Sea further modify local OA conditions. Long-term observations show accelerated acidification on shelves and slopes with increasing intensity and spatial extent. Long-lived sessile benthic fauna display a reduction in coral diversity and a shift toward sponge and other invertebrate dominance with reduced carbonate saturation. Bedrock walls and similar geological settings in NW Baffin Bay – habitats that would host cold water corals in warmer or more saturated conditions – are instead dominated by sponges, including carnivorous sponges, or by echinoderms. Cold water corals whose skeletons or sclerites are exclusively internal and never exposed directly to seawater persist in undersaturated regions. Carbonate contents in soft coral skeletons are investigated across this carbonate saturation gradient. The Canadian Arctic and Northwest Atlantic offer a possible space-for-time substitution, to help understand the biotic consequences of high latitude ocean acidification events in the geological past or predict their effects in the Anthropocene.

Better living through modern trace element geochemistry

Michael G. Babechuk, Inês G. Nobre Silva

Memorial University of Newfoundland.

E-mail: mbabechuk@mun.ca

Commercially available trace element data have revolutionized applied geochemistry through making analytical solutions widely available for both research and industry needs, enabling large dataset acquisition and driving technological advancements in enhanced sample throughput. However, there remains an analytical divide in the achievable levels of detection and precision between commercial facilities and trace element-focused academic laboratories. While the latter are rare in Canada due to high costs for laboratory development and ownership and the expertise needed for their specialist operation, the data advantages they offer translate into an ability to uniquely solve some geoscience problems when the fit-for-purpose calls for the resolution of ultra-trace abundance trends. With the aid of federal and provincial funding, Memorial University of Newfoundland recently renovated some of its wet chemistry, sample preparation space to add a low-metal, HEPA-filtered clean laboratory. Following an initial period of blank and reference material testing, the laboratory has completed its first year of analyzing trace-element data. This contribution provides an overview of the laboratory infrastructure, the primary workflows and highlights application examples that include igneous petrogenesis, streamwater aqueous geochemistry, carbonate chemostratigraphy/diagenesis and the origins and authigenic modification of siliciclastic sediment. The latter examples were selected to emphasize the advantages in detection limits, precision (especially for low abundance elements like Ta, W, Ti) and working with unconventional sample aliquot sizes, offered by the laboratory environment.

Low sulphur concentrations in the Mackenzie Dykes and Coppermine River basalts based upon sulphur in clinopyroxene

Don R. Baker¹, Sara Callegaro², Andrea Marzoli³, Kalotina Geraki⁴

¹McGill University, ²University of Bologna, ³University of Padova, ⁴Diamond Light Source Ltd.

E-mail: don.baker@mcgill.ca

Evidence of the assimilation of crustal sulphur in ore deposits and selected LIP lavas and near-surface intrusions is widespread, but the mechanisms responsible remain enigmatic. To further investigate crustal assimilation of sulphur, we measured S concentrations in the lavas and dykes along the 2100 km-long, Mesoproterozoic (~1.27 Ga) Mackenzie LIP. Synchrotron X-ray fluorescence (Diamond synchrotron) analysis of sulphur concentrations in clinopyroxenes of GSC legacy samples were used with a partition coefficient of 0.027 to calculate the sulphur concentration in melts from which the clinopyroxenes crystallized. Most clinopyroxenes from the Mackenzie Dykes and Coppermine River basalts display median concentrations of sulphur between 5 and 15 ppm, with a maximum of ~25 ppm. The calculated melt concentrations are ~185 to ~925 ppm S, lower than the ocean island basaltic melt inclusion average of 980 ppm S and the MORB glass median of 1126 ppm S. There is no apparent trend between the S concentrations and distance from the focal point of the dyke swarm on Victoria Island, and the low melt concentrations indicate low sulphur in the source rocks of the Mackenzie Dykes and minimal possible sulphur contamination by the crust. The clinopyroxenes in the lower basalts of the Coppermine River sequence are only slightly more enriched in sulphur, 5 to 15 ppm, than those of the nearby Mackenzie Dykes, 5 to 7 ppm. However, clinopyroxenes in the native Cu-bearing upper basalts in the sequence are richer in S, 10 to 25 ppm. Although fractional crystallization may explain some of this enrichment, we suggest the possibility that these upper basalts were from a different S-enriched source, or perhaps they were contaminated with sulphur at shallow levels in the crust during their final stages of ascent to Earth's surface.

Reconstructing West Avalonia in the northern Appalachian orogen

Sandra M. Barr¹, Chris E. White¹, Deanne van Rooyen¹, Susan C. Johnson², Margaret D. Thompson³, Cees R. van Staal⁴, Andrea J. Mills⁵, Ulf Linnemann⁶, Andreas Gärtner⁶

¹Acadia University, ²New Brunswick Department of Natural Resources, ³Wellesley College, ⁴Natural Resources Canada, Geological Survey of Canada,

⁵Geological Survey of Newfoundland and Labrador, ⁶Senckenberg Naturhistorische Sammlungen Dresden.

E-mail: sandra.barr@acadiau.ca

In the nearly five decades since Hank Williams wrote that the time and significance of late Precambrian development of the Avalon Zone are first-order problems in understanding the development of the Appalachian orogen, the individual components have become increasingly well defined and characterized. Carolina in the southern Appalachians is now generally excluded from components in the northern Appalachians which have come to be termed West Avalonia, to distinguish them from potentially related areas of similar age and rock types in Europe, which are termed East Avalonia. However, original provenance of and relationships among these three Neoproterozoic domains remain uncertain in continental reconstructions. West Avalonia itself comprises six geographically and geologically distinct areas/terrane onshore in the northern Appalachians, here termed from south to north Southeastern New England Avalon, Caledonia terrane, Cobequid Highlands, Antigonish Highlands, Mira terrane and Newfoundland Avalon. They are separated by various combinations of water, faults, and younger rocks, and extend offshore under the Grand Banks and the Gulf of Maine, and partially under the Meguma terrane. Each of these areas/terrane is itself composite, comprising fault-bounded belts/sub-terrane, among which relations are also typically complex or uncertain. However, each area contains at least one of three volcanic-sedimentary-plutonic arc sequences formed in the Tonian, Cryogenian and Ediacaran, probably with tectonic amalgamation of the Tonian and Cryogenian arcs during the main Ediacaran arc episode. In most but not all areas, the youngest arc rocks are overlain diachronously by late Ediacaran red-beds that continue upward into a marine platform with Atlantic fauna. In some areas the youngest arc rocks are directly overlain by a Silurian-early Devonian marine sedimentary cover. Provenance of most terrane remains speculative, as do links with East Avalonia and Carolina, but areas with Tonian arcs are typically less juvenile, suggesting that they may have originated in Baltica.

Paragenetic and compositional evolution of Stage 1 W–Mo mineralized veins at Lake George, New Brunswick: Implications for fluid chemistry and scheelite saturation

Marcela Barrera Cortes¹, David R. Lentz¹, Christopher McFarlane¹, Kathleen G. Thorne²

¹University of New Brunswick, ²New Brunswick Department of Natural Resources.

E-mail: marcela.barrera@unb.ca

The Lake George (LG) deposit, located in the Central Plutonic Belt of New Brunswick, is a significant polymetallic W–Mo–(Sb–Au) exocontact vein system associated with the Early Devonian Lake George granodiorite. While W–Mo mineralization has been recorded to be related to three different vein stages (with selvages), the principal hosts of tungsten (scheelite) correspond to "Stages 1 and 2" vein networks. This study characterizes the paragenetic sequence and compositional variations within Stage 1 veins to reconstruct the hydrothermal evolution of the system, integrating detailed petrography with energy dispersive (ED) micro-X-ray fluorescence (μXRF) elemental mapping. Preliminary results led to the identification of at least four distinct veining sub-stages (S1-1–S1-4) within the main Stage 1 event. The most prominent phase (S1-2) consists of quartz veins (up to 2 cm wide) with central carbonate–muscovite–chlorite sutures, which host coarse-grained subhedral scheelite (CaWO₄) and coarse-grained pyrrhotite. Overall, these four subsets of vein/veinlets show a strong fluid–rock interaction, which is evidenced by the occurrence of narrow calc-silicate halos with a mineral association that can vary in the proportion of tremolite–actinolite, biotite, chlorite, muscovite, carbonate, clinozoisite and titanite. Detailed petrography along with μXRF mapping reveals that scheelite is consistently localized along vein margins in S1-1 through S1-3, highlighting the role of wall-rock interaction as a primary precipitation trigger. In contrast, in S1-4, scarce scheelite crystals appear near the vein suture with subrounded morphologies. The changes in mineral assemblages within the veins and their respective halos suggest a variable input of calcium, to some extent driven by the infiltration of magmatic hydrothermal fluids into calcium-bearing host lithologies. By mapping these elemental and textural changes, this research shows that Stage 1 is a dynamic, multi-episodic magmatic hydrothermal event associated with the granodiorite cupola at depth, recording part of the chemical evolution of the W–Mo mineralizing fluids.

A mineralogical and geochemical study of "worm rocks" in unconformity-related uranium deposits in the Athabasca Basin and implications for ore genesis

Louis-Philippe Beaulieu, Guoxiang Chi

University of Regina.

E-mail: Guoxiang.chi@uregina.ca

Unconformity-related uranium (URU) deposits in the Athabasca Basin are the world's largest and highest grade uranium deposits. They are divided into two subtypes: monometallic (U) and polymetallic (U–Ni–Co–Cu–As). Despite sharing similar wall rock alteration characteristics and mineralizing fluids, the genetic relationship between the two subtypes, especially the relationship between U and Ni–Co–Cu–As mineralization in terms of timing and metal sources, remains a subject of debate. A particular type of rock called "worm rocks" can provide insights on this subject of debate. The "worm rocks" consist of millimetre- to centimetre-sized tubes or pods of ores surrounded by bleached alteration haloes encased in red sandstone or basement rocks, which resemble the deposit-scale mineralization and alteration features of both monometallic and polymetallic URU deposits. Polished thin sections of "worm rocks" from two polymetallic and two monometallic deposits were studied through transmitted and reflected light microscopy and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS). Petrographic analysis indicates that the polymetallic

samples contain two generations of uraninite that co-precipitated with Ni–Co–Cu–As minerals. In contrast, the monometallic samples solely contain two generations of uraninite with no co-existing Ni–Co–Cu–As minerals. Furthermore, the first generation uraninite from the monometallic samples have an unusual yellowish grey colour under reflectance light and show evenly distributed enrichment of Ni, Co, Cu and As according to SEM-EDS mapping. These observations indicate that Ni–Co–Cu–As were introduced at the same time as U, although not necessarily by the same fluids, to the site of mineralization of both monometallic and polymetallic deposits, at least during the precipitation of the first generation uraninite. Therefore, despite the difference in abundance of Ni, Co, Cu and As, monometallic and polymetallic URU deposits are genetically similar, which is consistent with their similarities in mineralizing fluids and geological characteristics.

The Proterozoic anorthosite problem revisited

Jean H. Bédard¹, Félix Gervais²

¹Natural Resources Canada, Geological Survey of Canada, ²École Polytechnique de Montréal.

E-mail: drgeobedard@gmail.com

Anorthosite massifs 100s of km wide contain feldspars of near-constant composition and were mostly emplaced during the Proterozoic. Most interpret massif anorthosites as kilometres-thick floatation cumulates from basaltic underplates that became unstable and rose to fill shallow chambers. However, the volume of melt required is implausibly large. By analogy, the ~6.5 km thick Stillwater intrusion developed < 1 km of monomineralic anorthosite. If magma emplacement took the form of multiple smaller intrusions, it would be impossible to concentrate the plagioclase from individual sills. Finally, this model requires that the plagioclase be in equilibrium with mantle melts, likely tholeiites or Al-basalts. However, trace element inversion models on Nain and Grenvillian anorthosites show that they crystallized from melts with very strong L/HREE fractionation and HREE depletion that resemble adakite, not tholeiitic basalt. We test whether metamorphic conditions in the Proterozoic, in tandem with consideration of how basaltic source chemistry varied with time, could explain the temporal distribution and melt chemistry of anorthosites. Partial melting of mafic rocks was simulated by phase equilibria modeling, and shows that Archean basalt can melt to a high degree (20–35%) with abundant residual garnet and no residual plagioclase for pressure-temperature conditions slightly deeper and hotter than the lower crust (~1.7 GPa at 850–1000°C estimated from thermobarometry) in the Grenville Province during the Shawinigan orogeny (1.18–1.14 Ga). As these voluminous partial melts rose into the crust they would have crossed the pressure-dependent plagioclase saturation surface and formed anorthosite mushes. Calculated model melts from Archean basalt sources yield trace element signatures that closely match those of model melts calculated from anorthosite massifs. In contrast, basalts from modern environments stabilize residual plagioclase to higher pressures, with less garnet in the residue, and generate less melt. The Proterozoic combines the conditions required for the destruction of fossil altered slab-top oceanic lithosphere (ASOL) to generate massif anorthosites.

The Neoproterozoic Natkusiak flood basalts and related Franklin Sills, Victoria Island, Arctic Canada

Jean H. Bédard¹, Charles D. Beard², Nicole M.B. Williamson³, Ben Hayes⁴, Trent del Oro³, Dominique Weis³, James Scoates³

¹Natural Resources Canada, Geological Survey of Canada, ²Utrecht University, ³University of British Columbia, ⁴University of the Witwatersrand.

E-mail: drgeobedard@gmail.com

The Natkusiak continental flood basalts and Franklin sills of Victoria Island record the 718–720 Ma Franklin large igneous province, emplaced during the breakup of Rodinia. Basal Natkusiak flows (< 100 m, V0, low-Ti Type 1 melt) are capped by a volcanoclastic lahar deposit (< 100 m), then by a thin quartz-rich volcanic sandstone that records the establishment of small river channels, and finally by thick tholeiitic sheet flows that mark the onset of the main phase of flood volcanism (< 1100 m, high-Ti Type 2 magmas). Variations of whole rock Mg# Cr and TiO₂ with height indicate three differentiation cycles in the sheet flow unit: V1 (350 m), V2a (225 m) and V2b (≥ 200 m). Coeval intrusions are differentiated into Type 1 Franklin sills (= V0) and doleritic Type 2 sills (= V1–V2), both isotopically correlative with the northernmost basalts on Victoria Island. Whole rock Pb–Sr–Nd–Hf isotopic compositions indicate that Type 1 had primary melt compositions (Fo₉₀ olivine) similar to enriched MORB and incorporated up to 10% granitoid basement. Values of initial εNd, initial εHf, and initial 87/86Sr become less radiogenic up-section. Type 2 doleritic sills and the northern sheet flow basalts incorporated up to 5% granitoid, consistent with a waning continental influence during maturation of the magmatic system. In contrast, basal Type 1 basalts from southwestern Victoria Island show negligible continental influence and have unusually high initial εNd ratios (+4.4 to +11.8) that are decoupled from initial εHf (+0.8 to +11.1, up to ΔεHf of –9). These radiogenic εNd compositions persist throughout the southern volcanic stratigraphy and indicate involvement of a component that may represent isotopically matured oceanic crust emplaced below the Slave Province during the 1.9 Ga Wopmay orogeny. As the northern and southern Natkusiak volcanic rocks exhibit contrasting isotopic signatures throughout their preserved stratigraphy, the magma plumbing system must have been compartmentalized, with limited lateral mixing and homogenization.

Spinel-rich feldspathic peridotite formed by hybridization between boninitic sills and tholeiitic host gabbros in the Bay of Islands ophiolite

Jean H. Bédard¹, Azam Soltanmohammadi¹, Hadrien Henry², Romain Tilhac³, Dogan Paktunc⁴, Nail Zagrtednov⁵, Alana Hinchey⁶, Guilmette Carl⁷

¹Natural Resources Canada, Geological Survey of Canada, ²Université de Toulouse, ³Université de Montpellier, ⁴University of Waterloo, ⁵Natural Resources Canada-CanmetMINING, ⁶Geological Survey of Newfoundland and Labrador, ⁷Université Laval.

E-mail: drgeobedard@gmail.com

The lower crust of the Bay of Islands ophiolite (Newfoundland) records emplacement of a boninite sill complex beneath an older tholeiitic gabbro complex. The basal ultramafic zone has interlayered pyroxenites and peridotites with a wide range of ol/opx/cpx. Field evidence shows many peridotites are sill-like syn-kinematic intrusions (1–40 m thick). The youngest (least deformed) sills range from dunite to opx-phryic dunitic harzburgite (grading to olivine websterite) to wehrlitic facies (grading to clinopyroxenite). Centimetre-scale high-Cr/Al chromite reaction rims separate intrusive dunite from lowermost crustal pyroxenites, and formed through incongruent dissolution of Cr-rich pyroxene into chromite-saturated melts. The overlying mafic-ultramafic zone is constituted of peridotitic sills nearly identical to those of the ultramafic zone that inject syn-kinematically into the older tholeiitic gabbros. Field evidence shows feldspathic peridotites are hybrids generated by mixing primitive replenishments with host gabbros. Feldspar in hybrid sills forms gabbroic lenses and is often amoeboid with low-Cr/Al spinel filling dissolution pits in plagioclase. Olivine is forsteritic (Fo₈₄₋₉₀) with high NiO (0.25–0.35%), but each sample has a distinct plagioclase population (An₉₆ to An₅₂). The sodic feldspars overlap with compositions of plagioclase from distal tholeiitic ferrogabbros and gabbro-norites and represent cases where the feldspar did not have time to re-equilibrate. Hybrid feldspathic peridotites contain 3–5% chromite (0.2–0.4 Cr₂O₃ wt.%) but there are cm-scale chromite schlieren, which likely represent disaggregated reaction rims. The chromite grains are coarse (0.5–3 mm), and recovery tests indicate they represent potential ferrochrome ore. Formation of spinel is locally inhibited by sulfides in host gabbros, as this lowers the oxygen fugacity and removes chromite from the liquidus. Conversely, addition of sulfur to the boninitic magma triggered formation of Ni-rich sulfide globules, some with associated fine-grained Pt and Pd sulfide minerals. The Pt and Pd would likely have been scavenged from the surrounding melt after immiscibility had been triggered.

Constraining metamorphic P-T-fluid conditions across a fault zone at the Great Bear deposit, southern Uchi Subprovince, Ontario

Joleen Belanger¹, Doug Tinkham¹, Stefanie M. Brueckner¹, Bruno Lafrance¹, Jack Simmons¹, Wieland H. Boehme¹, Margaret Laverge¹, Juan Carlos Ordóñez Calderón²

¹Laurentian University, ²Kinross Gold Corp.

E-mail: jbelanger11@laurentian.ca

Gold deposits of the Archean Red Lake Greenstone Belt in the southern Uchi Subprovince are typically hosted in rocks metamorphosed to the greenschist to amphibolite facies. The Archean Great Bear gold deposit records syn- to inter-tectonic amphibolite facies peak metamorphism. The deposit consists of a felsic and mafic domain overprinted by a NW–SE trending zone of strongly deformed rocks, referred to as the LP Fault Zone (LPFZ). Core logging, petrographic and phase equilibria analysis of metamorphic mineral assemblages and reaction textures allowed identification of the variability of metamorphic conditions and fluid production. Pelitic metamorphic mineral assemblages in the felsic and mafic domain in the vicinity of the LPFZ are characterized by quartz + plagioclase + white mica ± biotite ± garnet ± staurolite ± andalusite. Metapelitic rocks in the mafic domain are locally sulfidic and graphitic and contain graphite as inclusions in matrix minerals and porphyroblasts, indicating pre-metamorphic graphite deposition. The graphite acted as a carbon source during metamorphic COHS fluid production, potentially allowing a contribution to gold remobilization during metamorphic dehydration, and current modelling suggests ~5–25% carbon species in the fluid during peak metamorphism. The P-T estimates from pseudosections indicate peak metamorphic conditions were at least 530–560°C and 2.7–3.8 kbar in the felsic domain and 540°C and 2.5–3.1 kbar in the mafic domain, indicating similar metamorphic conditions on either side of the LPFZ. Metabasaltic rocks in the mafic domain have assemblages containing calcic amphibole + quartz + plagioclase ± biotite ± garnet ± Fe–Mg amphibole ± carbonate. Tschermakitic amphibole compositions and oligoclase–andesine plagioclase compositions indicate the mafic domain metabasites surpassed the greenschist–amphibolite facies transition, which is modelled to occur at 420–440°C at 2–4 kbar using mafic domain compositions. These results are compatible with the P–T estimates from the metapelitic rocks and indicate there is no distinct metamorphic discontinuity across the LP Fault.

Provenance of sapphires at Rock Creek (Montana): How heavy mineral analysis solved a 130-year-old mystery

Philippe Belley

Memorial University of Newfoundland.

E-mail: phil.belley@gmail.com

The source rock from which Rock Creek (Montana, USA) detrital sapphire originated has been the subject of speculation and investigation since the sapphires' discovery in the 1890s, with geologists proposing distal metamorphic or metasomatic rocks, proximal buried subvolcanic dykes, or rhyolitic rocks as possible origins. Heavy mineral analysis of unconsolidated sediments and clast examination were employed in a successful attempt to track down the source rock from which sapphires were eroded. Corundum at Rock Creek is far more abundant (~50x) in fine-grained fractions, especially 0.125–0.500 mm, relative to the coarse size fraction of economic interest, making the tiny corundum easier to find in small sediment or rock samples. The data point to an unlikely culprit: peraluminous rhyolite tuff, the first confirmed sapphire deposit of this type. Further investigations on the trace

element composition and inclusions in fine-grained corundum aim to refine their distinguishing characteristics for broader use in detrital corundum provenance analysis. This new approach to studying sapphire deposits is being expanded to other deposits in Montana and around the world.

Textural evidence of high-T overprinting in eclogite facies rocks of the Parautochthonous Belt, Grenville Province, Canada

Chaouki Bendimerad, Aphrodite Indares

Memorial University of Newfoundland.

E-mail: cdebendimerad@mun.ca

In the central Grenville Province, high pressure (high-P) metamorphism is localized near the Allochthon Boundary, in parts of the hinterland and in the Parautochthonous Molson Lake terrane. In the latter, eclogitized metagabbros and garnet amphibolites show high temperature (high-T) mineral assemblages and textures with antiperthite, and orthopyroxene–plagioclase partially overprinting the high P, garnet–omphacite±quartz–rutile assemblage. Moreover, thin plagioclase moats locally forming a network between high-P minerals may represent former melt pseudomorphs. Collectively, these features, which are reported here for the first time, are consistent with a mid-P granulite-facies overprint on the eclogitized metagabbros, potentially reaching suprasolidus conditions. In addition, meta-mafic rocks with garnet–orthopyroxene–plagioclase–clinopyroxene–amphibole±biotite–quartz–ilmenite–rutile assemblages, lacking preserved evidence of former eclogite-facies assemblages, are also reported for the first time here. The new data contrast the Molson Terrane high-P rocks with the well documented high-P granulites of the hinterland of central Grenville, where no lower-P overprint is recorded, and add new perspectives on the tectonothermal evolution of deep crust in the Grenville Orogen.

Polyphase evolution of orogenic gold systems revealed by in situ pyrite fluid inclusions and textures

Maxime Bertauts, Bertrand Rottier, Georges Beaudoin

Université Laval.

E-mail: bertauts.maxime@gmail.com

Studying quartz-hosted fluid inclusions in Archean orogenic gold deposits is commonly hindered by intense quartz deformation, widespread secondary fluid inclusion assemblages, poorly constrained timing between quartz veining and gold precipitation. Consequently, the physicochemical characteristics of auriferous fluids remain poorly defined. Pyrite, a major host for gold that is less affected by deformation, can preserve pristine fluid inclusions and is transparent under near-infrared (NIR) light. Detailed NIR petrography of pyrite grains from the Triangle and Ormaque orogenic gold deposits (Val-d'Or, Abitibi) allows the identification of seven pyrite textures in shear-hosted veins and three in extensional veins, based on cross-cutting relationships and inclusion patterns. These include primary growth textures (Py1–Py2) and remobilization textures (Py3–Py6, e.g. dissolution–reprecipitation). Primary and deformation textures (Py1–Py3) are consistent with repeated fluid pressure fluctuations characteristic of the fault valve model. Gold occurs in pyrite as inclusions within primary textures (Au1), along dissolution fronts (Au2), within healed cracks (Au3), and as fracture filling (Au4). Well-preserved primary aqueous–carbonic fluid inclusions occur within pyrite growth zones and as planes of secondary fluid inclusions (S1, S2, S3). Primary and S1 inclusions are aqueous–carbonic with low salinity (0.2–1.6 wt.% NaCl eq.) and 245 to > 320°C homogenization temperatures (Th). The S2 aqueous–carbonic inclusions display higher salinity (11.1–11.2 wt.% NaCl eq.), whereas S3 fluid inclusions are aqueous, moderately saline (4.65–7.45 wt.% NaCl eq.), low Th (~165°C). The coexistence of these secondary fluid inclusion types reflects multiple fluid events. Isochore calculation from the primary fluid inclusions hosted in Py2 are contemporaneous to Au1 mineralization and constrains vein formation to mid-crustal depths of ~6–7 km if a trapping temperature of ~350°C, and lithostatic pressure are assumed. The chemistry of fluids trapped in pyrite is consistent with some quartz-hosted inclusions in Abitibi orogenic gold systems, but offers a more restricted, gold-proximal record of mineralizing fluids.

Tectonic evolution of the southern Rae craton: crustal growth by accretionary processes from the late Neoproterozoic through early–mid Paleoproterozoic

Kathryn M. Bethune¹, Kenneth E. Ashton², Colin D. Card², Dillon D. Johnstone²

¹University of Regina, ²Saskatchewan Geological Survey.

E-mail: kathryn.bethune@uregina.ca

The Archean to early Paleoproterozoic transition is thought to represent a significant turning point in earth history but tectonic processes remain controversial. The southern Rae Province, however, preserves evidence for crustal assembly through subduction-related accretion over this period. Rather than a uniform crustal block, the southern Rae is now understood to contain a central core, the 'proto-Rae craton', composed of several terranes of Neoproterozoic (ca. 2.74–2.68 Ga) orthogneiss stitched by ca. 2.64–2.58 Ga plutons. This core is mantled by Paleo- to Mesoproterozoic (ca. 3.3–2.9 Ga) rocks within a contiguous belt comprising the Perry River terrane (PRT) in the west, the Taltson basement complex (TBC) in the south-southwest and the Chipman domain in the east that are intruded by several suites of late Neoproterozoic (2.52–2.48 Ga) to early Paleoproterozoic (ca. 2.45–2.38 Ga, ca. 2.35–2.28 Ga) granitoid rocks. The oldest of these suites marks (approximately) onset of a shared evolution between the cratonic core and this older crust. In the south, this history began with < 2.58 Ga accretion of the TBC-related Zemlak terrane to the Nolan domain and subsequent stitching of this boundary by ca. 2.52 Ga Zemlak suite plutons, while in the west it followed < 2.58 Ga accretion of the correlative PRT to Rae craton, before intrusion of chemically similar ca. 2.52–2.48 Ga plutons. This tectonism could represent the earliest stages of Arrowsmith orogeny, or an earlier, distinct event. In the TBC-PRT segment magmatism continued from ca. 2.45 Ga to 2.38 Ga, with subduction stepping outboard below another TBC-related terrane, or the Buffalo Head terrane. Ensuing collision marked the thermal culmination of Arrowsmith orogeny at ca. 2.37–

2.36 Ga with later emplacement of ca. 2.35–2.28 Ga post-orogenic granites. This unified crustal block stabilized and underwent rifting (ca. 2.2–2.0 Ga) before the subsequent Taltson (ca. 1.99–1.93 Ga), Snowbird (ca. 1.91–1.90 Ga) and Trans-Hudson (ca. 1.90–1.80 Ga) orogenies.

Distinguishing tectonic versus eustatic controls on high frequency (sub-million year) stratigraphic sequences in the Cretaceous foreland basins of North America

Janok P. Bhattacharya

McMaster University.

E-mail: bbhattaj@mcmaster.ca

There has been much debate as to the relative importance of tectonics versus eustatic sea level change in controlling the development of unconformities in high frequency (i.e. sub-million year) sequences. High resolution analysis of Cretaceous siliciclastic sequences in the Western Interior Seaway of North America, integrating correlations of isochronous bentonites, allow tectonic versus eustatic sequences to be distinguished. Eustatic sequence boundaries are characterized in landward areas by valley incision, accompanied by forced regressive translation of shorelines, tens to hundreds of kilometres basinward. These may be accompanied by development of a regressive surface of marine erosion, although development of this lower erosion surface is strongly dependent on the shoreline trajectory during eustatic falls. The subaerial unconformity is commonly more pronounced landward but can be extensively modified by wave or tidal reworking during subsequent transgression. Tectonic unconformities are of two main types. 1. Regional unconformities, associated with forebulge migration are characterized by low angle ($< 1^\circ$) unconformities that are more pronounced seaward. Erosion commonly occurs over muddy marine strata as a result of wave erosion of uplifted sea floor and development of a *Glossifungites* surface. 2. Erosion can also occur as a result of fault reactivation of basement structures. These unconformities are also low angle (typically $< 1^\circ$), but erosion tends to occur in the same position in the basin through multiple stratigraphic units. This contrasts with eustatic unconformities that migrate landward and seaward, tracking shoreline changes. Eustatic unconformities may appear to be pseudo-angular (again typically $< 1^\circ$), where clinoform strata are eroded and care must be taken to distinguish pseudo-angular eustatic unconformities from low angle tectonic unconformities that require lithospheric deformation. In distinguishing these different types of unconformities, extreme vertical exaggeration (10–100x) can be very helpful.

Large-scale zircon geochronology of Western Grenville metasedimentary rocks – a synthesis

Eleanore Blereau¹, Bertrand Rottier¹, Renaud Soucy La Roche², Carl Guilmette¹, Abdelali Moukhsil³

¹Université Laval, ²Institut National de la Recherche Scientifique, ³Ministère des Ressources naturelles et des Forêts.

E-mail: eleanore.blereau@gmail.com

The Western Grenville Province is a complex collage of different terranes and domains accreted before and during the Grenvillian orogeny. Correlation between different metasedimentary units from various terranes/domains across the Ontario–Quebec–USA border has been restricted thus far by limited detrital geochronological information, particularly from Quebec. To resolve this, we have dated detrital and metamorphic zircons ($n = 3599$) in 28 quartzite or metagreywacke samples from the Mont-Laurier (MLT) and Morin (MT) terranes and the Wabash Complex (WC). Obtained U–Pb geochronology shows that the protolith sediments for the MLT and MT were derived from similar Archean to middle Mesoproterozoic sources and likely deposited synchronously within the same sedimentary basin system (maximum deposition ages in MLT: 1287 ± 26 to 1219 ± 51 Ma; MT: 1271 ± 19 to 1252 ± 11 Ma). While also deposited at a similar time (1279 ± 24 to 1249 ± 50 Ma), the protolith to the WC could not have been deposited in the same basin system as the MLT and MT due to a general lack of Archean detritus. New and published detrital geochronology data from similar lithologies of the Western Grenville Province can be grouped into three types based on multi-dimensional scaling and cumulative age distributions plots; (1) the MLT, MT, and Adirondack Lowlands and Highlands with the bulk of age peaks occurring in similar ranges between ca. 1.9–1.25 Ga; (2) the Barrois Complex and Frontenac and Kiosk domains with significant 1.9–1.8 Ga age peaks; and (3) the WC, and Parry Sound and Shawanaga domains skewed towards relatively younger ages between ca. 1.6–1.2 Ga. The U–Pb dates distribution from Type 1–2 sediments plot within a foreland basin depositional system, and Type 3 sediments within a fore/back-arc depositional system. Detrital zircon analysis allows the interrogation of the pre-Grenvillian orogeny tectonic architecture.

Detrital zircon geochronology and tectonic setting of the Silurian to early Devonian Rockville Notch Group in the western Meguma terrane, Nova Scotia, Canada

Leslie Boateng-Dwomoh¹, Deanne van Rooyen¹, Chris E. White¹, Andreas Gärtner²

¹Acadia University, ²Senckenberg Museum of Mineralogy and Geology, Natural History Collections Dresden.

E-mail: deanne.vanrooyen@acadiau.ca

The Meguma terrane in Nova Scotia comprises Ediacaran to early Ordovician metasedimentary rocks of the Goldenville and Halifax groups representing marine deep water to passive margin successions with Gondwanan affinities. The top of the Halifax Group is a terrane-wide unconformity with a depositional hiatus of ca. 30 Myr interpreted as the Sardian Gap. North of the Chebogue Point shear zone through the Annapolis Valley the Rockville Notch Group (RNG) is a Silurian to lower Devonian succession of shallow water, rift-related sedimentary and volcanic rocks unconformably overlying the Halifax Group. The RNG includes (from oldest to youngest) the White Rock (sandstone with minor siltstone and ironstone interlayered with mafic and felsic volcanic rocks), Kentville (black slate with minor limestone), Torbrook (sandstone and minor mafic tuff, ironstone, slate and limestone) and laterally equivalent New Canaan (mafic lava flows and tuff interbedded with minor sandstone and limestone) formations. New detrital zircon data from the RNG reveal a consistent pattern of ages. The major peaks in seven samples from the White Rock and Torbrook formations are between ca. 600–650 Ma and between ca. 2.0–2.2 Ga. Minor populations occur at ca. 550–600 and ca. 650–700 Ma and

Meso- and Paleoproterozoic grains are sparse. Single grains of Silurian or Devonian ages are present in only three samples. The detrital zircon age distributions in the RNG are indistinguishable from those in the underlying Goldenville and Halifax groups, which shows that either the Goldenville and Halifax groups were the major source of detrital material or the RNG was deposited proximal to the same source areas that supplied those groups with detrital material. Absence of Silurian–Devonian zircon shows that syn-depositional volcanism in the RNG did not contribute to the sediments. This knowledge may have implications for paleogeographic reconstructions.

Catchment analysis applied to regional lake sediment geochemistry, watershed dynamics as a control of geochemical signal in northern Manitoba, NTS 064J/K

Matthew M. Bodnar¹, Alexandre Voinot², Matthew I. Leybourne¹, Tyler J. Hodder³

¹Queen's University, ²Natural Resources Canada, Geological Survey of Canada, ³Manitoba Geological Survey.

E-mail: matthew.bodnar@queensu.ca

Lake sediment sampling is a proven regional geochemical surveying strategy for mineral exploration in recently glaciated landscapes of low to moderate relief. Most suitable 1:250 000 scale NTS map sheets in Canada were surveyed with a sampling density of approximately 1 sample per 13 km² under the National Geochemical Reconnaissance program starting in 1975 with a mandate to delineate areas with uranium and base metal potential. The original analytical suite was robust for the time, using a combination of atomic adsorption spectroscopy (AAS) and colorimetric analyses; however, significant advancements in analytical chemistry were made over the 40–50 years since collection, leading to a reanalysis of the original archived sample material in 2022 and 2023 by aqua regia digestion and ICP-MS analysis. Traditional lake sediment geochemistry visualization is as a point value or an interpolated gridded raster on a plan map without integration of lake footprint or watershed dimensions. In this study, data from the recently reanalyzed samples were evaluated across two 1:250 000 scale NTS map sheets in northern Manitoba by applying watershed analysis. A 30 m DEM was used to calculate a flow direction model and digital drainage network. Basin watershed polygons were calculated for each lake sampled and the interpreted lake outlet position. Geochemical data were then evaluated as a function of watershed area and dominant surficial material per catchment. Preliminary results indicate that watershed size has notable but inconsistent influence over geochemical patterns observed and the type of surficial material within the watershed appears to have a strong control influence on concentrations of elements such as U and Mo. The watershed approach to lake sediment geochemical data evaluation appears to be a worthwhile strategy to visualize results and apply a more data-driven spatial workflow.

Timing of gold mineralization at the LP deformation zone of the Archean Great Bear deposit: metamorphosed vs. metamorphogenic

Wieland H. Boehme¹, Stefanie M. Brueckner¹, Bruno Lafrance¹, Margaret Laverge¹, Jack Simmons¹, Doug Tinkham¹, Joleen Belanger¹, Juan Carlos Ordóñez Calderón²

¹Laurentian University, ²Kinross Gold Corp.

E-mail: wboehme@laurentian.ca

The Great Bear deposit is a new world-class gold deposit in the Archean Red Lake Greenstone Belt, Superior Province, Ontario. Its resource estimate (measured + indicated) of 2.7 Moz Au at 2.81 g/t Au with an additional inferred resource of 3.9 Moz Au at 4.71 g/t Au occurs within a WNW–ESE trending transpression zone (D3), known as the LP deformation zone. Stratigraphic and petrographic analysis of drill core intervals, microprobe analysis of gold and LA-ICP-MS U–Pb titanite geochronology were conducted to constrain whether gold mineralization at the LP deformation zone predates metamorphism or formed during ductile deformation. Gold in the LP deformation zone is predominantly hosted by aphyric and quartz–feldspar–phyric felsic volcanic to volcanoclastic, as well as fine-grained, massive to thinly bedded metasedimentary units. The ore assemblage comprises disseminated pyrite, arsenopyrite and pyrrhotite, minor chalcopyrite, sphalerite, galena and magnetite, trace Bi±Ag±Pb tellurides, scheelite and native gold. A subtle zoning shows gold enrichment and increased sulfide abundance in the central and southeastern LP deformation zone and is expressed by pyrite–arsenopyrite- and pyrite–pyrrhotite-dominated ore assemblages, respectively. Titanite, which locally host sulfide inclusions and is aligned parallel with the dominant S3 foliation in gold-hosting quartz–feldspar–phyric unit, yielded a lower intercept concordia age of 2704 ± 13 Ma. Native gold occurs disseminated in deformed cm-scale quartz ± carbonate veins and surrounding host rock and locally as inclusions within recrystallized pyrite and foliation-parallel biotite. These relationships indicate that gold mineralization predated D3 transpression and sulfide recrystallization. Significant gold fineness variation ranging from 830 to 968 further indicates post-depositional gold refinement, possibly during amphibolite-facies metamorphism. Alignment of titanite with the dominant foliation indicates fluid-assisted syn-deformational metamorphic titanite growth. These results suggest that gold mineralization at the LP deformation zone was emplaced prior to 2704 ± 13 Ma and predated metamorphism and ductile deformation.

Expanding a Paleoproterozoic Large Igneous Province: Geochemistry and geochronology of the Kelly LIP, East Pilbara

Jayme Bonnell, Steven W. Denyszyn

Memorial University of Newfoundland.

E-mail: jebonnell@mun.ca

The Paleoproterozoic Kelly Large Igneous Province in the East Pilbara Craton of Western Australia includes 3.3 Ga flood basalt, granite and rhyolite, as well as a swarm of linear mafic dykes dated by previous workers to 3317 ± 1.1 Ma (U–Pb ID-TIMS on baddeleyite). Our geochemical and geochronological study of 12 samples of dykes from the Kelly LIP expands the extent of this swarm and indicates more geochemical variability than previously identified. Petrographic study reveals variably altered compositions ranging from clinopyroxenite to diorite, but predominantly diabase. U–

Pb analysis using LA-ICP-MS on 19 zircon grains recovered from a dioritic sample yielded the same 3.3 Ga magmatic age. Among these, an inherited population of zircon was identified, dated to 3.7 Ga. This implies an ancient basement extending under East Pilbara, a discovery that supports previous work that suggests this basement is an extension of the 3.7 Ga Narryer Terrane in the Yilgarn Craton to the southwest, or another Narryer-aged geological unit at depth. The implications of identifying a widespread linear mafic dyke swarm at 3.3 Ga contributes to the longstanding debate on the transition from vertical to horizontal plate tectonics as dykes emplaced in this manner require a rigid, thick lithosphere that allows for brittle fractures. These characteristics could have accommodated horizontal tectonics in the Pilbara Craton as far back as the Paleoproterozoic. Additionally, the age of the Kelly LIP permits a lithological and temporal association of the East Pilbara Craton with similar units in the Kaapvaal Craton in South Africa, which if continuous support the existence of the hypothesized paleocontinent Vaalbara. If correct, re-joining these cratons increases the scale of the Kelly LIP substantially, though further characterization and research is required to test this correlation.

Metasedimentary lower crustal xenoliths in Ganderia preserve evidence for Acadian ultra-high temperature metamorphism

Tyler Boyce¹, Eric Thiessen¹, Hamish Sandeman², Susan Strowbridge¹, Aphrodite Indares¹

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador.

E-mail: ethiessen@mun.ca

Crustal xenoliths can preserve the pressure–temperature–time record of deep orogenic processes, which may be otherwise inaccessible when exhumation is limited. In Newfoundland, the Acadian orogeny (ca. 421–400 Ma) affected the eastern Gander margin where exposed metamorphic rocks contain amphibolite-facies, garnet–staurolite–muscovite assemblages developed at ca. 410 Ma. In addition, two newly discovered ca. 148 Ma lamprophyre dykes on the Gander Lake shoreline contain a suite of crustal xenoliths that offer insight into deeper crustal units. Most of the xenoliths consist of other 148 Ma lamprophyre-associated rocks as well as pyroxenite and gabbro-norite dated at ca. 420 Ma, which may derive from the proximal Mt. Peyton Intrusive suite. However, rare aluminous metasedimentary xenoliths also occur with high temperature restitic assemblages of garnet+sillimanite+orthoclase+rutile+quartz or leucocratic assemblages of quartz+feldspar+garnet+rutile. Garnet and quartz in these metamorphic xenoliths have crystallographically oriented rutile-ilmenite needles throughout, presumably from exsolution post thermal peak. In situ U–Pb detrital zircon dating yielded a late Ordovician–early Silurian ca. 450–430 Ma maximum deposition age while U–Pb monazite dating yielded early Devonian high temperature metamorphism at ca. 420–400 Ma. Phase equilibria modelling and Zr-in-rutile thermometry reveal the peak metamorphic conditions to be > 900°C and up to 12 kbar during Acadian orogenesis. Similar mineral assemblages and ultra-high temperatures are preserved ~1500 km along strike in the Central Maine Terrane in Connecticut and point to a regional high thermal structure in the lower crust during the Acadian orogeny. Given the relatively low metamorphic grade of the Gander Zone locally, we suggest the metasedimentary xenoliths examined represent late Silurian sediments that were deposited in a forearc region before being subducted during early Avalonia convergence and re-laminated/underplated to the lower crust. Lower crust emplacement was followed by Devonian thermal pulses between 390 and 365 Ma and then remained stable until magmatic exhumation at 148 Ma during incipient rifting.

When halite freezes time: Preserved diagenesis of the Dawson Bay Formation

George Bradley^{1,2}, Edward Matheson², Peir Pufahl¹, James Isbister³, Nathan Morgan³

¹Queen's University, ²Cape Breton University, ³Nutrien Ltd.

E-mail: george.bradley@queensu.ca

This study re-assesses the depositional environments and diagenetic history of the Dawson Bay Formation, a Middle Devonian (Givetian) carbonate unit located in the Elk Point Basin of Saskatchewan. The formation is a halite-cemented carbonate unit with an average thickness of 35 m. It is a part of a cyclic carbonate–evaporite motif that is repeated several times in Middle to Upper Devonian strata of the Elk Point Basin. Given its pervasive halite cementation, the Dawson Bay Formation is used herein as a natural archive to explore the influence of evaporite deposition and cementation on the post-depositional alteration of the intervening carbonates. Data were collected from 17 potash industry cores from across southern Saskatchewan, as well as outcrops in western Manitoba. From these data, paragenetic models, diagenetic histories, lithofacies relationships and a sequence stratigraphic framework were documented and interpreted. Petrography, IRMS and wireline logs were utilized to supplement core data as needed. The formation has limited deep compactional features despite being buried to at least 2,500 m. The diagenetic data suggest that carbonate deposition was followed by sabkha dolomitization and burial dolomitization while preserving some porosity. Following burial dolomitization, halite brines infiltrated the formation, cementing any remaining open porosity. This “freezing” arrested further burial compaction while retaining the evidence of early diagenetic alteration. Elucidating the source and timing of these brines is integral to reconstructing the evolution of the pore systems in similar deposits worldwide. Thus, the Dawson Bay Formation illustrates the complex interaction between evaporite and carbonate diagenesis that can occur in a mixed system, giving valuable insight into how evaporite diagenesis and cementation affect carbonate diagenesis on a formation scale.

Building a conceptual 3D geological model of the Wollaston fold–thrust belt, northern Saskatchewan: Implications for pegmatite-related rare earth elements (REE) targeting

Joseph A. Bravo, Irvine R. Annesley, Camille A. Partin

University of Saskatchewan.

E-mail: joseph.bravo@usask.ca

The rising demand for rare earth elements (REE) underscores the need to improve exploration strategies, particularly for pegmatite-hosted systems in Precambrian terranes. The Archean–Paleoproterozoic Wollaston Domain of northern Saskatchewan represents a favourable tectonic setting for the genesis and emplacement of REE-bearing pegmatites. This study develops a regional-scale conceptual 3D geological model to integrate publicly available geological, geophysical, structural and geochemical datasets, with the objective of assessing the consistency of existing geological interpretations, identifying key knowledge gaps and refining criteria relevant to targeting pegmatite-related mineral occurrences. The workflow method here incorporates regional/local structural lineament analyses derived from aeromagnetic data and correlated with existing geological and structural interpretations to refine the lithostructural framework. Northeast-trending regional lineaments are associated with D1/D2 ductile structures that likely controlled crustal-scale anisotropy and melt–fluid pathways, whereas northwest-trending brittle faults are interpreted as late D3 reactivation features that may have influenced pegmatite localization or preservation. To constrain the subsurface architecture relevant to pegmatite emplacement (i.e. the z-axis), the 3D framework integrates interpretations from Lithoprobe seismic reflection profiles (e.g. THOT Line S2B) and co-located magnetotelluric (MT) transects, extending the model beyond 600 m to lower crustal depths and providing independent constraints on crustal layering, major shear zones and conductive domains potentially associated with fertile source regions and melt–fluid-rich zones. Interpreted geological surfaces were discretized and voxelized to generate a 3D geological framework suitable for forward and inverse geophysical modeling, particularly magnetic, gravity and MT data. Our resulting model integrates surface and subsurface observations into a coherent regional lithotectonic framework, highlights areas of uncertainty and supports the identification and evaluation of structural and lithological controls on pegmatite-related REE systems. This conceptual model establishes a building block for future geologically constrained geophysical modeling. Ultimately, it contributes to improved exploration targeting strategies for REE-bearing pegmatites and critical mineral systems in the Wollaston Domain.

Pathologies and colour banding in Cretaceous marine reptile teeth

Kirstin Brink, Virginia Gold

University of Manitoba.

E-mail: kirstin.brink@umanitoba.ca

Banding and other colouration patterns in the dentine and enamel of fossilized teeth are relatively common in vertebrate non-mammalian carnivores. However, it is unknown if these colourations are due to the fossilization process (i.e. diagenesis) or if they formed during tooth development. In mammals, colour changes associated with other defects (e.g. enamel hypoplasia) have biological significance, marking life history events or periods of stress, however, this has not been demonstrated in reptiles. In this study, we examined teeth with banded dentine from extinct Cretaceous marine reptiles, mosasaurs, to determine if they formed through fossilization or before the death of the animal and have biological significance. To do so, transmitted light microscopy, electron probe microanalysis, scanning electron microscopy and transmission electron microscopy analyses were used to determine chemical, morphological and textural features of normal and banded dentine. Results show that the banded dentine is translucent in thin section, has infilled dentine tubules with a similar elemental composition to the surrounding intertubular dentine and has smaller intratubular crystals than the surrounding intertubular dentine. Counts of von Ebner lines suggest the banded dentine formed over 30 days. We interpret this band as sclerotic dentine, formed during the life of the animal. However, the aetiology of this patterned dentine remains unknown, as no similar occurrences have been described for humans or other animals. This study emphasizes the use of the fossil record to understand the deep homologies of modern tooth tissues and the diversity of occurrences in vertebrates.

Nelsonitic melts beyond continents: evidence from the oceanic lower crust

Daniele Brunelli¹, Alessio Sanfilippo², Marco Ligi³, Azam Soltanmohammadi⁴

¹University of Modena and Reggio Emilia, ²Università degli Studi di Pavia, ³Istituto di Scienze Marine-CNR, ⁴Natural Resources Canada, Geological Survey of Canada.

E-mail: daniele.brunelli@unimore.it

Nelsonites – Fe–Ti oxide–apatite rocks classically described from Proterozoic anorthosite intrusions – are widely regarded as emblematic products of continental magmatic systems and are well known for their economic significance. In contrast, their occurrence and relevance in oceanic settings have remained unclear. We present evidence for the first clear identification of nelsonitic melts in the lower oceanic crust, based on gabbro and ferrodiorite recovered from the Vema Lithospheric Section at the Mid-Atlantic Ridge. These rocks record injection of extremely differentiated, Fe–Ti–P saturated melts into a pre-existing gabbroic crystal mush, producing hybrid ferrodiorite enriched in oxides and apatite. Textural disequilibrium, modal proportions close to nelsonite eutectic compositions and mineral chemistry demonstrate that these melts were mobile, overpressured and externally sourced, rather than products of in situ fractional crystallization. We argue that nelsonitic melts formed through lateral differentiation and melt immiscibility at the margins of axial magma chambers, followed by tectonically driven melt squeezing and injection during deformation near the brittle–ductile transition. This oceanic example expands the genetic framework of nelsonites beyond continental massif and layered intrusions and highlights the role of melt transport, immiscibility and deformation in generating highly differentiated Fe–Ti–P melts. Recognizing nelsonites as process-driven rather than province-restricted features opens new perspectives on melt evolution in both oceanic and continental magmatic systems.

Melt diversity, alkaline melts, and the deep time memory of the convecting mantle

Daniele Brunelli¹, Léna Verhoest¹, Marco Ligi², Marcia Maia³, Anna Cipriani¹, Mateusz M. Michailow¹, Azam Soltanmohammadi⁴

¹University of Modena and Reggio Emilia, ²Istituto di Scienze Marine-CNR, ³Geo-Ocean Laboratory, ⁴Natural Resources Canada, Geological Survey of Canada.

E-mail: daniele.brunelli@unimore.it

Mid-ocean ridges are commonly viewed as sites of efficient chemical renewal, where partial melting progressively homogenizes the upper mantle and erases pre-existing heterogeneity. Yet recent models of melt separation beneath spreading centres emphasize that melt extraction is inherently heterogeneous, producing a wide spectrum of melts – including low degree, chemically enriched and locally alkaline compositions – that segregate intermittently through a dynamically evolving permeability structure. Such melt diversity implies that melting may not be uniformly homogenizing. We integrate this process-based perspective with new isotopic constraints from peridotite recovered at the Eastern Romanche Ridge–Transform Intersection (ERRTI). These samples preserve coupled Nd–Hf systematics that cannot be generated by recent ridge melting alone, and instead require survival of billion years old, ancient depleted-mantle domains within the present day MORB source region. We argue that chemically diverse, including alkaline, melts play a key role in this preservation: efficient, channelized extraction selectively removes enriched melt fractions while leaving behind residual mantle that retains deep time isotopic memory. This synthesis links melt transport physics to the longevity of mantle heterogeneity and suggests that the convecting mantle can remain both productive and archival. ERRTI peridotites thus provide a window into how ridge melting generates diversity while allowing ancient mantle residues to persist through multiple melting cycles.

Mapping the surficial geology of Big Bay, Labrador: A late deglacial landsystem in north-central Labrador

Heather Campbell¹, Jessey Rice², Pierre-Marc Godbout², Roger Paulen²

¹Government of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: heathercampbell@gov.nl.ca

The surficial geology of the Big Bay area of Labrador was mapped in 2022–2023 as part of a Geomapping for Energy and Minerals (GEM) collaborative project with the Geological Survey of Newfoundland and Labrador to support mineral exploration and infrastructure development in northern Canada. Field observations, combined with remotely sensed data from air photos and satellite imagery were used to map four 1:50 000 NTS map sheets (13N/9, 10, 14, 15). Mapping identified three distinct glacial regions: 1) eroded bedrock highlands with minor glacial sediments in the southeast; 2) a deglacial landsystem in a northeastward-oriented valley south of Big Bay in the centre of the map, and 3) streamlined till and moraine to the northwest. The deglacial landsystem consists of sandy outwash deltas with reworked surfaces forming a 100 m thick flat-topped marine terrace. Post-glacial subaqueous, subaerial and eolian processes have variably eroded the terrace, as evidenced by beach ridges, ice push moraines and dune ridges. A linear channel of kettle holes extends along the terrace. Northeast (045°) and east-northeast (060°) till ridges and variably oriented crevasse-squeeze ridges occur directly west of the landsystem. The map records landform changes in Big Bay during isostatic depression and readjustment. During higher relative sea levels, shelf ice extended into Big Bay, depositing subaqueous outwash fans. Large blocks of ice were abandoned and buried along the northwest valley wall, then melted, leaving kettled depressions. Falling sea levels and topographic confinement resulted in crevasse and shifting ice flow, leaving ice imprints in outwash. Marine and eolian erosion occurred during relative sea level fall, observed from dunes and beach strands. Erosion of glacial, deglacial and post-glacial deposits continues into the present, through coastal winds and tidal activity, sea ice, alluvial incision, rockfall and landslides.

Unsupervised classification of till geochemical data to detect elemental contributions from bedrock and geochemical anomalies from mineral deposits; case studies from the Burin and northern Avalon Peninsulas

Heather Campbell, Greg Sparkes, Joyeeta Bhattacharjee, Andrea Mills

Government of Newfoundland and Labrador.

E-mail: heathercampbell@gov.nl.ca

In Newfoundland, mineralization is easier to detect in exposed bedrock outcrops near the coast. Where till cover is extensive, in the central part of the island, mineralization can be difficult to trace without surficial geochemical data. Fortunately, most till-covered areas have been sampled by the government of Newfoundland and Labrador at a density of 1–2 km² for over 50 elements, and elemental distributions can facilitate identification of underlying bedrock and associated mineral occurrences. However, individual till geochemical element anomalies or dispersal trains that can help identify underlying and up-ice sources can be inconsistently distributed in till, due to glacial erosion and dilution, mixing and weathering. To better obtain anomalous surficial geochemical patterns to detect material from underlying bedrock, we investigated combined element geochemical indices. Unsupervised classification, using principal component (PC) analysis of isometric log ratio transformed till geochemical data from the Avalon and Burin was used to derive indices associated with known and potentially unrecognized mineral deposit types. The PC scores were combined by k-means clustering to identify broad geochemical groupings that reflect bedrock. We tested whether established epithermal, base metal and critical metal showings were identified through anomalous PC scores and whether bedrock was reflected in colour-coded k-means clusters of PC scores. Results indicate close visual correlation between clustered PC scores and spatially associated bedrock units. Individual PC component score anomalies are spatially located near and down-ice of base metal and critical mineral occurrences. These results demonstrate the veracity of unsupervised classification using large regional till datasets to reflect bedrock composition and to identify anomalies. The indices can also clarify ice flow patterns, assisting with ice flow reconstructions in complex glacial regions.

Supergene enrichment at the Teghout Cu–Mo porphyry deposit, Armenia: Did it make an economic difference?

Rene Carapetian¹, Grigor Grigoryan², Henrik Thalenhorst¹

¹Independent, ²Vallex Group Co.

E-mail: geothalenhorst@gmail.com

The Teghout porphyry copper–molybdenum deposit is located in northern Armenia. Soviet-era exploration from 1972 to 1990 resulted in officially “approved reserves” of more than 450 million tonnes at 0.36% copper and 0.022% molybdenum. Modern verification investigations were undertaken from 2004 to 2010. Waste stripping started in 2011 and from November 2014 until September 2017, 20 million tonnes with 0.50% copper and 0.012% molybdenum were treated in a flotation plant. A fossil supergene zone of copper enrichment is the main economic feature of this otherwise low-grade deposit. The supergene zone contained the copper derived from 200 to 250 m of now leached and oxidized rock above. The supergene zone ranges up to 140 m in thickness, averaging 35 m. The primary sulfide minerals pyrite and chalcopyrite are coated and partly replaced by chalcocite and covellite; bornite is accessory. The average copper grades of the oxide, supergene and hypogene zones are 0.10%, 0.40% and 0.17%, respectively. The top of the supergene zone was of higher copper grade than the bottom. Molybdenum may be slightly enriched. Compared to the more homogeneous primary mineralization, several items with negative economic impact were associated with the supergene zone and its formation. Pre-stripping is required of the substantial oxide waste tonnage, increasing pre-production costs and delaying income. The upper and lower contacts of the supergene zone are sharp but irregular. This results in mining dilution and ore loss along both contacts on the mining benches. The metallurgical performance of the supergene mineralization is degraded. We completed a study that compares, prior to mining, the presence of the supergene zone with a hypothetical case whereby the low-grade primary mineralization extends upwards to the present-day surface. Pit-optimization results demonstrate that without the supergene zone the deposit would not have been economic to bring into production.

Comparison of petrochronological characteristics from the P-Patch and Karpinka Lake pegmatites, northern Saskatchewan: What can they tell us about U and REE mineralization in the region?

Alan Cardenas-Vera¹, Ana Cláudia Santos¹, Joseph Bravo¹, Irvine R. Annesley¹, Tania Martins^{1,2}, Camille A. Partin¹

¹University of Saskatchewan, ²Manitoba Geological Survey.

E-mail: alan.cardenas@usask.ca

Syn- to late-kinematic Paleoproterozoic granitic pegmatites in the Wollaston Domain of northern Saskatchewan are interpreted to be generated by mid- to deep-crustal anatexis, resulting from overthrusting and granulite-facies metamorphism. These granitic pegmatites intrude the metasedimentary rocks of the Wollaston Group and are highly variable in composition with U- and Th-REE-enriched occurrences that are spatially associated with barren pegmatites. However, the character and occurrence of the mineralization is a matter not yet fully understood. Many unaltered leucogranites and pegmatites, which occur near U deposits like those from P-Patch, are variably enriched in radioelements (Th/U = 2–15; and < 0.05 when overprinted by unconformity hydrothermal U), resulting in a middle-crustal high heat production zone. The main mineral hosts are uraninite, U-rich monazite, and Th-REE-rich monazite. In contrast, pegmatites from the Karpinka Lake area are not significantly radiogenic (Th/U = 0.5–2) and contain fewer U–Th-REE-bearing minerals despite lying on the same northeast-trending structural corridor zone as P-Patch in the southeastern Athabasca Basin. This heterogeneity indicates variations in the source rocks and differences in melting processes, with similar Th/U ratios to groups A and B pegmatites from the Fraser Lakes area. Migration and ascent within a complex structural framework further enhance the differences between rocks of contrasting composition. Detailed characterization of these pegmatites and their host rocks using whole rock geochemistry in conjunction with monazite, zircon and uraninite mineral chemistry provides key constraints to the genetic processes that are responsible for the generation of these different melts, ultimately pointing to the composition, mineralogy, depth (P–T conditions) and heating (e.g. shearing versus radiogenic) of the source rock(s) as the major factors controlling the compositional variation of these pegmatites from two geologically similar areas.

Structural evolution and the timing of high grade gold–silver mineralization at Mount Hinton, Yukon

Maria Carter¹, Daniel Gibson¹, Patrick Sack², Pilar Lecumberri-Sanchez³

¹Simon Fraser University, ²Yukon Geological Survey, ³University of Alberta.

E-mail: mrcarter@sfu.ca

High grade gold- and silver-bearing veins and breccias are widespread in the Mount Hinton property in central Yukon. The property is situated in the northwestern Selwyn Basin and lies within the Tombstone Gold Belt, a ~800-km long region of reduced intrusion-related gold system (RIRGS) deposits. These RIRGS are genetically and spatially associated with the mid-Cretaceous Tombstone and Mayo plutonic suites. While there are several intrusion-related deposits near Mount Hinton such as Dublin Gulch and Scheelite Dome, there is no apparent evidence of major plutonism on the property that would fit the RIRGS model. However, preliminary geochemical results on Mount Hinton and recent studies at the adjacent Keno Hill mine area suggest that the mineralization at both are related and in the distal zones of a RIRGS deposit model. Located in the Tombstone Strain Zone between the Robert Service and Tombstone thrusts, Mount Hinton records a complex history of pervasive ductile and brittle deformation. This regional deformation likely directed mineralizing fluid flow, as shown by structurally controlled veins. Field and analytical techniques are utilized to characterize the relationships between mineralization and structures. U–Pb dating of igneous bodies provides bounds on the intervals of deformation, while direct Rb–Sr and Ar–Ar dating of select vein stages constrains the timing of emplacement. Anchored by these isotopic ages, vein paragenesis indicates an early mineralization stage of arsenopyrite + gold ± pyrite ± jamesonite followed by a silver-rich stage of sphalerite + galena + jamesonite ± remobilized gold ± Ag-tetrahedrite that crosscuts earlier veins. Initial Rb–Sr dates of calcite–arsenopyrite–muscovite veins suggest Late Cretaceous

carbonation of Triassic sills. Preliminary graphite thermometry offers insight into the thermal evolution of the system. Results from this ongoing study will be used to refine the deposit model for Mount Hinton and reconcile it with the regional RIRGS framework.

The dunitic mantle–crust transition zone in the Oman ophiolite: Origin and impact on geochemical transfers

Georges Ceuleneer¹, Mathieu Rospabé², Hadrien Henry¹, Mathieu Benoit¹

¹Centre National de la Recherche Scientifique, ²Institut Français de Recherche pour l'Exploitation de la Mer.

E-mail: georges.ceuleneer@get.omp.eu

In ophiolites, dunite is abundant along the contact between mantle peridotites and lower crustal cumulates where it forms the “dunitic transition zone” (DTZ). The genesis of the DTZ was envisioned in a dry igneous system through two non-mutually exclusive processes: (a) fractional crystallization of a Mg-rich melt followed by olivine accumulation and (b) infiltration melting of the mantle pyroxenes due to the pressure dependence in silica saturation of the percolating melt. We conducted an extensive survey in the Maqad area of the Oman ophiolite where the DTZ reaches a thickness of ~350 m at the top of a fossil mantle diapir. We show that dunite is mostly issued from infiltration melting, with cumulate dunite restricted to the very top of the DTZ. Unexpectedly, the minerals entrapped in chromite, a by-product of the melting reaction, include abundant pargasite, biotite, aspidolite, diopside and enstatite that do not fit a primitive olivine tholeiite crystallization sequence. It indicates that the initial stages of dunite formation should be attributed to an exotic melt different from the MORB that percolated eventually in the DTZ and fed the crustal section. This exotic ‘pioneer’ melt has the characteristics of a hybrid between a primitive MORB and hydrous, alkali-rich fluids. There is a body of corroborating field and geochemical evidence for a shallow origin of these fluids that migrated along syn-magmatic faults down to Moho level. We propose that a scenario for the origin of DTZs must include hydrothermal fluids. The capacity of hydrous fluids to create dunite by dissolving orthopyroxene and exporting silica was first demonstrated experimentally by Bowen and Tuttle and perfectly reproduces what we observe in the field. The formation of DTZs involves the destabilization of huge amounts of pyroxenes, mobilizes the elements preferentially hosted by these minerals, and impacts the geochemical budget of the Earth.

The unfamiliar "familiar" aegirine: What controls its compositional variation in alkaline rocks?

Anton Chakhmouradian¹, Ekaterina Reguir¹, Roger H. Mitchell², Jake Bhakta¹, Yan Liu³

¹University of Manitoba, ²Lakehead University, ³Chinese Academy of Geological Science.

E-mail: anton.chakhmouradian@umanitoba.ca

Sodic clinopyroxenes (aegirine and aegirine-augite) are one of the most characteristic constituents of peralkaline igneous rocks, fenites and certain calcite carbonatites. Compositional variation of these minerals across genetically related rock series has been addressed in numerous publications, but its treatment is typically limited to major end-members (aegirine, diopside and hedenbergite), while such minor elements as Al, Ti, V, Mn and Zr have not received much attention at all. Virtually nothing is known about the partitioning of trace elements (Sc, Cr, Sr, Y, Nb and lanthanides) between sodic clinopyroxenes and melts or fluids, and about factors that control cation substitutions in the M1 and M2 sites of their structure. In this exploratory study, we revisited > 100 samples of peralkaline syenites, fenites and carbonatites to establish the extent of compositional variation in sodic clinopyroxenes and to see if any important crystal chemical controls (e.g. structural, paragenetic or thermodynamic) may have been overlooked in previously published research. Notable highlights of this study include: (1) Al enrichment of aegirine produced by fenitization of syenites at their contact with carbonatites (up to 11.2 wt.% Al₂O₃ or 48 mol.% jadeite); (2) structurally controlled V enrichment of aegirine in carbonatites contaminated by (ultra)mafic rocks (up to 1.3 wt.% V₂O₅); (3) structurally controlled Ti, Mn and Zr enrichment of aegirine associated with late stage carbonate parageneses in agpaite syenites (up to 10.0 wt.% TiO₂, 5.6 wt.% MnO and 4.3 wt.% ZrO₂); (4) strong crystal chemical controls over the incorporation of Y and lanthanides in sodic clinopyroxenes. In many cases, trace element partitioning in sodic clinopyroxenes does not follow predictions based on experiments or thermodynamic models assuming equilibrium and appears to be controlled by either kinetic factors (e.g. growth rates) or paragenetic constraints (e.g. the absence of other suitable hosts for these elements).

Stratigraphic evidence for rising plumes – around the North Atlantic in the Maastrichtian

James Chalmers¹, Peter Japsen¹, Paul Green²

¹Geological Survey of Denmark and Greenland, ²Geotrack International Ltd.

E-mail: geusjac@yahoo.co.uk

Stratigraphic evidence shows the presence of an unconformity starting at 68 Ma (Maastrichtian) in the Canadian Arctic archipelago, on- and off-shore west and north Greenland, in Svalbard, on the Lomonosov Ridge, in East Greenland, on- and off-shore Norway and the Faroe Basin. These observations are consistent with onset of cooling ages observed from apatite fission track data in the same areas. We suggest that this unconformity is the first surface effect of the rising Iceland plume that impacted the lithosphere at 62 Ma, 6 Myr later. These observations are consistent with predictions that show that pre-impact doming can become evident 3 to 10 Myr before plume impact and that the diameter of the dome can be of the order of 1000 to 2000 km.

Petrology and geochronology of ore zone assemblages from the Niobec Mine, St. Honoré carbonatite, Quebec

Sreejita Chatterjee¹, Bruce A. Kjarsgaard², Janina Czás², Duane Petts², Chiranjeeb Sarkar¹, Sarah J. Woodland¹, D. Graham Pearson¹

¹University of Alberta, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: sreejit2@ualberta.ca

The Niobec mine (Quebec) currently accounts for approximately 8% of the global niobium supply and is the sole Canadian producer of niobium. The mine, within the Saint-Honoré carbonatite complex, was emplaced at ~578 Ma within the Mesoproterozoic Grenvillian diorite and gneiss suite (~935 Ma). The Nb-bearing minerals at Niobec are pyrochlore, columbite-(Fe) and fersmite. Despite several petrological and geochronological studies on this deposit, significant uncertainties persist regarding the timing of formation of the ore zone assemblages, which we aim to address by studying ore samples from the mine, encompassing calcite and dolomite carbonatites from the 1450' level. Three types of pyrochlore were identified: Type-1, hydrokenopyrochlore, which is well zoned; Type-2, fluorcalciopyrochlore, which has numerous inclusions of apatite, calcite, and dolomite, along with columbite-(Fe) and fersmite; and Type-3, fluorcalciopyrochlore, which is very fine-grained and occurs within banded apatite. Columbite-(Fe) occurs along the grain margins and fractures in pyrochlore, often pseudomorphing pyrochlore, sometimes containing remnant inclusions of pyrochlore surrounded by fluorite or calcite. Fine-grained fersmite occurs with columbite-(Fe), forming primarily as a pyrochlore alteration product. Apatite, calcite, dolomite, biotite and phlogopite are present as gangue minerals. They all show multiple modes of occurrences and variable major, minor and trace element geochemical signatures, suggesting multiple stages of crystallization (both magmatic and hydrothermal). A paragenetic relationship is established among these different ore and gangue phases to understand their relative timing of crystallization. Preliminary Rb–Sr dating of biotite and phlogopite yields ages ~25–35 Ma younger than the intrusive age of the complex. Dating of Nb-bearing phases (in progress) will further delineate the timing of magmatic and hydrothermal mineralization at this deposit.

A plate tectonic framework for predicting porphyry copper deposit formation

Jakub Ciazela¹, Matthew Leybourne², Taras Gerya³, Christian Verard⁴, Robert Stern⁵, Wenying Duan³

¹Polish Academy of Sciences, ²Queen's University, ³ETH Zürich, ⁴University of Geneva, ⁵University of Texas at Dallas.

E-mail: j.ciazela@mwarda.pan.pl

The short term transition to renewable energy needed for the long term sustainability of human civilization depends on ensuring adequate supplies of ore minerals. By 2040, mineral demand from clean energy technologies will double to quadruple, raising concerns because anthropogenic extraction operates on timescales much longer than the magnitudes of geological ore-forming rates. We present a plate kinematic framework to forecast ore formation over the next 10 Myr by coupling tectonic setting-specific deposit-generation functions to a forward plate motion model. Unlike reserve- or discovery-trend extrapolations, this approach explicitly links plate tectonics to mineralization rates, providing a first-order estimate of Earth's natural "mineral renewal" capacity. Before moving on to other tectonic settings and elements, we apply the method to Cu in porphyry-epithermal Cu–Mo–Au systems in continental arcs, parameterized by plate convergence rates and lithospheric factors (crustal thickness, slab composition and proxies for slab oxidation state), reflecting how rapid convergence and thick crust favour porphyry formation, while explicitly accounting for melt–fluid mass transfer within subduction zones. Given that additional time is needed for the exhumation of deeper porphyry copper deposits, the erosion rate and the ratio of epithermal to porphyry deposits are included in the calculations. These parameterizations are integrated into a global 2°-resolution plate model based on the inventory of deposits (including those no longer preserved) over the last 50 Myr to understand whether regional long term trends are increasing, decreasing or constant. These trends are then extrapolated 10 Myr into the future to produce spatially explicit, time-dependent maps of ore-forming potential. The resulting formation- and accessibility-weighted metrics provide benchmarks for Earth's natural mineral replenishment rate, against which scenario-based demand projections can be compared, thereby strengthening sustainability discussions with geodynamic constraints. In addition, lithospheric copper budgets will be better constrained because the ratio of copper trapped in deposits to lithospheric copper can be more precisely determined.

Arc volcanism, plutonism and slab breakoff recorded in the Coastal Complex, Bay of Islands, western Newfoundland

Mark Coleman¹, Francois Fournier-Roy¹, Frédérique Baron¹, Alana Hinchey², Jean H. Bédard³, Azam Soltanmohammadi³, John Wakabayashi⁴, Carl Guilmette¹

¹Université Laval, ²Geological Survey of Newfoundland and Labrador, ³Natural Resources Canada, Geological Survey of Canada, ⁴California State University, Fresno.

E-mail: macol150@ulaval.ca

In western Newfoundland, the Taconic orogeny initiated by east-directed subduction and closure of a peri-Laurentian basin. The Coastal Complex (CC) is a metamorphosed assemblage of mafic, ultramafic, and metasedimentary rocks distributed across several Taconic nappes. The CC is located at the leading edge of the terranes that overrode the passive margin of Laurentia; its position presents an opportunity to examine the initiation of the Taconic orogeny. Plagiogranites within the CC crosscut the bedrock assemblage described above and have been associated with mid-Cambrian arc magmatism (515–501 Ma). The U–Pb ID-TIMS dating of zircon from plagiogranites yields dates as young as 498 Ma, extending the known duration of CC magmatism. Geochemical analyses reveal the plagiogranites are depleted in high field strength elements and suggest they are the product of melting of a Ti-bearing, hornblende-rich source like the metamorphic sole of the Bay of Islands ophiolite. Pseudosection modelling of sole amphibolite predicts a plagiogranite melt, and depth estimates for the plagiogranite source rock coincide with depth of melting estimates from the metamorphic sole. The evidence suggests the subducted slab is the source of the CC plagiogranites, which record the subduction that initiated the Taconic orogeny. The CC plagiogranites are crosscut by NE–SW trending mafic dykes. Geochemical analyses of these samples yield N-MORB compositions lacking a supra-

subduction zone signature. Zircon U–Pb LA-ICP-MS dating of a leucogabbro of equivalent composition to the dykes yielded ~450 Ma. The composition of the dykes reflects melting of a mantle source that was not part of the mantle wedge. The uppermost Ordovician age and depleted signatures suggest these late mafic intrusions record slab breakoff during collision between the arc and Laurentia, introducing fresh depleted asthenosphere beneath the CC. This study demonstrates how oceanic closure and slab breakoff can result in a protracted yet episodic magmatic record in the forearc domain.

Detrital zircon geochronology of Devonian strata at the eastern margin of the Bohemian Massif

Stephen Collett¹, Igor Soejono¹, Tomáš Kumpan², Pavel Hanžl¹, Jitka Míková¹, Nikol Novotná¹

¹Czech Geological Survey, ²Masaryk University.

E-mail: stephen.collett@geology.cz

The Bohemian Massif preserves one of the most complete records of Devonian–Carboniferous high- to ultra-high-pressure and high-temperature metamorphism in Europe. Brunia, exposed at its eastern margin, acted as a rigid indenter against which these metamorphic units were exhumed. Despite this geodynamic importance, the paleogeographic affinity of Brunia remains unresolved due to sparse preservation of early Paleozoic strata. Competing models alternatively suggest that Brunia belonged to a shared crustal domain with internal parts of the Bohemian Massif on the Gondwana side of the Rheic Ocean, interpret it as a far-eastern extension of Avalonia accreted to Baltica in the early Paleozoic, or propose a long-lived affinity with Baltica. We present the first systematic detrital zircon study (U–Pb geochronology and Lu–Hf isotopic compositions) from Devonian sedimentary rocks that overlie Brunia's Neoproterozoic basement. Two sharply contrasting provenance signatures are identified. Type-1 spectra, widespread across Brunia, are dominated by a near-unimodal late Neoproterozoic age population derived from local arc-related sources. Type-2 spectra are multimodal, with prominent Late Ordovician–Silurian and Paleoproterozoic–early Neoproterozoic age populations and only minor late Neoproterozoic input. Neoproterozoic zircons from Type-1 samples yield nearly uniformly positive $\epsilon_{\text{Hf}}(t)$ values, distinguishing Brunia from other Variscan terranes in central and western Europe and demonstrating derivation from juvenile Neoproterozoic crust. These signatures closely match Avalonian detrital zircons from Newfoundland, establishing a Neoproterozoic connection between West Avalonia and Brunia. In contrast, the Type-2 provenance signature matches Devonian detrital zircon populations from the British Isles, the Rhenish and Harz Mountains, Dobrogea and NW Turkey, which together delineate the northern margin of the Rheic Ocean. The absence of this signal from the internal Bohemian Massif demonstrates that the Rheic Ocean remained open as an effective barrier to sediment transport until at least the Devonian, firmly placing its suture internally within the Bohemian Massif.

The Cinq Cerf Inlier: A fragment of composite Ganderia in southern Newfoundland

James Conliffe¹, David Lowe², Donnelly Archibald³, Deanne van Rooyen⁴, Corey Wall⁵

¹Geological Survey of Newfoundland and Labrador, ²Memorial University of Newfoundland, ³St. Francis Xavier University, ⁴Acadia University,

⁵University of British Columbia.

E-mail: jamesconliffe@gov.nl.ca

The Cinq Cerf Inlier in southern Newfoundland consists of a lower Cryogenian amphibolite-facies granitic gneiss complex that is overlain by a low-grade supracrustal sequence of siliciclastic and volcanic rocks (Whittle Hill sandstone and Third Pond tuff). The tectonic affinities of the Cinq Cerf Inlier remain enigmatic, with previous studies suggesting it represented either an Avalonian or Ganderia basement complex. Previous studies indicated that this supracrustal sequence is Late Neoproterozoic (585 ± 5 Ma), based on a U–Pb zircon age from a felsic tuff at the former Hope Brook gold mine in the eastern part of the Cinq Cerf Inlier. This study presents new detrital zircon U–Pb LA-ICP-MS data and crystallization ages from the Whittle Hill sandstone and Third Pond Tuff. Detrital zircon data from the Whittle Hill sandstone stratigraphically below the Hope Brook mine indicated a minimum depositional age (MDA) of 587 ± 10 Ma and significant populations of Neoproterozoic (~680 Ma), Mesoproterozoic (~1200, 1400 Ma) and Paleoproterozoic (~1800 Ma) zircon populations. In contrast, detrital zircons in two samples from west of the Hope Brook gold mine yield significantly younger MDA (563 ± 2.6 and 560 ± 3 Ma), and > 90% of analyzed zircons are Ediacaran or younger with rare Mesoproterozoic to Neoproterozoic zircons. These younger MDAs are confirmed by new U–Pb zircon age from a quartz-phyric tuff ~10 km southeast of the Hope Brook mine, which yielded a preliminary crystallization age of 560.9 ± 3.7 Ma. These new geochronological constraints, combined with Hf isotopic data, will be compared with data from other Ganderia and Avalonian detrital zircon studies, and will provide important age constraints on the provenance of the Cinq Cerf Inlier and its significance in the tectonic history of Ganderia.

Building collections and community through nature exchange programs

Tara Conroy

Canadian Museum of Nature.

E-mail: taraconroy@gmail.com

Nature exchange programs build on natural human curiosity and instinct to collect. They provide opportunities to build STEM skills, cultivate inquiry-based learning interactions and raise community awareness on environmental issues. Why are exchange programs important right now? Nature exchanges strengthen connections to our natural world at a time when many are feeling very disconnected. How can we integrate these programs into our classes, clubs or museums? An exchange can be a simple rock swap at a local mineral club or an established trade program with a database and a back room filled with exciting treasures. Trade programs can be engaging in-person experiences or expand into virtual programs supported by apps. Building and supporting a trade program is an investment in environmental stewardship. The Canadian Museum of Nature in Ottawa offered a trading

program onsite for over 25 years, reaching tens of thousands of visitors. One of the primary goals of the program was to empower visitors of all ages to identify their own treasures and share their discoveries at the Nature Trade (rebranded in 2015 and closed in 2020). In this session, participants will learn about the wide scope of nature trade programs available. Participants will then break out into trading groups and practise their science communication skills while learning more about their favourite rocks and minerals. The goal of this presentation is to inspire each participant to integrate a nature exchange program into their own classroom, community or institution.

Trace element mineral chemistry of bedrock and till from the Cu–PGE Marathon Deposit, northwestern Ontario

Willian Valentin Coqueiro Sanches¹, Alexandre Voinoit², Pedro Maciel de Paula Garcia³, Daniel Layton-Matthews¹, M.B. McClenaghan², Lyndsay Moore², James Kidder²

¹Queen's University, ²Natural Resources Canada, Geological Survey of Canada, ³Universidade Federal de Mato Grosso.

E-mail: w.sanches@queensu.ca

This study compares the mineral chemistry of the mineralized bedrock and the overlying till from the Cu–PGE Marathon Deposit in northwestern Ontario, located within the Coldwell Complex, an igneous province of the Midcontinent Rift. The Two Duck Lake Gabbro hosts Cu–PGE mineralization and is subdivided into three ore zones. The Footwall Zone is characterized by net-textured pyrrhotite with minor chalcopyrite and trace platinum group minerals (PGM). The Main Zone, the thickest and most continuous zone, hosts disseminated chalcopyrite with minor pyrrhotite and PGM, mainly kotulskite [Pd(Fe,Bi)₂] and sperrylite [PtAs₂]. The W-Horizon exhibits lower sulfide abundance, mainly as bornite and chalcopyrite, along with a diverse PGM assemblage, including common keithconite [Pd₂(Te)₂], zvyagintsevite [Pd₃Pb], and isoferroplatinum [Pt₃Fe]. This project integrates petrographic characterization with scanning electron microscope (SEM), electron microprobe (EPMA) and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to assess variation in mineral chemistry across the ore zones. Trace element mineral chemistry data for sulfides were obtained exclusively from analyses of bedrock in thin sections, whereas magnetite and clinopyroxene were evaluated in both bedrock and till. Multivariate statistics, principal component analysis (PCA) and element ratio biplots reveal systematic trace element variations in clinopyroxene and magnetite across the Footwall Zone, Main Zone and W-Horizon. Proximal till grains consistently overlap with mineralized bedrock compositional fields, whereas background till form a distinct geochemical population, illustrated by background clinopyroxenes with higher Mg concentrations (> 75 000 ppm), and generally lower Fe, Zn, and Co compared to samples from mineralized zones. These results demonstrate that the trace element chemistry of silicate and oxide minerals provides a valuable complement to conventional sulfide and PGM indicator mineral methods for exploration of Cu–PGE deposits in previously glaciated terrains. This approach improves discrimination of mineralized zones and background signatures, enhancing vectoring toward Cu–PGE anomalies, with direct implications for brownfield and greenfield exploration.

Juxtaposition of high T–low P and Barrovian-style metamorphic zones along the eastern margin of the Thompson Nickel Belt, Manitoba

Chris Couëslan

Manitoba Geological Survey.

E-mail: chris.coueslan@gov.mb.ca

The Thompson Nickel Belt makes up a portion of the Superior Boundary Zone in Manitoba. The belt was subjected to high temperature–low pressure regional metamorphism during terminal collision between the Superior craton and the internides of the Trans-Hudson Orogen towards the end of the Trans-Hudson orogeny (ca. 1800–1775 Ma). Metamorphic assemblages range from middle amphibolite facies to lower granulite facies with temperature–pressure estimates of 550–620°C and 3.0–5.0 kbar to 775–830°C and 5.0–7.0 kbar, respectively. These rocks form a nested pattern of zones with middle amphibolite facies rocks occurring along the central axis of the north-northeast-trending belt and metamorphic grades increasing towards the northwest (internal zone of the Trans-Hudson Orogen) and southeast (Superior craton). Recent mapping in the transition zone between the Archean Pikwitonei Domain of the Superior craton and the Superior Boundary Zone has revealed the presence of kyanite-bearing aluminous rocks. Although these rocks are Archean, the metamorphic overprint appears to be related to the Trans-Hudson orogeny and suggests a zone of Barrovian-style metamorphism along the southeastern margin of the Thompson Nickel Belt. Amphibolite-facies mineral assemblages suggest temperature–pressure conditions of 650–700°C and 6.5–8.0 kbar. In situ analyses of monazite in a sample from Partridge Crop Lake yielded a mean ²⁰⁷Pb/²⁰⁶Pb age of 1766 ± 7 Ma, suggesting the timing of metamorphism could be slightly younger than in the main portion of the Thompson Nickel Belt. A model is proposed in which hotter nappes of infolded Archean basement and Paleoproterozoic cover sequence were emplaced on top of cooler Archean crust of the Pikwitonei Domain during terminal collision, possibly along a proshear. A switch to transpressional tectonics resulted in relatively quick exhumation before a thermal equilibrium could be attained.

Syn-metamorphic growth of snowball garnets from the West Highlands of Scotland

Richard Cox, Kari Osfolk

Dalhousie University.

E-mail: richard.cox@dal.ca

Garnet-bearing polydeformed metapelitic rocks from two sites in the West Highlands of Scotland have been the subject of a detailed field and petrological study. Both areas show similar structural histories, with S1 and S2 fabrics overprinted by a pervasive S3 crenulation. Garnet porphyroblasts in both areas are syntectonic, growing during the S2 deformation event. At Rhubha Claddaich, on the shores of Loch Leven, 10 km west of the village of Onich, the garnet porphyroblasts are around 2 mm in size and show major element zoning patterns consistent with a single stage of prograde

growth. Samples from Cononish Glen, near the village of Tyndrum, have smaller (~1 mm) but more abundant garnet porphyroblasts. Major element zoning patterns in these garnets suggests two stages of growth. The matrix in both samples is dominated by plagioclase, muscovite and quartz, with minor amounts of rutile, ilmenite, apatite and monazite. At Rhubha Claddaich, both biotite and chlorite are also part of the main assemblage, whereas at Cononish, chlorite has replaced biotite, probably during the second metamorphic event. LA-ICP-MS mapping of trace elements in garnet show the effects of differential rates of diffusion versus growth rates for Cr, Y, REE and a number of other elements. Zoning varied from spiral patterns, where Cr diffusion is slow, to almost oscillatory zoning in Y and REE where growth during reactions with plagioclase and phosphates was likely involved. These zoning patterns allow for a more precise selection of points for P-T determinations where minerals have likely grown in equilibrium, and therefore a better estimate of the metamorphic P-T conditions recorded. In addition, by using published diffusion coefficients with the recorded peak metamorphic temperatures, the duration of the metamorphic event(s) can be estimated. In short, these rocks provide an opportunity for the construction of relatively complete P-T-d-t paths.

New in situ U–Pb monazite geochronology bearing on the timing of deformation and metamorphism within the Tazin River shear zone, Hill Island Lake area, southern Taltson orogen, Northwest Territories

Connor Crook¹, Kathryn Bethune¹, Ken Ashton¹, Rebecca Canam², Jordan Deane¹, Kyle Larson³

¹University of Regina, ²Northwest Territories Geological Survey, ³University of British Columbia Okanagan.

E-mail: connor10.crook@gmail.com

The Tazin River shear zone (TRSz) is a ductile-brittle fault zone separating the Taltson basement complex from the Nonacho basement complex in the northern Taltson orogen of the western Canadian Shield. At Hill Island Lake, this shear zone is localized within supracrustal rocks of the Hill Island Lake assemblage (HILA) and subjacent basement orthogneiss. Fieldwork carried out in the summer of 2023 focused on lithostructural mapping along an E–W transect of the shear zone. The turbiditic metasedimentary rocks of the HILA show a relatively sharp increase in metamorphic grade across the lake, from middle greenschist facies (biotite zone) in the west to middle amphibolite facies (andalusite–sillimanite–cordierite ± garnet-bearing schist) in the east, within equivalent schistose to phyllonitic rocks of the shear zone. Orthogneiss within and east of the shear zone contains older amphibolite-facies assemblages pre-dating the three main episodes of deformation. These episodes affected both the HILA and basement rocks: D1 is expressed as rare isoclinal folds with axial planar S0/1 foliation. D2 is manifest as regional NW-trending, Z-asymmetric folds with well-defined axial planar cleavage. D3, in contrast, is represented by NE-trending S-folds concentrated mainly within the HILA schist phyllonite. Quartz c-axis distribution analysis on shear zone phyllonites showcase sinistral displacement, reinforcing kinematic determinations in outcrop. In situ U–Pb dating of monazite in these rocks yields two distinct age populations. The dominant population is ca. 1850 Ma, inferred to mark late-Taltson (or younger) sinistral strike-slip reactivation (D3) of the shear zone; while a subordinate population is ca. 1940 Ma (D2), inferred to represent peak Taltson metamorphism. Further U–Pb dating (titanite), along with Rb–Sr dating (hornblende, muscovite, biotite) will be undertaken to better constrain the timing of deformation-metamorphism and related cooling history. These approaches will help to better establish connections between the three locally observed deformational phases and regional-scale (Taltson or younger) orogenic events.

Unexpected effects of CO₂–H₂O bubble on terminal velocity and mass transport in an andesitic melt

Tom Crouzal¹, Don Baker¹, Reghan J. Hill¹, Moïse Rousseau²

¹McGill University, ²Calcul Québec.

E-mail: tom.crouzal@mail.mcgill.ca

From sub-micrometre-scale bubbles to kilometre-scale volcanic conduits, the dynamics of bubbles play a fundamental role in controlling magma transport and eruptive processes. At the bubble scale, recent experimental and numerical studies suggest that mass transfer between bubbles and melt can significantly modify the local melt rheology and crystallization temperature of minerals. In a viscous-dominated regime, diffusion-driven water depletion in the melt surrounding the bubble leads to viscosity enhancement and reduced ascent velocity of the bubble. Steady state numerical simulations of a CO₂–H₂O bubble ascending through an andesitic melt isolated the effects of volatile exchange on local rheology and bubble dynamics. The model explicitly resolves water diffusion in the melt surrounding the bubble and its feedback on melt viscosity and bubble ascent terminal velocity. The numerical results indicate H₂O-poor bubbles enhance the melt viscosity locally, leading to a reduction in terminal velocity, whereas H₂O-rich bubbles decrease the melt viscosity locally, so bubbles ascend more rapidly. In addition, diffusion-driven water redistribution between the bubble and the silicate melt modifies the local liquidus temperature. Water depletion around a bubble increases the local liquidus temperature, promoting crystallization in the bubble vicinity, further increasing the viscosity, while water enrichment lowers the local liquidus temperature, favouring local crystal dissolution. The coupled effects of diffusion, viscosity variation, and phase change suggest that bubble ascent can locally modify magma rheology and crystallinity. Furthermore, bubble interactions associated with water transport in their surrounding melt can alter coalescence timescales by up to an order of magnitude, potentially shifting a volcanic eruption from quiescent to explosive.

Yukon virtual geology: Digital field experiences in Canada's North

Joel F. Cubley, Mary A. Samolczyk, Quinn Worthington

Yukon University.

E-mail: jcubley@yukonu.ca

The Yukon Virtual Geology Project is a multi-year initiative funded by the Geological Survey of Canada to develop a suite of virtual field experiences at sites of geologic interest across the Yukon. The limited accessibility of many sites due to cost and logistical considerations precludes public awareness and appreciation. By bringing them into the digital realm, the project aims to provide secondary and post-secondary students, as well as the general public a mechanism to increase their collective knowledge of the territory's geology and generally address the need for improved geoscience literacy. Since 2023, the project has developed virtual field experiences across the Yukon that cover a variety of topics such as mining and mineral exploration, paleontology, geohazards, volcanism and glacial geomorphology. In addition, a Geoscience Research in the North series of field experiences shadows geoscience researchers across the discipline as they introduce their field sites, methods and pathways into geoscience. This presentation will highlight the suite of field experiences developed, which could be incorporated into course work and/or field schools at the undergraduate level. In addition, it introduces the workflow and technology used to create these experiences, with an eye towards low-cost and accessible techniques that help ensure the longevity of the experiences themselves.

Stratigraphy and trilobite biostratigraphy of the Cambrian (Marjuman; Guzhangian) Sullivan Formation, southern Canadian Rocky Mountains, Alberta and British Columbia

Michael B. Cuggy¹, Stephen R. Westrop²

¹University of Saskatchewan, ²University of Oklahoma.

E-mail: michael.cuggy@usask.ca

The Sullivan Formation is a mixed siliciclastic-carbonate succession overlain and underlain by the carbonates of the Waterfowl and Lyell formations, respectively. The limited published record of the trilobite faunas is more than 80 years old but is sufficient to show that the Sullivan corresponds to the traditional *Cedaria* and *Crepicephalus* zones. These zones span an interval of high sea level with flooding of the interior of the continent in Wisconsin and Minnesota. As such, the Waterfowl-Sullivan boundary may record carbonate platform drowning during sea level rise. In the Mt. Murchison area, Banff National Park, the Sullivan is composed entirely of fine siliciclastics with cm- to dm-thick carbonate interbeds. To the southwest, at Paget Peak, Yoho National Park, the siliciclastics are punctuated by a carbonate unit with a basal interval of thrombolitic buildups. The lower third of the Sullivan yields low diversity trilobite assemblages that include *Nixonella* and *Paracedaria*. The middle Sullivan is dominated by diverse species of *Arapahoia*, which points to correlation with successions in western United States, including the DuNoir Limestone of Wyoming and the Abrigo Formation of Arizona. Rapid turnover of *Arapahoia* species will be the basis for a high-resolution zonation that can be applied throughout the study area. The upper Sullivan includes oolitic grainstone units in an interval that is transitional with the overlying Lyell Formation. Faunas are sparse, but genera such as *Unaspis* and *Dresbachia* indicate a correlation with the traditional *Crepicephalus* Zone.

Mineralogy of polymetallic metasedimentary rocks of the Cambrian Goldenville Group and significance for critical mineral exploration

Celeste M. Cunningham, Donnelly B. Archibald, Justin Poirier

St. Francis Xavier University.

E-mail: ccunning@stfx.ca

Metasedimentary rocks of the uppermost unit of the Cambro-Ordovician Goldenville Group are known to have high concentrations of manganese (up to 15 wt.% MnO). However, there remain many unanswered questions regarding the depositional environment, sedimentary provenance, Mn concentration processes and potential for Mn deposits. The Goldenville Group is part of the Meguma terrane, which is interpreted to have originated as a lower Paleozoic continental margin on Gondwana, although its original position and underlying basement are not known. It may have developed adjacent to the West African craton during the Cambrian, but other workers included the Meguma terrane as part of Avalonia or interpreted it to have formed as a continental margin succession on Avalonia. Previous workers have interpreted strata of the Goldenville Group to be progradational turbiditic continental slope and fan deposits. Field work conducted at two study sites in Nova Scotia demonstrates that Mn-rich facies in the upper Goldenville Group are often fine-grained, associated with thin-bedded lower slope turbidites and characterized by brown-purple nodules and laminations. Mineral chemistry and SEM-MLA imaging demonstrate that Mn occurs in several mineral phases, primarily carbonates (rhodochrosite, rhodochrosite-calcite and manganiferous calcite) and spessartine garnet, as well as chlorite, Mn-ilmenite and pyrolusite. Whole rock and EPMA data indicate that the Mn-rich strata are also associated with elevated concentrations of iron, copper, cobalt, lead, zinc, nickel, gold and arsenic. These metals occur in association with the manganiferous nodules and laminae as chalcopyrite, arsenopyrite, sphalerite, magnetite, pyrite, ilmenite and galena, and may be the result of mixed hydrogenetic and hydrothermal influences operating in an oxygen-poor, deep-marine environment. The polymetallic nature of these sedimentary rocks, combined with their wide geographic extent, has the potential to be significant for critical mineral exploration in the province.

Towards truth and reconciliation through communication: Description of a new course for geo- and non-geology majors

Jennifer P. Cuthbertson

University of Calgary.

E-mail: cuthberj@ucalgary.ca

Historically, geology has been viewed as an extractive industry focused on securing metals, coal, oil, natural gas, water and other resources of economic value. The quest for resources led to conflicts with or exploitation of Indigenous people, and unfortunately this trend continues in some areas of the world today. With the goal of educating post-secondary students, a new course entitled “Impacts of Resource Extraction on Indigenous People” is being designed in the Department of Earth, Energy and Environment at the University of Calgary. The course will be open to both geology and non-geology majors and will begin by exploring Indigenous and Western worldviews. Most of the course will revolve around a series of case studies, some in Canada and some international, starting with historical conflicts and moving towards modern day disputes. Preliminary ideas for historical case studies include impact of the gold rushes in BC and Yukon, impact of mining in Australia, development of copper and gold in Indonesia, and Spanish, British, Portuguese and Dutch colonial pursuit of metals in the Americas and Caribbean. Possible Canadian case studies of modern day disputes include Innu Nation and the Voisey’s Bay nickel mine, Little Salmon/Carmacks First Nation and the Mt. Nansen gold mine and Makivik Corporation and the Raglan mine. The final third of the course will pivot towards positive interactions between Indigenous people and geo-industries, with examples including Māori and geothermal energy development in New Zealand, Aboriginal communities and the Amrun mine in Australia and the Tu Deh-Kah geothermal project in northeastern B.C. Further ideas for case studies are entirely welcome, as the course is currently in development to be taught for the first time in Winter 2027. Courses such as this that communicate the social, cultural and community impacts of geoscience are encouraged to be added to post-secondary curricula.

Reworking field schools based on geoscience education research

Jennifer P. Cuthbertson

University of Calgary.

E-mail: cuthberj@ucalgary.ca

There has been a growing body of educational research that traditional geoscience field schools at the post-secondary level are not working for all students. Key areas of concern are the financial cost of multi-week field schools including accommodation, gear, transport and food; physical accessibility of localities; anxiety about what to expect; and discomfort with overnight trips and group dynamics. Educational research has provided suggestions for alleviating some of these concerns, such as providing clear outlines for each day of work (including bathroom availability), planning field sites that are physically undemanding, and halting the practice of requiring students to share a bed on overnight trips. However, the financial costs largely remain. At the University of Calgary, we have reworked our required field schools in order to decrease the cost for students. In the new curriculum (starting in Spring 2026), students take a two-week introductory “Field Methods and Safety” course, which consists of classroom work, walking trips from campus, half-day bus trips, and full-day bus trips. The learning outcomes of this course include how to operate a compass, locate themselves on a topographic map, sketch and interpret landscape features, make a basic map, and mitigate fieldwork risks. In addition, first aid training will be provided to all students. The second required course “Geoscience Field School”, which was previously entirely geology-focused, will now be 1/3 geology, 1/3 hydrogeology, and 1/3 geophysics. This 12-day course has two main benefits: a broader range of topics and techniques, and decreased cost because the hydrogeology and geophysics sites are within or close to Calgary, thus not requiring overnights. For students who would like more field experience, advanced geology and hydrogeophysics field schools are offered. Geoscience education research, along with feedback from students, informed the modification of the UCalgary field schools.

What can the modern tell us about facies stacking patterns in peritidal carbonate successions

Robert W. Dalrymple, John M. Rivers

Queen's University.

E-mail: dalrympl@queensu.ca

The classic facies model for peritidal carbonates shows an ordered, upward-shallowing facies succession, passing from subtidal limestones through progressively more restricted and increasingly dolomitic, microbially laminated tidal-flat micrites to desiccation-cracked and evaporite-bearing dolomudstones. Transgressive deposits are absent or of negligible thickness. Reviews of modern carbonate coastal settings, coupled with insights from better studied siliciclastic coastal zones, shows that this organization is rarely developed. Instead, transgressive deposits are common, ranging from forming most of the Holocene succession in low-energy settings such as Abu Dhabi and Andros Island, to thin transgressive lags that contain bioclasts formed in hypersaline environments in high-energy settings like the Southern Australian shelf. Erosive ravinement surfaces that are formed by landward-migrating barrier islands, which are not mentioned in reviews of carbonate sedimentation, are important elements of these transgressive successions, making facies contacts erosive rather than gradational. (Today, “shoals” are much less abundant than barrier islands and represent either incipient or overstepped barrier islands.) Progradational upward-shallowing successions are uncommon in the modern, in part because of the recent sea-level rise. Where they exist, evidence of wave action is widespread, with classic tidal flat facies existing only in the most sheltered settings. Elsewhere, progradational successions are typically more like wave-dominated shorefaces. Thus, the modern predicts that tidal flat facies should most commonly lie at the base of successions, overlain erosively by lagoonal and open marine facies. Progradational successions, if preserved, form the top of successions and are typically wave-influenced to -dominated. The most recent work on ancient peritidal deposits indicates that facies-stacking patterns are “random”, calling into question the use of ordered facies models. Although such observations are important, they do not help understand

how such successions form. Stratal removal by erosional ravinement surfaces provides one explanation for such disorder and suggests that accommodation determines the degree of preserved order.

Characterization of South Mara and Avondale members offshore Newfoundland and assessment of their CO₂ storage potential

Morgan Dauphinee, David Lowe

Memorial University of Newfoundland.

E-mail: mgdauphinee@mun.ca

Geological carbon storage is essential for achieving net-zero carbon dioxide (CO₂) emission goals in accompaniment to the clean energy transition. Previous research suggests offshore Newfoundland as an attractive location to provide storage potential in eastern Canada, hosting numerous reservoirs and pre-established infrastructure. Preliminary results are presented to determine the suitability of Paleocene to Eocene South Mara and Avondale members in the central Jeanne d'Arc Basin as CO₂ storage reservoirs. These post-rift saline aquifers appear ideal as risks are limited by a lack of faulting and absence of hydrocarbons which would otherwise undergo displacement. Seismic data and wireline logs permit characterization of submarine fan architecture. However, while high quality seismic data are available, only few, sparse wells provide petrophysical data, cuttings and 0.6 m of core leaving these members uncharacterized at the sub-seismic reservoir scale. To fill this gap, Gipuzkoa, Spain was selected as an analogue outcrop study location due to its similarities to South Mara and Avondale in age, environment, and mineralogy. These outcrops match existing models of sedimentation that permit their characterization as middle fan, outer fan, fan fringe and basin plain facies associations. Stratigraphic logs, hand samples, drone images, core samples and gamma radiation measurements were collected during the 2025 field season from these Spanish outcrops. Comparisons made between Gipuzkoa fan successions and the Jeanne d'Arc Basin confirm the suitability of this analogue and provide a means to guide static and dynamic models of CO₂ storage in the Mara fan complex. Furthermore, preliminary analyses show evidence of potential as a CO₂ reservoir through high net-to-gross middle and outer fan facies intervals, adequate depth and stratigraphic trap of regional cap rock. Further work to compare these systems and analyze reservoir components will be essential to assess reservoir suitability.

Cretaceous tectonic heritage of the Laurentian Margin: What calcite U–Pb dating of brittle faults network in the Montreal region tells us (Quebec, Canada)

Joshua Davies¹, Natasha Frost², Alain Tremblay¹, Thibault Ducat³, William Amidon⁴, Galen Halverson², Héloïse Pinon¹, Claire Musajo²

¹Université du Québec à Montréal, ²McGill University, ³Dahrouge Geological Consulting Ltd., ⁴Middlebury College.

E-mail: morgann.perrot@mgill.ca

The St. Lawrence Lowland platform, upon which Montreal sits, is crosscut by a complex network of brittle faults with variable orientations not explained solely by structures inherited from the Appalachian orogeny. Understanding the origin and timing of these fault systems carries both scientific and practical significance since they pose challenges for urban infrastructure development, while their origin is likely linked to post-rift tectonic evolution of the North American passive margin. To address these questions, we integrated three-dimensional subsurface modeling based on field structural analysis and U–Pb geochronology of syn-kinematic calcite cements. Brittle faults in the Montreal area are mainly normal faults intersecting the St. Lawrence platform in two dominant orientations, E–W and NW–SE, with fewer N–S and NE–SW sets. Main fault zones display complex anastomosing architectures, appearing locally coeval with emplacement of mafic dykes associated with the Cretaceous Mont Royal intrusion. U–Pb calcite ages from UQAM's Geotop labs range from ca. 150 Ma to near-recent, peaking around 110–120 Ma, coinciding with emplacement of the Mont Royal intrusive complex and the broader New England–Quebec magmatic province (90–110 Ma). This timing is coeval with rifting and opening of the Equatorial and North Atlantic branches of the Atlantic Ocean. Notably, these ages are significantly younger than initial Atlantic rift opening, long considered the primary driver of faulting in this region. We propose that the Mont Royal intrusion and passage of the North American plate over the Great Meteor hotspot acted as primary trigger for crustal weakening and fracturing of the St. Lawrence platform, enabling fluid infiltration and fault development. Subsequent reactivation likely reflects far-field intraplate stresses from Atlantic plate reorganization, crustal uplift driven by changes in mantle magmatic circulation, or fluid migration within the basin. U–Pb dating of fault-hosted calcite proves a powerful tool for documenting protracted brittle deformation along ancient passive margins.

Analytical spectroscopic and imaging tools and techniques at the Imaging and Chemical Analysis Lab (ICAL) to characterize Earth science systems through numerous collaborations

Bret H. Davis¹, David W. Mogk¹, Marie D. Jackson², Carly Ross¹, Lisa M. Keller¹, Colin A. Shaw¹, Alberto Perez-Huerta³, Amit Acharjee¹, Nathaniel Rieders¹, Eric Boyd¹, Chelsea Heveran¹, Henry Sun⁴

¹Montana State University, ²University of Utah, ³University of Alabama, ⁴Desert Research Institute.

E-mail: bret.davis1@montana.edu

The Imaging and Chemical Analysis Laboratory (ICAL) at Montana State University hosts a suite of imaging and spectroscopic instruments to characterize materials, including their size, shape and textures; bulk composition and variations; crystal structure and orientation; and surface chemistry. Analytical methods include field emission scanning electron microscopy (FEM), backscattered electron imaging (BSI), energy dispersive X-ray spectroscopy (EDS), electron backscattered diffraction (EBSD), cathodoluminescence imaging with spectroscopy (CL), powder X-ray diffraction (XRD) in addition to thin film analysis using X-ray reflectometry (XRR) and grazing incident X-ray diffraction (GID), surface (atomic monolayers) analysis using Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), time-of-flight secondary ion mass spectroscopy (ToF-

SIMS) and atomic force microscopy (AFM). In aggregate, these methods provide numerous complementary lines of evidence for independent verification of results. This is particularly important for interdisciplinary studies of the physical and chemical properties of diverse and heterogeneous materials and also interactions with biota. Through many academic, industrial, and government collaborations we have successfully applied these techniques in the fields of Earth and environmental science on projects ranging from microbial interactions with minerals (biomineralization and mineral dissolution), mineral ore deposits and environmental remediation, forensic investigations of ancient Roman structural concretes and corrosion processes. While performing these analyses, surface, bulk and interfacial properties are explored to build a comprehensive understanding of material formation and transformation processes, reactive histories and environments. “Bulk” and “surface” properties can be directly compared for processes that involve sorption, catalytic, diffusion and redox reactions. We welcome collaborations through imaging and spectroscopic services to the scientific community for further understanding the Earth sciences through the lens of surface, interface and bulk material characterization. ICAL is part of the NSF-sponsored National Nanotechnology Coordinated Infrastructure program, and we welcome collaborative research from across the STEM disciplines. For more information: <https://physics.montana.edu/ical/>.

Tracking volatile redistribution in metapelites during prograde metamorphism using integrated EPMA–SIMS analyses

Noralinde de Leijer, Anne-Sophie Bouvier, Thomas Bovay, Jonas Vanandois, Pierre Lanari

University of Lausanne.

E-mail: noralinde.deleijer@unil.ch

Volatile elements, including water (H₂O), chlorine (Cl) and fluorine (F), exert a first-order control on mineral stability, melting behaviour and the chemical evolution of the continental crust. Despite their importance, the behaviour of volatiles during prograde metamorphism remains poorly constrained. Thermodynamic models predict decreasing volatile (LOI) contents with increasing metamorphic grade, yet natural metapelites commonly show only limited variation across wide pressure-temperature ranges. In addition, mineral- and texture-scale heterogeneities, as well as retrograde overprinting, complicate the reconstruction of peak volatile budgets. In amphibolite-facies metapelites, biotite and muscovite, together with apatite, are the principal hosts of F, Cl and H₂O. These phases frequently display complex chemical zoning that reflects the interplay of prograde and retrograde reactions, making it difficult to isolate peak compositions. Micas such as biotite often show strong thin section-scale heterogeneity and upgrade trends, notably Ti enrichment linked to H₂O depletion. While parameters such as Mg# are largely controlled by bulk-rock composition, the processes governing F and Cl distribution during metamorphism remain unclear. We hypothesize that volatile contents in biotite primarily record peak metamorphic conditions, but local variations reflect both textural heterogeneities and retrograde overprinting. To test this hypothesis, we integrate electron probe microanalysis (EPMA) compositional mapping with secondary ion mass spectrometry (SIMS) to directly link major element zoning and volatile distributions. This approach is applied to metapelites from three metamorphic sequences spanning ~500–875°C and 0.2–1.4 GPa. Potential analytical biases related to EPMA mapping, including apparent volatile loss, are assessed using SIMS analyses of biotite standards acquired before and after EPMA. By coupling major element zoning with volatile measurements, this study provides new constraints on volatile redistribution during prograde metamorphism and refines estimates of peak biotite volatile budgets across a broad P–T range.

Investigating Archean migmatization using μ -XRF mapping: Insights from English River Subprovince and Kapuskasing Structural Zone, Superior Craton

Lorena de Toledo Queiroz¹, Renée Tamblyn¹, Jillian Kendrick²

¹University of Lausanne, ²Saint Mary's University.

E-mail: lorena.detoladoqueiroz@unil.ch

Migmatites are partially melted rocks that provide valuable information into the middle to lower crust. Anatexis of the crust leads to melt segregation, forming a melt-poor residuum and melt-rich domains, such as leucosomes. This melt may eventually be extracted, leading to the formation of felsic plutonic rocks which are an important constituent of the continental crust. In the Archean, partial melting of basalts has been pinned as an important process which forms voluminous tonalite–trondhjemite–granodiorite (TTG) suites, but the processes of chemical differentiation via migmatization of different potential source rocks are vital to understanding the major and trace element compositions of these TTGs. In the Canadian Shield, the Superior Craton hosts important exposures of Archean migmatites formed from different protoliths and metamorphic conditions. These migmatites are key to understanding major and trace element differentiation in the Archean lower crust during anatexis. In the English River Subprovince, a high-T and low-P migmatite domain is represented by a pelitic cordierite–garnet gneiss and greywacke garnet–biotite gneiss with peak conditions of 600–725°C and 0.4–0.6 GPa. Conversely, the Kapuskasing Structural Zone contains exposures of high T–P garnet–amphibole $\pm$ clinopyroxene mafic migmatites and garnet-bearing pelitic migmatites with peak conditions of ~740°C and 0.9 GPa. In both field locations, melt volume ranges from 1–90 vol.% within the centimetre to metre scale. This work aims to chemically map large areas of these migmatites using micro-X-ray fluorescence (μ -XRF) to investigate chemical differentiation during partial melting of the Archean crust in different compositions. This approach may be able to identify (i) chemical equilibrium/disequilibrium during melting reactions, (ii) the subsolidus, peritectic or magmatic origin of phases such as garnet and amphibole, and (iii) the in situ, in-outcrop or externally derived origin of leucosomes. Understanding these chemical and textural features will improve our understanding of differentiation during anatexis of Archean rocks.

Mineral chemistry of spodumene from LCT pegmatites in the La Grande Subprovince (Superior Province, Quebec)

Romain Delafosse¹, Kim Berlo², Benoit Saumur¹, Stéphane De Souza¹

¹Université du Québec à Montréal, ²McGill University.

E-mail: romain.delafosse02@orange.fr

Spodumene from LCT-type pegmatites is one of the main sources of lithium. This mineral may contain trace elements that can provide information on the formation and evolution of pegmatites, offering potential as a regional tracer. For this study, the samples analysed come from multiple pegmatites associated with various lithium projects (e.g. Galinée, Mirage, Pikwa) in the Eeyou Istchee James Bay region, mainly in the La Grande Subprovince (Superior Province, Quebec). These pegmatites exhibit a diversity of geological contexts and mineralogical assemblages, with spodumene showing variations in size, colour and texture. LA-ICP-MS analyses were performed on spodumene from the Galinée property. Certain elements known to be regularly found in trace amounts in spodumene, such as Fe, Mn, Sn and Ga, showed wide variability in values among different samples, with values ranging from 10 to 4,000 ppm for iron, for example. This high heterogeneity in trace elements within the same property could be due to several factors, including the presence of different generations of pegmatites or spodumene, the alteration of some of the spodumene, or intracrystalline zoning of the crystals analyzed. These observations from Galinée constitute a preliminary framework that will be expanded to the entire sample set. All spodumene samples will be analyzed by LIBS-ICP-MS, allowing for the simultaneous acquisition of major, minor and trace elements. Ultimately, this dataset will make it possible to link the chemistry of spodumene with formation processes (magmatic, hydrothermal or petalite decomposition), the identification of multiple generations and lithium enrichment mechanisms.

Lithogeochemical discrimination of source rocks of carbonaceous mudstones in volcanic assemblages of the western Abitibi Greenstone Belt

Rhian Dentelbeck, Mark Hannington, Marc Fassbender

University of Ottawa.

E-mail: rdent087@uottawa.ca

The Abitibi Greenstone Belt (AGB) is host to world-class base metal deposits. However, increasing depletion of near-surface deposits requires improved geological models to guide the exploration. Carbonaceous argillites, or black shales, are common ore-hosting units in the AGB and their distinct electromagnetic properties have resulted in many of these rocks being targeted during drilling campaigns. This resulted in a vast yet widely underappreciated archive that holds valuable information to locate deeper mineral deposits. The black shales are mainly synvolcanic and formed in volcano-sedimentary basins spatially correlated with volcanic centres. Whole rock geochemical analysis was performed on 564 samples of carbonaceous argillite collected during a regional-scale sampling program in 2011 from more than 75 different townships. This study develops a detailed classification of the carbonaceous argillite as a tool for mineral exploration. Although black shale is visually unclassifiable, multivariate statistical analysis reveals distinct compositional variation reflecting source rock composition (felsic, mafic) and associated mineralization style. In addition, alteration indices highlight hydrothermally influenced units, including mineralized shales and shales that were derived from volcanic rocks already altered at their source. Two machine learning approaches identify the different shale units, including spatial variations in the shale geochemistry and their host volcanic rocks. Principal component analysis (PCA) and Random Forest predict the source rock composition with an accuracy of 92% based on titanium, zirconium, vanadium, scandium and chromium concentrations. Blind tests show the Random Forest model can predict shale provenance and potential links to mineralization (VMS versus orogenic gold) in the target region.

CanmetMINING's Mining Value from Waste program: Advancing tailings characterization, resource recovery and driving a national collaborative approach to tailings reprocessing

Julie Deriaz^{1,2}

¹Natural Resources Canada-CanmetMINING, ²Memorial University of Newfoundland.

E-mail: julie.deriaz@nrcan-rncan.gc.ca

Mine tailings in Canada present significant opportunities for critical mineral recovery, carbon footprint reduction and land rehabilitation. Legacy tailings, waste rock and other mining by-products are increasingly being reframed as potential resources rather than waste. Realizing this potential requires robust characterization methods to evaluate site value and liability offset potential. Growing interest from provinces, territories and industry underscores the need for a coordinated national approach to tailings reprocessing. Established in 2015, CanmetMINING's Mining Value from Waste (MVfW) program has since leveraged work completed under Federal Budgets 2021 and 2022 Critical Minerals RD&D programming to advance this goal through development of the Canadian Mine Tailings Inventory, expansion of systematic sampling programs and progress on the Stirling tailings case study in Nova Scotia. This presentation will provide updates on these efforts and outline plans to broaden the program to support future tailings characterization efforts in Canada.

Tectono-structural framework and evolution of the southwestern Grand Banks, Newfoundland, Canada: Implications for an offshore carbon sequestration feasibility assessment

Justina T.S. Devries, Alexander L. Peace, Adedapo N. Awolayo

McMaster University.

E-mail: devrij8@mcmaster.ca

The Grand Banks passive margin forms a structurally complex segment of the North Atlantic rift system, resulting from Paleozoic terrane assembly and Mesozoic rifting. This produced structurally heterogeneous rift basins characterized by extensional fault systems, salt deformation and inherited fabrics. Within this context, the Laurentian Basin provides a compelling setting to examine tectonic and structural controls on subsurface storage potential in eastern Canada. As carbon capture and storage (CCS) becomes central to reducing net anthropogenic greenhouse gas emissions, identifying geologically secure offshore storage sites is critical. Despite advantageous geological formations, proximity to major CO₂ sources and existing offshore infrastructure, the Grand Banks remains underexplored for CCS. However, uncertainties in structural framework, fault architecture and seismic history limit detailed geological modelling needed for storage assessment. Hence, this study investigates the tectono-structural evolution of the offshore Grand Banks region of Newfoundland using two-dimensional seismic reflection data, structural analysis and numerical modelling to assess CCS feasibility. We investigate 1) regional structural framework and tectonics, 2) fault geometry and kinematics, and 3) fault–salt interactions and effects on CO₂ migration and pressure behaviour through fluid flow simulations. Integration of structural models with logistical constraints like existing well infrastructure facilitated identification of candidate CCS sites, optimal injection locations and safe injection thresholds that minimize induced seismicity risk. Our fault map reveals dominant N–S and E–W normal fault sets associated with widespread salt structures, graben and half-graben structures, indicating Mesozoic extension and coupled fault–salt evolution. This presents a complex yet strategically favourable setting where faults may act as barriers or conduits for fluid flow, while salt influences trapping efficiency. Our findings raise fundamental questions for future investigation: how can computational efficiency be balanced with accurate representation of structural heterogeneity in passive margin settings? How do fault–salt interactions and inherited structural weaknesses influence stress distribution, salt mobility and CO₂ migration?

The Penobscot Arc in Maine: Evidence of incipient rifting, backarc development and VMS formation within the Cambrian Castine Volcanics

Michelle DeWolfe¹, Douglas Reusch²

¹Mount Royal University, ²University of Maine.

E-mail: mdewolfe@mtroyal.ca

The Cambrian Ellsworth terrane, well-exposed in eastern Penobscot Bay, Maine, hosts a variety of marine volcanic and sedimentary rocks, variably deformed and metamorphosed to greenschist. Volcanic rocks in the area, grouped together as the “Castine Volcanics”, include remarkably well-preserved sequences of basalt, rhyolite and associated rhyolitic volcanoclastic rocks, which host the ca. 504 Ma Harborside volcanogenic massive sulfide (VMS) deposit. Volcanic textures, previous geochemical studies and the occurrence of a VMS deposit have led previous researchers to suggest an oceanic setting, which has been compared to the Gulf of California, Cayman Trough and the passive side of a wide backarc rift. Our work aims to carefully document the different depositional units within the Castine Volcanics, to better understand the internal stratigraphy, and to elucidate the complex Cambrian tectonics within Maine. Here we present new mapping from the Cape Rosier area, including the subdivision of volcanic lithofacies, high-precision whole rock major and trace element geochemistry, structures within the Castine Volcanics and their relationships with the overlying shales of the Ordovician Penobscot Formation and the underlying Ellsworth Schist (ca. 509 Ma). Our interpretations based on these data suggest volcanic rocks of the Castine Volcanics were erupted through, and deposited unconformably on, the Ellsworth Schist. They display trace element geochemical signatures (e.g. Nb depletions relative to Th and La) typical of modern arcs, an interpretation that is further supported by the volcanology and mineralogy of the Harborside VMS deposit. We interpret the Castine Volcanics to have been erupted during incipient rifting and development of a backarc basin, due to Iapetan subduction dynamics, and associated with the Penobscot arc, during opening of the Rheic Ocean and separation of Ganderia from Gondwana.

A general framework for mitigating visitor impacts at geoparks

Daniel Dick, Elli Papangelakis, Alex Peace, Carolyn Eyles

McMaster University.

E-mail: dickd3@mcmaster.ca

Present in numerous countries and covering an extremely wide array of geological contexts, geoparks present unique conservation challenges, particularly with regards to small-scale visitor impacts. Individual geoheritage sites within geoparks vary widely in substrate durability, scientific value and visitor motivations, rendering one-size-fits-all approaches ineffective. Here we draw from empirical studies on geoparks and comparable protected wilderness areas to propose a general framework for mitigating visitor impacts. The framework is based on linking four mutually reinforcing approaches: visitor segmentation, visit tailoring, behavioural modification tools and activity zoning. Rather than serving as stand-alone interventions, these approaches are here presented as a set of mutually reinforcing and iteratively refined systems. Initially, visitor segmentation informs dispersal strategies and guides the development of behavioural modification tools. Next, context-specific behavioural modification tools are implemented to shape and/or reduce the incidence of specific on-site actions. Finally, activity zoning translates the insights gained via visitor segmentation and monitoring of the efficacy of the behavioural modification tools into broader management decisions. Within this general framework, we present educational infrastructure and monitoring/feedback systems as meta-interventions that are most effective when they guide the application and iterative

improvement of the four ground-level interventions explored here. The resulting framework provides geopark managers with an evidence-based system for mitigating visitors impacts at geoheritage sites.

Niagara Escarpment erosion quantification using unmanned aerial

Vehicles and LiDAR

Daniel Dick, Elli Papangelakis, Alex Peace, Carolyn Eyles

McMaster University.

E-mail: dickd3@mcmaster.ca

Determining the rate of erosion along the Niagara Escarpment – as well as which specific units or structures are most liable to experiencing erosion – remains an open question. Here we describe a LiDAR drone-based system for detecting change along the Niagara Escarpment. The Niagara Escarpment presents a significant challenge to researchers using 3D LiDAR technology, as classic vegetation removal algorithms were not designed to handle vertical cliff faces and frequently give unusable results. As the surface of the Niagara Escarpment (and adjacent land) features dense vegetation that can occlude LiDAR scans and complicate the interpretation of change detection approaches, we developed a random forest classifier for isolating the exposed rock faces of the escarpment, to ensure that detected changes are not impacted by changes in vegetation position/density. While the vegetation removal algorithm shows promise, several challenges continue to complicate the detection of change along the Niagara Escarpment. We present preliminary results and discuss future directions.

Magmatic evolution of the Mesoarchean Florence Lake Group: Geochemical constraints and implications for crustal growth in the Hopedale Block, Labrador

David Diekrup, Marina Schofield, Alana M. Hinchey, Hamish A.I. Sandeman

Geological Survey of Newfoundland and Labrador.

E-mail: DavidDiekrup@gov.nl.ca

Volcanic rocks from the ca. 3.0 Ga Florence Lake Group in the Hopedale Block, north-central Labrador, were analyzed to evaluate whether volcanism reflects discrete eruptive episodes or a temporally prolonged magmatic system. Basalt whole rock data and trace elements in detrital zircons were employed to assess internal chemical variability, inform mapping and facilitate comparison with other Archean greenstone belts. Basalt compositions (45–60 wt.% SiO₂; < 12 wt.% MgO) in the Florence Lake Group exhibit progressive continuums from flatter REE, higher Ti to LREE–Th-enriched, HREE-depleted compositions. Principal component analysis and fuzzy clustering delineate spatially organized geochemical domains instead of discrete compositional boundaries. These domains display a broad west–east distribution that is tentatively consistent with inferred stratigraphic younging, although structural constraints remain incomplete. The observed variability is significant at map-scale but does not warrant subdivision of the Florence Lake Group into separate formation-level units. Thorium serves as a key discriminant, and variability in whole rock Th is mirrored in zircon compositions: Florence Lake zircons show slightly elevated Th/Y, with a minor subset displaying high Th/Y (~1–1.5; locally Th/U > 1). These differences are not accompanied by systematic changes in Ti-in-zircon temperatures (~5–20 ppm Ti) or HREE slopes, reflecting continuous temporal evolution within a stable crustal framework rather than tectonic reorganization. Florence Lake Group basalt compositions were compared with a dataset from the Abitibi greenstone belt. The closest corresponding classes in the Abitibi are the Blake River-types (Noranda, Western Blake River, Chibougamau), characterized by dry to moderately hydrous melting regimes. Although the comparison is relative, it places Florence Lake within the compositional range of heterogeneous Archean volcanic systems. Collectively, the data support incremental Mesoarchean crustal growth in the Hopedale Block through sustained mantle melting and gradual source evolution, rather than abrupt tectonic changes.

Refining the paleomagnetism of the East Superior Craton: A keystone for Paleoproterozoic paleogeography

Grey DiMascio, David Evans

Yale University.

E-mail: grey.dimascio@yale.edu

Paleoproterozoic time (ca. 2.5–1.6 Ga) marks the proposed assembly of Earth's supercontinent, Nuna, yet its paleogeography remains poorly constrained. The Superior craton plays a central role in Nuna reconstructions, but its apparent polar wander (APW) path between ca. 1.9–1.8 Ga remains controversial. Paleomagnetic data from the ca. 1870 Ma Haig and Flaherty mafic rocks of the Belcher Islands differ significantly from poles of the ca. 1880 Ma Molson dyke swarm, implying ~40° of APW over ~10 Myr—an episode of unusually rapid plate motion. Alternatively, the Haig rocks may have been remagnetized, rendering the inferred rapid motion false. Our proposed project aims to test these competing hypotheses using modern paleomagnetic methods. Oriented samples will be collected from the 1.87 Ga Haig intrusive suite, targeting intrusion interiors and margins to conduct a robust baked-contact test. This approach directly evaluates whether the magnetization is primary (acquired during cooling) or secondary. Complementary sampling of nearby Paleoproterozoic sedimentary units will further refine the APW path of the East Superior craton between 2.0–1.9 Ga. Stepwise thermal demagnetization, directional analysis and structural corrections will isolate characteristic remanent magnetization components and assess data reliability. Results will be compared with coeval regional poles to determine whether the previously inferred rapid APW shift reflects true plate kinematics or regional remagnetization. By resolving this discrepancy, this study will strengthen the paleomagnetic framework for the Superior craton and contribute higher confidence constraints on Nuna assembly, advancing understanding of early Proterozoic tectonic dynamics.

Chlorite compositions, prograde metamorphism and gold-related trace elements

Lauren DiPietro, Richard Cox

Dalhousie University.

E-mail: kdipietro2000@icloud.com

The reaction and growth history recorded by chlorite–muscovite schists from the West Highlands of Scotland, and the effect of chlorite reactions on trace element behaviour during progressive metamorphism, has been the focus of a detailed field and analytical study. The rocks from Port Appin, Cuil Bay, Onich, St. John's Church and Ballachulish represent progressive metamorphism from mid-greenschist to mid-amphibolite facies. All the samples are chlorite–muscovite schist with at least two stages of deformation and variable prograde and retrograde reactions present. Microstructures preserved by sheet silicates are widely used to examine P-T conditions and deformation. The samples were examined using a multi-method approach involving SEM, EMPA, XRD, XPS and LA-ICP-MS, with the goal of determining the P-T conditions and trace element variations during multistage deformation. The data were first used to carry out a P-T analysis which linked field measurements with the microstructures present. This involved the application of chlorite thermometry and mica–plagioclase thermobarometry, which record the different stages of Caledonian deformation. Trace element analysis focused on volatile metalloid (VM) elements (S, Se, Te, Sb, Bi, Hg, As, etc.). VM elements are commonly related to orogenic gold mobilization and the compositions of sheet silicates have been used as indicators of gold deposition. In polymetamorphic terranes, different deformation events may be responsible for the reactions releasing volatiles and VM elements. Understanding the breakdown liberation processes during metamorphism is therefore essential to mapping subsequent potential gold-related processes. This presentation will involve (i) SEM and petrographic analysis of chlorite schists with identification of chlorite growth generations during varying metamorphic conditions, (ii) XRD analysis to determine the main sulphide minerals present, (iii) XPS mapping and EMPA analyses of major elements in the sheet silicates to produce P-T-d maps and (iv) trace element analysis using LA-ICP-MS to determine which deformation event(s) released VM metal elements.

Presenting settled science does not provide the royal road to learning: A critical look at undergraduate geoscience topic sequencing

Glenn Dolphin

University of Calgary.

E-mail: glenn.dolphin@ucalgary.ca

Humanity faces growing concerns from the natural world, including clean air and water supplies, mineral and energy resource extraction and consumption, natural hazards and increased climate change-related risks. To mitigate such concerns, we need a population that is geoscience literate. Engagement and learning within the geosciences are highly dependent on the nature of teaching and how responsive instruction is to how students learn. Recent research documenting the order of topics taught in undergraduate introductory geoscience course (in this issue) as well as a survey of commercially available introductory geoscience textbooks shows that the first topics students experience in introductory courses deal with the origin of the universe, the solar system and earth, as well as the theory of plate tectonics, before then addressing chemistry – atoms, bonding, and molecules. These concepts are well outside the students' experiential frameworks in both scales of time and space. What we know from how people learn, philosophically, theoretically and empirically, is that students require concrete experiences as building blocks for abstract ideas. Learning must begin within the scale of the students' everyday concrete experiences before moving to the abstract. This paper elaborates on this argument and then puts forth implications for instruction to be effective, including understanding the origin of common misconceptions, breaking down large explanatory concepts (like theories) into hierarchies of supporting elements that are more concrete, and providing students with concrete experiences they can leverage effectively to develop more reliable (i.e. scientific consensus) concepts.

Mineralogical and chemical evolution of the alteration haloes of the Triangle orogenic gold deposit

Valentin Drouillot¹, Bertrand Rottier¹, Crystal LaFlamme¹, Georges Beaudoin¹, Maxime Bertautes¹, Jacques Simoneau², Tim Baker², Pape Mactar-Dieng²

¹Université Laval, ²Eldorado Gold Corp.

E-mail: valentin.drouillot.1@ulaval.ca

The Triangle orogenic gold deposit (Val-d'Or, Québec) consists of several well-defined quartz–carbonate ± tourmaline + Au (QTC) shear veins. The shear veins, numbered from C1 to C10 crosscut an intermediate lapilli to block tuff and a dioritic plug (Triangle plug), with the C4 vein being the largest and most economically important. Four transects, all in the tuff, were sampled from 1 m of the shear vein to 120 m away, at the C2, C3, C4, and C5 shear veins. Along these transects the major element composition of chlorite was measured by WDS-EPMA, as well as whole rock composition for the C3 and C4 transects. In these transects the proximal alteration halo (1–2 m) of the QTC veins consists of a sericite–carbonate ± chlorite–pyrite–tourmaline assemblage. The distal alteration (5–10 m) is characterized by a chlorite–carbonate assemblage, sometimes with epidote. The distal alteration is followed by a background alteration consisting of epidote as well as variable amounts of chlorite, biotite and amphibole. For the C3 and C4 transects, whole rock geochemistry shows no significant changes in major elements from proximal to background alteration assemblages, apart from LOI and C content which progressively decreases to background levels at a distance of 5 to 10 m from the vein. The chemical composition of chlorite shows an increasing trend of Mg# as a function of the distance from the shear with a Mg# between 43 and 54 in the proximal alteration to ~65 in the background. In the C4 transect, this transition is progressive and can be tracked over 30 m, in the background, whereas, for C2, C3 and C5, the variation of Mg# is only observed at 7 to 10 m from the vein. This work suggests that chlorite chemistry changes could be tracked up to 30 m away from the most mineralized veins, indicating a good potential for mineralization vectoring.

Paleoenvironmental reconstructions of Late Cretaceous rivers within a tephrostratigraphic framework, Dinosaur Park Formation, Alberta

Paul Durkin¹, Mira Thompson¹, Kirstin Brink¹, Alfredo Camacho¹, Caleb Brown^{1,2}

¹University of Manitoba, ²Royal Tyrrell Museum of Palaeontology.

E-mail: Paul.Durkin@umanitoba.ca

Paleoenvironmental reconstructions of fluvial systems in the stratigraphic record commonly lack the chronological resolution required to quantify processes such as channel migration rates or avulsion frequency. Conventional geochronologic and biostratigraphic methods that are effective in other depositional environments are often difficult to apply in fluvial strata. As a result, interpretations are typically limited to extrapolation from experimental datasets or linear interpolation between widely spaced chronostratigraphic horizons. The Dinosaur Park Formation (DPF), exposed in Dinosaur Provincial Park (DPP), Alberta, provides a rare opportunity to develop a robust tephrostratigraphic framework in which detailed paleoenvironmental reconstructions of Late Cretaceous river systems can be temporally constrained. This integration allows direct quantification of fluvial process timescales and rates of environmental and faunal change. The Upper Cretaceous (Campanian) DPF is characterized by meandering fluvial channel belt and floodplain deposits that record a large river system flowing from the Cordilleran highlands in the west to the Western Interior Seaway in the east. At DPP, extensive badlands exposures provide exceptional three-dimensional views of channel belt sedimentology and stratigraphic architecture. More than a decade of fieldwork has produced detailed reconstructions of fluvial paleohydraulics, channel evolution and floodplain sub-environments, forming a comprehensive paleoenvironmental and paleogeographic model for southeastern Alberta during the Late Cretaceous. Recent geochemical fingerprinting and regional correlation of at least five dated bentonite horizons have enabled construction of a high resolution tephrostratigraphic framework. This framework constrains paleoenvironmental reconstructions at unprecedented temporal resolution and allows refinement of sedimentation rates beyond simple linear interpolation methods. In addition, the new tephrostratigraphy has important implications for dinosaur biostratigraphy, as bentonite horizons provide more precise chronostratigraphic datums for fossil placement.

Anchored or adrift? Kinetic controls on salt crystal nucleation

Brendan V. Dyck, Xavier Chang

University of British Columbia.

E-mail: brendan.dyck@ubc.ca

Crystal nucleation kinetics influence rock texture, phase distribution and whether reactions proceed as predicted by equilibrium thermodynamics. In crystalline systems, epitaxy — where a daughter phase inherits crystallographic orientation from a parent substrate — is generally the lowest energy nucleation pathway. Examples include kyanite–staurolite, biotite–tourmaline and amphibole–pyroxene pairs, identifiable by distinct crystallographic orientation relationships (CORs). However, even where epitaxial CORs are common, not all grains nucleate epitaxially because local variations in mass-transport efficiency can drive nucleation along higher energy pathways. Structural and lattice compatibility are necessary for epitaxy, but they alone are not always sufficient to cause orientation inheritance. For example, previous work shows that halite can nucleate homogeneously at evaporative boundary layers despite compatible carbonate substrates. What, then, determines whether nucleation proceeds epitaxially, heterogeneously, or homogeneously? Using the 1-component halite (NaCl), niter (KNO₃) and sylvite (KCl) salt systems we test whether the slope of a salt's temperature–solubility curve predicts its default nucleation pathway. Shallow temperature–solubility slopes (i.e. NaCl) require evaporation to reach saturation, promoting diffusion-limited, boundary layer nucleation. In contrast, steep slopes (i.e. KNO₃) can be crossed by system-wide cooling alone, reducing the influence of diffusion. We crystallize niter in the presence of carbonate and quartz, and halite and sylvite in the presence of fluorite and used electron backscatter diffraction (EBSD) to quantify parent–daughter CORs between substrates and overgrowths. We find halite nucleates homogeneously under all tested conditions, including in solution volumes < 10 μm^3 and with nuclei < 100 nm diameter. In contrast, niter readily nucleates epitaxial to carbonate substrates. Sylvite–fluorite pairs record mixed epitaxial and homogeneous nucleation behaviour. These results demonstrate that higher energy nucleation pathways are favoured in systems with mass transport-limited kinetics. The absence of epitaxial CORs in certain metamorphic and igneous reactions may therefore be indicative of diffusion-limited reaction kinetics rather than a lack of crystallographically compatible, low-energy nucleation sites.

Visualization and constraints on paleo-evolution of Earth systems: Including a call for improved compilation of geoscience information

Bruce Eglington¹, David Evans², Sally Pehrsson³, David Huston⁴, Dene Tarkyth¹, Hoang Anh Tu (Lavie) Nguyen-Ridgway¹, Peter Hone¹

¹University of Saskatchewan, ²Yale University, ³Natural Resources Canada, Geological Survey of Canada, ⁴Australian National University.

E-mail: bruce.eglington@usask.ca

Both temporal and spatial data are necessary to illustrate the development of Earth systems in deep time and to constrain the processes involved. Many studies focus on the processes without consciously considering spatial context. Unfortunately, many standard mapping, research and reporting procedures support this. Compilation of information which may aid in resolving contrasting concepts is made more difficult by use of publication procedures that hinder compilation and by publication of maps presented in ways that were suitable for printed paper, rather than utilizing modern digital approaches which include the full level of detail captured by field geologists. The Earth has a long history, exhibiting substantial changes. The higher level of detail often available in Phanerozoic settings provides ample evidence for complex, changing processes, so we ought to expect considerable variability through Precambrian time, roughly nine times longer in duration. Uniformitarian concepts provide guidance for possible scenarios, but alternative views need to be considered. More nuanced and detailed compilation of multiple sets of data would aid in determining

appropriate parsimonious interpretations which need to be considered in their full 4D context if we are to better constrain Earth evolution, changing environmental and climatic factors and influences on the formation of mineral and energy resources critical to the sustainability of life on our planet. Combination of domain expertise with new machine learning and artificial intelligence capabilities will enable us to do more, provided we can provide suitable, structured data. Examples of systems, maps and procedures already exist that we can emulate to provide strong links for detailed mapping that provides geodynamic and environment of formation information, combined with data which address both process and geotectonic setting.

Mineralized chonolith conduits: Insights from Venusan sinuous rilles as potential analogues

Hafida El Bilali, Richard E. Ernst

Carleton University.

E-mail: hafidaelbilali@cunet.carleton.ca

Chonoliths are important targets for magmatic Ni–Cu–PGE sulphide deposits within mafic–ultramafic magmatic systems. They are also described as channelized intrusions, tube-like conduits or conduit-type intrusions. Their characteristic geometry consists of elongate, tube-shaped, channelized bodies that represent focused magma flow within intrusive plumbing systems. This enhanced magma flux makes them priority targets for sulphide mineralization. Recent work suggests that major mineralized chonolith regions can form during rapid stress transitions associated with mantle plumes, particularly a 90° shift from plume-driven uplift (radial stress) to lateral plume-head spreading (circumferential stress). Examples include Norilsk chonoliths of the Siberian Traps and those associated with the Midcontinent Rift along Lake Superior. Here, we explore possible Venusan analogues for insights into chonolith formation on Earth. Venus is dominated by plume-related magmatism, lacks plate tectonics and experiences no surface erosion due to the absence of liquid water. With near-global radar coverage at ~75 m resolution, Venus provides an exceptional laboratory for studying preserved plume-driven tectono-magmatic systems. Canali are long, sinuous volcanic channels of relatively constant width, interpreted as channelized lava flows. In contrast, sinuous rilles are generally shorter, narrower and frequently associated with coronae. These rilles often emanate from circular or elongate collapse features (termed coronae) and extend downslope as channelized flows. Our research on Venus indicates that about a dozen coronae so far exhibit sinuous rilles linked to circumferential graben systems, which likely overlie dyke swarms. If sinuous rilles represent surface expressions of laterally fed intrusions, they may provide insight into chonolith geometry and magma flux. Measurements of flow length, elevation of effusion and associated plume-head diameter may help estimate magma throughput and assess whether similar processes could explain the volume and tenor of terrestrial chonolith mineralization.

Predicting metal deportment in granulite facies rocks: A case study from the Somerset Trough, Nunavut

Karim El Ghawi, James Mungall

Carleton University.

E-mail: karimelghawi@mail.carleton.ca

The Paleoproterozoic Somerset Trough on Somerset Island, Nunavut, is a granulite-facies volcano-sedimentary rift basin within the Boothia terrane on the western margin of the Rae craton. These granulite facies rocks preserve mineral assemblages that equilibrated at high temperature conditions and provide a natural laboratory for evaluating how high temperature metamorphism governs the redistribution of metals in the continental crust. This study examines a representative suite of lithologies including pegmatite, psammite, paragneiss, tonalite, diorite, rhyolite and mafic litharenite to quantify mineralogical controls on metal deportment across contrasting protoliths. The facies concept, in equilibrium thermodynamics, predicts that rocks of fixed bulk composition stabilize predictable mineral assemblages at defined pressure and temperature conditions. Because metals partition among coexisting phases according to crystal-chemical constraints, systematic relationships between metamorphic grade, mineral assemblage and metal distribution are expected. Bulk compositions are reconciled with quantitative mineral modes obtained from automated SEM-based X-ray mapping and Mineral Liberation Analysis (MLA), establishing a statistically robust and texturally constrained phase inventory for each sample. Trace element concentrations in major rock-forming minerals and accessory phases are determined by in situ laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), enabling direct quantification of critical and chalcophile element distribution at the mineral scale. Comparison between mineral-scale trace element data and bulk rock compositions identifies the major and minor hosts of metals, resolves discrepancies in elemental budgets and highlights accessory phases that exert disproportionate control on whole rock metal inventories. Empirical mineral–mineral partition coefficients derived from coexisting phases are integrated with pseudosections calculated using THERIAK-DOMINO to evaluate how variations in pressure, temperature and bulk composition influence predicted metal distribution. By linking quantitative mineralogy, in situ trace element geochemistry and thermodynamic modeling within a single granulite facies terrane, this work establishes a systematic and predictive framework for understanding metal deportment in high-grade crust and for assessing the mineralogical conditions that concentrate economically significant elements.

Geomodels and exploration indicators for poorly understood REE pegmatites in Saskatchewan

Holly A.L. Elliott¹, Eimear Deady², Alicja Lacinska¹, Camille A. Partin³, Claudia Santos³, Nick M.W. Roberts¹, Richard Shaw¹, Tania Martins^{3,4}

¹British Geological Survey Keyworth, ²British Geological Survey Edinburgh, ³University of Saskatchewan, ⁴Manitoba Geological Survey.

E-mail: elliott@bgs.ac.uk

Net zero goals are causing a global drive to decarbonize energy and transport systems. Green technologies are essential to limit climate change in a low-carbon society, and their manufacture will increase the demand for a range of raw materials. Rare earth elements (REE) are integral to the manufacture of permanent magnets required for green technologies, such as wind turbines and electric cars, and have been recognized as critical raw

materials by both UK and Canadian governments. The REE supply chain is geographically limited, with China extracting nearly 69% but processing > 90% of REE in 2024, enabling the country to influence prices, causing supply risks and affecting REE criticality. Developing a secure, resilient and diverse REE supply chain with high environmental, social and governance standards is a key priority for both the UK and Canadian governments. The discovery of REE–Th-enriched pegmatites in Saskatchewan could provide a future supply of monazite (a REE ore mineral) for the Rare Earth Processing Facility recently built by the Saskatchewan Research Council. Establishing a Canadian REE supply would diversify and increase resilience of global supply chains. The petrogenesis of REE-enriched pegmatites is poorly understood but typically considered to be associated with peralkaline granites. However, there is no clear parental granite source for either the REE–Th-pegmatites or U-pegmatites in the Wollaston Domain of Saskatchewan. This project aims to develop a source-to-sink geomodel to understand the formation of these REE-enriched pegmatites and develop exploration methods and indicators of REE–Th-pegmatites over barren U-enriched end-members. Results will be applicable on a global scale to similar deposits. Preliminary results indicate a multi-stage formation model for these pegmatites. Petrographic associations indicate that emplacement is followed by metasomatism, fluid infiltration and alteration. Geochemical and isotopic analyses are being undertaken to test whether these processes have enhanced REE-enrichment and to constrain pegmatite source.

Laser ablation-based multi-method dating provides new avenues for basin studies

Eva Enkelmann¹, Birk P. Härtel¹, Akeek Maitra¹, Emily G. Johns-Buss², Muhammad Rafeeza¹

¹University of Calgary, ²Memorial University of Newfoundland.

E-mail: eva.enkelmann@ucalgary.ca

Laser ablation techniques enable the application of multiple geo- and thermochronometers to individual mineral grains. Because of the time and cost efficiency, these multi-method analyses are particularly powerful when applied to detrital settings, which require the analysis of a large number of grains. Depending on the geologic setting and the geo- and thermochronometer used, the data can provide pre- and post-depositional information ranging from sediment provenance and cooling histories of source rocks to the thermal history after deposition due to burial and basin erosion. We present several case studies from Paleozoic and Mesozoic strata in western and eastern Canada, and abroad. These case studies combine U–Pb geochronology with (U–Th)/He, fission track and/or Raman thermochronology on detrital apatite and zircon grains. Our results highlight the potential of multi-method approaches to answer new geological questions for basin studies. We share our learning to guide future project designs and best analytical strategies. In addition, we present recent methodological developments and resulting data interpretation tools for multi-method datasets.

Cenozoic exhumation and fault reactivation in the southern Canadian Cordillera

Eva Enkelmann¹, Douglas MacLeod¹, Tobias Stephan²

¹University of Calgary, ²Lakehead University.

E-mail: eva.enkelmann@ucalgary.ca

The southeastern Canadian Cordillera is characterized by Mesozoic to early Paleocene compression and magmatism that was followed by post-orogenic collapse. This Paleocene–Eocene extension and core complex development has been well documented by structural and geochronological data that show the role of large detachment faults to rapidly exhumate lower crustal rocks. However, the upper crustal post-Eocene processes, those that ultimately resulted in today's landscapes, are mostly unknown. Recent analysis of the current crustal stresses indicates that the region between the southern Rocky Mountain Trench and the Fraser River Fault is under extension, driven by high gravitational potential. This presentation reviews recent studies that use low temperature thermochronology to target some of the major faults in southeastern British Columbia including the Columbia River Fault, the southern Rocky Mountain Trench, the North Thompson Albrede Fault and the Gallagher Fault zone. Together they reveal several phases of post-40 Ma fault reactivation and exhumation. Oligocene and Miocene sediments occur in fault-bounded basins across the southern Cordillera post-Eocene fault reactivation. The spatial pattern of these younger phases of faulting varies across the region, revealing the need for further thermochronology studies combined with structural field measurements that quantify the brittle deformation.

Frontiers in Large Igneous Province (LIP) research

Richard E. Ernst¹, Hafida El Bilali¹, Kenneth L. Buchan²

¹Carleton University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: RichardErnst@cmet.carleton.ca

Over the past two decades, the record of Large Igneous Provinces (LIPs) has expanded significantly in the Proterozoic and, more recently, the Archean. When continental and oceanic provinces are combined, their average emplacement frequency approaches one every 20 million years. Given this recurrence and their far-reaching geodynamic consequences, plume-generated LIPs represent a first-order Earth process comparable in importance to plate tectonics. High precision U–Pb geochronology increasingly supports LIPs as major drivers of environmental and climatic change. Improved temporal correlations link individual provinces to perturbations in the sedimentary record. Current research frontiers include integrating detailed emplacement histories — particularly eruptive pulses — with specific climatic responses and quantifying the magnitude and duration of volatile release from both primary volcanic degassing and thermogenic gases generated by intrusion into volatile-rich sedimentary basins. The largest LIPs may also serve as chronostratigraphic markers for Proterozoic and Archean time boundaries previously only defined to the nearest 50–100 Myr. In the deep mantle, recognition of two long-lived Large Low Shear Velocity Provinces (LLSVPs) beneath Africa and the Pacific connects plume generation to deep mantle structure for at least the past ~300 Myr. Extending this framework further back in time integrates plume geochemistry — such as bilateral chemical zonation reflecting mixing between ambient mantle and LLSVP-derived material — with paleomagnetic reconstructions of

ancient mantle structure. Characterizing LIP architecture remains central to understanding plume–lithosphere interaction. Geophysical imaging and geochemical “LIP-printing” constrain mantle sources, magma pathways and lithospheric controls. Plume head dimensions, linked to depth of origin, can be inferred from uplift, sedimentary hiatuses, magmatic extent and dyke swarm geometry. Plume-related LIPs are also fundamental to metallogeny for numerous types of critical minerals, ranging from orthomagmatic, hydrothermal, sedimentary-hosted to plate boundary-related. Comparisons with Venus and Mars — plume-dominated planets lacking plate tectonics — help clarify plume-tectonic coupling and long-term planetary evolution.

Novel exploration strategies for a wide range of commodity types (including orthomagmatic, hydrothermal, sediment-hosted, orogenic/subduction-related) using the plumes/LIPs paradigm

Richard E. Ernst¹, Hafida El Bilali¹, Simon M. Jowitt²

¹Carleton University, ²University of Nevada Reno.

E-mail: RichardErnst@umet.carleton.ca

The association between plume-generated Large Igneous Provinces (LIPs) and magmatic sulphide Ni–Cu–PGE deposits is well established, exemplified by the Norilsk ores of the Siberian Traps. Previous work expanded the link between LIPs and metallogeny to include not only orthomagmatic deposits, but also hydrothermal systems driven by LIP-derived heat and fluids, LIPs acting as barriers or reactive zones to fluid flow, laterites enriched in Al, Ni, and Co formed through LIP-related weathering (including weathering of associated carbonates), and indirect relationships between LIPs and distal orogenic ore deposits within a plate tectonic framework. Here we further broaden these connections by evaluating the dynamic effects of mantle plumes responsible for LIPs and the metallogenic consequences of geologically rapid stress and topographic changes they generate. We focus on both proximal effects above plume heads and distal effects related to plume-head push. Above the plume head, four key processes are identified. (1) Rapid ~90° stress-field transitions from plume-driven uplift to plume-head spreading may facilitate emplacement of chonoliths, an important host of magmatic sulphide mineralization. (2) Regional uplift can influence the orientation of hydrothermal vein systems. (3) Plume-induced tilting of sedimentary basins may redirect mineralized brines, contributing to sediment-hosted ore formation. (4) Localized vertical ascent of plume material through thick lithosphere may introduce heat and fluids into the crust, promoting mineralization. Distally, lateral spreading of the plume head against cratonic roots (“plume-head push”) may alter plate motions, generating stress changes that favour convergence-related mineralization, including orogenic gold and potentially porphyry systems. Together, these processes highlight the broader and dynamic metallogenic footprint of mantle plumes beyond traditional LIP-associated deposits.

Metamorphic history of the Matawinie graphite deposit, southern Grenville Province, Quebec

Lütfi Ersay¹, Renaud Soucy La Roche¹, Bertrand Rottier², Antoine Godet³, Kyle P. Larson⁴

¹Institut National de la Recherche Scientifique, ²Université Laval, ³Natural Resources Canada, Geological Survey of Canada, ⁴University of British Columbia Okanagan.

E-mail: lutfi.ersay@inrs.ca

Graphite, a critical mineral, forms the Matawinie deposit in the central Morin terrane of the southern Grenville Province where it is hosted primarily in fine-grained semipelitic quartzofeldspathic rocks and secondarily in sillimanite–K-feldspar-bearing migmatitic paragneiss. Flake graphite occurs in various textural settings: 1) flake inclusions (< 500 µm in size) in garnet porphyroblasts, 2) foliation parallel or non-oriented flakes within quartz and plagioclase-rich paleosome, 3) interstitial, extra-large flakes (> 1 mm) between K-feldspar and quartz in leucosome and 4) in hydrous selvages dominated by biotite ± muscovite. Here we investigate the influence of high-grade metamorphism on the graphite mineralization through quantitative P–T–t estimates. Raman spectroscopy on graphite flakes reveals sharp G bands with little to no D1 and D2 bands in these texturally distinct graphite flakes, indicating a high crystallinity degree attained at elevated temperatures (> 750°C). Phase equilibria modeling of a layered garnet–sillimanite-bearing migmatitic gneiss confirms peak metamorphic conditions of ~870°C and ~750 MPa and a retrograde path passing through ~835°C and ~560 MPa. In addition to the specimen above, three graphite-bearing samples including a residual migmatite, a garnet-rich leucosome and a layered cordierite–garnet–sillimanite–K-feldspar gneiss were analyzed for in situ monazite U–Pb geochronology. The ²⁰⁷Pb/²⁰⁶Pb dates (n = 460) define two main peaks at 1145–1130 Ma and 1085–1060 Ma with several dates in between. Although the peaks overlap with the end of the Shawinigan orogeny and the onset of the Ottawa phase of the Grenvillian orogeny, respectively, the spread of intermediate dates may point to a protracted metamorphic history (> 100 Myr) involving partial melting and fluid remobilization as mechanisms that contributed to distribution and concentration of the graphite at Matawinie.

Investigating the role of magmatism in the formation of volcanogenic massive sulfide deposits of the Victoria Lake Supergroup, Newfoundland, Canada

Alicia P. Escribano¹, Stephen J. Piercey¹, John G. Hinchey², Nicole M. Rayner³, Greg R. Dunning¹

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador, ³Natural Resources Canada, Geological Survey of Canada.

E-mail: adpescribano@mun.ca

The Victoria Lake Supergroup (VLSG) in central Newfoundland, Canada, is host to a variety of volcanogenic massive sulfide (VMS) deposits of varying mineralization styles including replacement (e.g. Duck Pond deposit), exhalative (e.g. Long Lake deposit) and magmatic fluid-influenced (e.g. Lemarchant and Bobby's Pond deposits) and is an ideal location to study the role of magmatism in their formation. Stratigraphic observations and sampling of rocks from deep footwall, footwall and hanging wall lithologies were undertaken to distinguish those representing high temperature magmatism (e.g. high REE, HFSE, Nb/Ta, and Nd and Hf isotopes signatures) within the stratigraphic column. Stratigraphy combined with whole rock chemistry shows that high temperature magmatism occurs prior to emplacement of footwall rocks in replacement-style deposits, whereas high temperature magmatism occurs after deposition of footwall rocks in exhalative-style deposits. Footwall zircon from VMS deposits that lack evidence of magmatic fluid contributions (e.g. Duck Pond deposit) has lower Th/U and Th/Nb and high Zr/Hf ratios compared to zircon from VMS deposits where magmatic volatiles probably contributed metals to their formation (e.g. Bobby's Pond deposit). Proximal (< 400 m to VMS deposits) apatite from VMS deposits with evidence of magmatic contributions has high S^{6+} contents interpreted to result from sulfur disproportionation of magmatic derived SO_2 .

Pyroxenite veins in the Loma Caribe peridotite massif of the Caribbean island arc: A record of boninitic magma crystallization, melt–harzburgite reaction and lithospheric deformation during embryonic intra-oceanic subduction

J. Escuder-Viruet¹, Mercedes Castillo-Carrión¹, F. Pérez-Varela², F.J. Fernández-Rodríguez³, P. Valverde-Vaquero¹

¹Instituto Geológico y Minero de España, ²Universidad de Alicante, ³Universidad de Oviedo.

E-mail: p.valverde@igme.es

Boninite volcanism in supra-subduction zone environments marks the onset of intra-oceanic subduction and has been linked to formation of pyroxenite veins in the mantle section by reaction with the ascending boninitic melts. One such section to study and document such processes is the Loma Caribe peridotite massif (LCP; Cordillera Central, Dominican Republic), a mantle section of the Early Cretaceous intra-oceanic Caribbean island arc with pyroxenite veins ranging from orthopyroxenite to websterite. These pyroxenites have variable amounts of olivine, spinel and calcic amphibole, low major elements (Al, Ca, Ti, Na and K) and trace element-poor whole rock compositions with sub-chondritic REEs. They contain high Cr# spinel, forsteritic end-member olivine and ortho and clinopyroxene with high Mg#. The ortho- and clinopyroxene have low contents in Th, HFSE (Nb, Zr, Hf and Ti) and REE, well below the primitive mantle values, and a relative LILE enrichment. Modification of the whole rock trace element composition at the contact of the pyroxenites with the host harzburgites gives evidence for melt–rock reaction processes induced by melt percolation. Trace element modelling indicates orthopyroxenite vein crystallization from Mg- and Si-rich, hydrous, ultra-depleted melts derived from a source analogous to the LCP clinopyroxene-rich harzburgites. Websterites crystallized from melts of boninitic affinity, a mixture of infiltrating melt and partial melting of depleted host peridotites. Thermobarometric calculations based on two-pyroxene REE and major element partitioning yield vein formation under spinel-facies conditions of 1100–1200°C and 1.0–1.2 GPa, at the base of the sub-arc lithosphere, and subsolidus re-equilibria around 790–1060°C and 0.24–0.98 GPa during cooling and exhumation of the LCP. Subhorizontal shearing of the pyroxenite veins indicates boninitic magma emplacement pre-dating and synchronous with the high-T porphyroclastic foliation in host peridotite, suggesting that the veins formed during lithospheric extension of the Caribbean island arc induced by the fast rollback of the subducting slab.

Are precursor uranium deposits necessary for the formation of high grade unconformity-related uranium deposits?

Mostafa Fayek

University of Manitoba.

E-mail: mostafa.fayek@umanitoba.ca

Unconformity-related uranium (URU) deposits in Proterozoic basins, include some of the highest grade deposits in the world (e.g. McArthur River and Cigar Lake). The prevailing models, particularly for the high grade Athabasca Basin deposits, suggest that a fertile uranium source is considered necessary for the formation of high grade URU deposits. These deposits are not formed by a single event but require multiple, protracted episodes of hydrothermal alteration, leaching, transport and redeposition of uranium. However, the spatial extent of the ore systems and lower crustal features capable of driving the hydrothermal cells remains largely unresolved. A recent geophysical study of the Patterson Lake corridor uranium deposits (western Athabasca basin) suggests a deep heat source (high heat-producing intrusions) enhanced hydrothermal fluid flow and incursion of basinal brines along brittlely reactivated ductile shear zones. While most URU deposits show a strong association with precursor features, some, such as the Centennial deposit, suggest more complex, perhaps non-graphitic, or deeper sources, though still requiring a fertile source. Research on the Beaverlodge deposits (north of the Athabasca basin) has suggested that these deposits represent precursor uranium deposits with an age of ~1.82–1.85 Ga. Inversion followed by subsidence resulted in formation of the Martin Lake basin, a successor basin filled with sediments, mafic flows and sills that formed during the Trans-Hudson orogeny. Overlying the Martin Lake basin are outliers of the Athabasca Formation associated with the last stage of uranium mineralization, at ca. 1.62 Ga, from oxidizing basinal brines. Each successive event overprinted to varying degrees the previous events. Here I propose that precursor, lower grade uranium deposits are an important source of uranium and necessary for the formation of high grade URU deposits.

Geochronology and petrography from the Kiggavik and Lac Cinquante uranium deposits show evidence of a pre-existing uranium system that has been significantly overprinted by numerous hydrothermal events.

Rare Earth mobilization in roof zones of alkaline igneous intrusions

Adrian Finch¹, Curtis Rooks^{1,2}, Krzysztof Sokol^{1,3}, George Frangeskides²

¹University of St Andrews, ²Alba Mineral Resources, ³University of Oxford.

E-mail: aaf1@st-andrews.ac.uk

The roof zones of alkaline igneous intrusions often contain significant mineralization in critical metals such as rare earth elements, tantalum or niobium. One such location is the Motzfeldt Region, southern Greenland, which hosts what is considered to be one of the world's largest Ta deposits, as well as commercially significant amounts of Nb and REE. Glaciation has provided spectacular km-high vertical sections through the structure creating an extraordinary natural laboratory for the study of magmatic processes. In this system, a nepheline syenite magma ponded underneath sedimentary quartzite (the Eriksfjord Group) forming a km-wide magma chamber. Interaction between the quartzite roof and the magma led to vertical gradients in silica content such that the top is quartz syenite grading down after ~300 m to nepheline syenite below. The interaction triggered the formation of Ta-rich pyrochlore in the roof zone. The magma was associated with an aggressive fluorine-rich fluid phase, which then modified the magmatic assemblage. The fluid mobilized REE and HFSE (but not Ta) from the pyrochlore. Rafts of quartzite, detached from the roof, were strongly hydrothermally altered ("finitized") by this fluid, adding Na, Ca, REE and many HFSE elements scavenged from the pyrochlore. The replacement of quartz in the sediment by feldspar lowered the solidus temperature and the xenoliths partially melted to give a highly REE- and HFSE-enriched albite syenite melt. These melts penetrated the roof zone, forming a second phase of mineralization in the system. The process by which country rocks are finitized and then melted is a new genetic model. It explains the quite separate behaviour of REE and other HFSE in this system.

The oldest Ediacaran fossils in Newfoundland

Danielle M. Fitzgerald^{1,2}, Guy M. Narbonne¹, Shuhai Xiao², Robert Dalrymple¹, Christopher Spencer¹, Mark Schmitz³

¹Queen's University, ²Virginia Polytechnic Institute and State University, ³Boise State University.

E-mail: narbonne@queensu.ca

The Ediacara biota records the appearance and diversification of Earth's first large, soft-bodied eukaryotes, including the interpreted oldest animals, yet their evolutionary origins remain unresolved. Previously, the oldest known large (centimetre- to metre-scale) Ediacara-type macrofossils known anywhere were 571–574 Ma fronds and other soft-bodied taxa from the upper Drook Formation at Mistaken Point Ecological Reserve in Newfoundland, Canada. The Drook fossils are large, diverse and architecturally complex, implying that they may have had macroscopic precursors, a view consistent with molecular clock estimates of 830–650 Ma for the origin of animals. We herein report two occurrences of putative Ediacaran macrofossil remains a thousand metres lower in the Newfoundland section. These structures occur in the Mall Bay Formation, which underlies the glacial deposits of the Gaskiers Formation, and are probably 8–10 million years older than the oldest currently described fossils from Mistaken Point or anywhere else worldwide. More than 30 specimens comprising two distinct types have been identified. The structures are simple, even by Ediacaran standards, but are morphologically comparable to well known Ediacaran taxa and the largest of the two types are bipartite structures that range up to 2 m in length.

Micro-X-ray diffraction and in situ XRD as exploration tools – with emphasis on kimberlite indicator minerals

Roberta L. Flemming¹, Phil J.A. McCausland¹, Jayshri Sabarinathan¹, Stanislav L. Veinberg², Ken A. McIsaac¹

¹Western University, ²Proto Manufacturing Ltd.

E-mail: rflemmin@uwo.ca

Minerals can be characterized by their crystal structure and their chemical composition. Most exploration programs use chemical analysis as the go-to technique for mineral characterization. X-ray diffraction offers an alternative tool, which can complement chemical techniques. Kimberlite indicator minerals garnet, chromite and ilmenite have been examined by laboratory-based micro-X-ray diffraction (μ XRD) to assess their unit cell size changes in response to variation in chemical composition, thus acting as a proxy for composition. Cr-pyrope garnet, $\text{Mg}_3(\text{Cr,Al})_2(\text{SiO}_3)_4$, has a relatively small unit cell compared to non-kimberlitic garnets, where peridotitic pyrope garnets exhibit $a_0 < 11.780$ (± 0.005) Å. Magnesiochromite, MgCr_2O_4 , has an intermediate-sized unit cell for spinel-group minerals, where kimberlitic magnesiochromite exhibits $a_0 = 8.329$ (± 0.007) Å. Ilmenite is hexagonal and has two variable parameters, a and c . In ilmenite, the c -axis is more responsive than the a -axis to chemical substitution and pressure effects. Kimberlitic magnesian ilmenite, $(\text{Mg,Fe})\text{TiO}_3$, exhibits $c_0 < 14.02$ (± 0.01) Å. A field-deployed miniaturized μ XRD instrument would enable analysis of minerals in situ, as grab samples or within their host rocks. A prototype miniaturized in situ XRD (ISXRD) has been developed by a multidisciplinary team of scientists and engineers from Western, Guelph and Brock universities and Proto Manufacturing in Ontario. It features a 16 cm source operating at 125 W (25 kV, 5 mA), $\text{CoK}\alpha$ radiation ($\lambda = 1.79026$ Å), and an SPD detector. In the field, the three kimberlite indicator minerals above could be analyzed in 'triage' to be identified as potentially kimberlitic by their XRD signatures and then flagged for further chemical analysis. Such an in situ technique would be useful in exploration or for mine site processing. While this example focuses on kimberlite indicator minerals, miniaturized μ XRD is promising for mineral identification to support other exploration or monitoring programs such as for sulfides, tellurides and REE minerals.

Geochemical constraints on the origin of mafic and ultramafic intrusions in the northern Rottenstone Domain, Trans-Hudson Orogen (Saskatchewan)

Tyrin Foley¹, Kevin Ansdell²

¹Saskatchewan Geological Survey, ²University of Saskatchewan.

E-mail: kevin.ansdell@usask.ca

Mafic–ultramafic rocks on Reindeer Lake, Saskatchewan, occur as small dykes, sills and larger plutonic bodies hosted within the Paleoproterozoic Rottenstone Domain of the northwestern Reindeer Zone. The regional geology of the northern Rottenstone Domain is dominated by broad successions of psammite–pelite, slivers of metavolcanic rocks and several phases of crosscutting plutonic rocks. The region has been affected by upper amphibolite-facies and polyphase deformation related to the Trans-Hudson orogeny. As part of the bedrock mapping initiative by the Saskatchewan Geological Survey, this M.Sc. research focuses on the tectonic affinity, magmatic evolution and structural history of the mafic–ultramafic rocks. Bedrock mapping at 1:20 000 and 1:50 000 scales has identified small-bodied pyroxenite and actinolite-rich dykes and sills, as well as gabbroic plutons, emplaced within the Milton Island Lithodeme and undivided metavolcanic rocks. Pyroxenite is characterized by MgO ranging from 14.6 to 21.3 wt.%, variable SiO₂ (43.0 to 55.7 wt.%), CaO ranging 3.9 to 16.3 wt.%, elevated Cr (up to 2290 ppm) and variable Ni (67 to 568 ppm), with gabbroic end-members having lower MgO and higher CaO and SiO₂. The actinolite-rich rock is defined by high MgO (14.9 to 19.7 wt.%), variable SiO₂ (43.9 to 54.8 wt.%), high CaO (12.3 to 16.9 wt.%), high Cr (2940 to 4380 ppm) and lower Ni (81 to 304 ppm). The main gabbroic pluton has approximately 50 wt.% SiO₂, MgO (8.1 to 16.4 wt.%), CaO (9.2 wt.%) and Al₂O₃ (11.2 wt.%). Chondrite-normalized REE patterns and Nb, Th, Yb, Y, TiO₂, Zr and MgO ratios for all mafic–ultramafic rock units in the project area are consistent with magma generation in a back-arc environment from a subduction modified, slightly enriched mantle wedge.

Crust of the North Atlantic Realm

Gillian R. Foulger

Durham University.

E-mail: g.r.foulger@durham.ac.uk

The disintegration of Laurussia to form the North Atlantic and neighbouring seas, was preceded by a long history of tectonic unrest throughout a broad region extending deep into North America, Scandinavia and Europe. The fundamental cause of breakups is unknown, but clearly structure within destabilized supercontinents heavily influences breakup and accompanying magmatism. When initial, broad zones of extension coalesce on a single axis, older orogenic belts with suitably orientated fabric function as weak zones that are preferentially selected. In the North Atlantic additional complicating factors required departure from this simple model. Migrations of the rotation poles, complex structure including converging orogens, and piecemeal breakup resulted in multiple continental fragments. Initial breakup forming the Labrador Sea was impeded at the transverse Nagssugtoqidian/Rinkian orogenic confluence, and the Davis Strait formed. Northeast of present-day Iceland the Ægir spreading axis formed obliquely within the Caledonian orogeny and propagated south, stalling where the orogenic front meets the Nagssugtoqidian orogen. South of present-day Iceland the Reykjanes Ridge propagated north through the North American craton, but also stalled at this transverse barrier. The Ægir ridge later became extinct and spreading north of Iceland migrated west to form the Kolbeinsey ridge. Between the northern ocean ridges and the Reykjanes Ridge, some 350 km to the south, extension and magmatism have been persistently diffuse and the nature of the underlying, 30 km-thick swathe of crust between Greenland and the Faroe Islands is unclear. It may contain continental material, as do Baffin Bay, the Greenland and Norway volcanic passive margins, the Jan Mayen Microcontinent Complex, Rockall and the Faroe Islands. It is thus possible that Canada, Greenland, Iceland and Britain/Scandinavia may still be united by continental- and hybrid crust. Further investigation of this may be possible with new international, cross-disciplinary collaborations.

Crustal structure of the Greenland–Iceland–Faroe Ridge

Gillian R. Foulger¹, Ilmo Kukkonen²

¹Durham University, ²University of Helsinki.

E-mail: g.r.foulger@durham.ac.uk

The crust beneath the Greenland–Iceland–Faroe Ridge (GIFR) (“Icelandic-type crust”) has been studied extensively using active and passive seismology, magnetotellurics, gravity, magnetics, heat flow, geology and drilling. Despite this, major puzzles persist. The GIFR comprised a land bridge for the first ~35–40 Myr of ocean opening. It is now ~1200 x 300 km in area and all except Iceland has subsided a few hundred metres below sea level. Beneath it the crust is everywhere 30 ± 10 km thick. The upper crust is typically 7 ± 1 km thick and the lower crust 15–30 ± 5 km thick. Low seismic attenuation and normal Vp/Vs ratios in the lower crust suggest there is no pervasive partial melt, so temperatures are subsolidus i.e. less than ~900°C. The exceptional, 40 km-thick patch of lower crust beneath central Iceland may represent a trapped block of older oceanic or continental crust. There is no clear Moho – refracted head waves are extremely rare. The crust–mantle boundary is a transition zone ~5 ± 3 km thick throughout which Vp increases from ~7.2 km/s to ~8.0 km/s. The density contrast between the lower crust and underlying mantle is only ~145 ± 15 kg/m³ compared with ~300 kg/m³ for normal oceanic crust. Uppermost mantle velocities are normal, implying temperatures lower than at equivalent depths beneath the East Pacific Rise. It is commonly assumed that Icelandic-type crust is oceanic crust thickened by high melt productivity resulting from elevated mantle temperatures. However, this model cannot accommodate the observations without special pleading and models that are incongruent between data types. Consequently, other explanations must be considered. The mostly appealing is that the GIFR crust is heavily magmatized continental crust – a continuation of the crust beneath volcanic passive margins of Greenland and Britain/Scandinavia.

Three-dimensional sediment dispersal archive in ancient shallow water, siltstone-dominated clinoforms

Patricia E. Fraino¹, Carolyn M. Furlong², Per K. Pedersen³

¹Manitoba Geological Survey, ²MacEwan University, ³University of Calgary.

E-mail: patricia.fraino@gov.mb.ca

Fine-grained sediment dispersal in marine settings is governed by competing physical processes, yet direct paleocurrent evidence linking multidirectional transport pathways to depositional architecture remains rare in ancient successions. Exceptionally well exposed two- and three-dimensional outcrops of the Lower Triassic Sulphur Mountain Formation (southern Alberta, Canada) allow documentation of sediment routing across a complete shallow water, siltstone-dominated clinoform system. A total of 638 paleocurrent measurements integrated across shoreline, subaqueous platform, and clinoform deposits indicate that sediment dispersal is governed by the interaction of oscillatory fair-weather wave reworking, episodic downslope storm- and gravity-driven transport, including turbidity currents, channelized flows and localized mass wasting. Notably, these deposits are overprinted by dispersal trends associated with semi-permanent along-shore and along-slope (i.e. geostrophic) currents. Paleocurrent measurements from unidirectional current ripples are consistently oblique to, and in some instances nearly perpendicular to, the dominant direction of shoreline progradation. These contrasting dispersal trends highlight the complex spatial interplay between downslope sedimentation and more omnipresent sediment dispersal by geostrophic currents, demonstrating that fine-grained sediment was distributed over a wide area both basinward and along strike. This strongly three-dimensional dispersal archive provides rare ancient documentation of the process complexity increasingly recognized in modern shelf systems (i.e. mudbelts, clinoforms, contourites), with implications for predicting fine-grained facies distribution in analogous ancient and subsurface datasets.

Thick underplating and the buoyancy of the Bermuda swell

William Frazer¹, Jeffrey Park²

¹Carnegie Science, ²Yale University.

E-mail: wfraser@carnegiescience.edu

Bermuda is an example of a hotspot volcanic ocean island that has long been puzzling because it does not conform to traditional mantle plume theory. When a hot mantle plume upwells beneath a tectonic plate, it often generates a chain of volcanic islands or seamounts and a wide (~500 km) bathymetric swell. Bermuda sits atop a wide and prominent bathymetric swell, but unlike other swells, such as Hawaii, it lacks evidence for a deeply rooted mantle plume and modern volcanism. We conduct high-frequency receiver function imaging of the shallow lithosphere to image sharp interfaces with data from a permanent seismometer on Bermuda. Our imaging reveals two prominent interfaces interpreted as the fossil oceanic Moho and the bottom of previously unreported underplated layer. The underplated layer is ~20 km thick, ~2x greater than observations at many other intraplate ocean islands. This thick layer beneath the crust likely was emplaced when Bermuda was volcanically active ~30 million years ago. Based on the topography of the swell, this layer could be rock that is ~50 kg/m³ less dense than the lithospheric mantle it has replaced. We suggest Bermuda is supported by a ~20 km thick layer of modified lithospheric mantle, not a hot thermal anomaly from a mantle plume.

Paleoenvironmental reconstruction of an arid coastline of western Pangea: Case study of arid deltaic systems from the Lower Triassic Montney Formation, Alberta, Canada

Carolyn M. Furlong¹, Rebecca Cruickshank¹, Patricia E. Fraino², Omid H. Ardakani^{3,4}, Per K. Pedersen⁴

¹MacEwan University, ²Manitoba Geological Survey, ³Natural Resources Canada, Geological Survey of Canada, ⁴University of Calgary.

E-mail: furlongc2@macewan.ca

Deltas along arid coastline settings are poorly preserved in the rock record due to their episodic discharge and extensive sediment reworking during fair weather conditions. Consequently, the frequently absent eolian components must often be inferred from associated shallow marine deposits. One such example is the Lower Triassic Montney Formation, which was deposited along the western margin of Pangea at a paleolatitude of ~32–34°N under arid paleoclimatic conditions. Through the sedimentological analysis of subsurface drill cores, three deltaic systems have been identified within the northern, central and southern regions of the Western Canada Sedimentary Basin during the time when the Montney Formation was deposited. Lower Montney deposits are characterized by shoreface successions in the south and wave-dominated delta to shoreface successions in the central and northern regions. The northern delta system exhibits coarsening-upward succession (up to 15 m thick) of silty shale, siltstone and very fine-grained sandstone with occasional syneresis cracks, low-diversity *Cruziana* ichnofacies and soft sediment deformation reflecting ephemeral deltaic input. Total clay ranges from 10–35% and TOC < 1%, whereas the wave-dominated delta in the central region exhibits deposits that are thinner (5–10 m thick succession), with sandstone beds less than 10 cm thick, moderate total clay (< 15%) and TOC < 2%. During the deposition of the Middle Montney, both the southern and central regions are dominated by fluvial-dominated deltaic succession (10–20 m thick), which are made up of fining-upward beds (10–50 cm in thickness) of fine- to medium-grained sandstone that are capped by organic and clay-rich beds (total clay < 46% and TOC < 2%). Sandstone beds are massive, planar through trough-crossed stratified with frequent soft sediment deformation. The overall shift from wave-dominated delta and shoreface deposits within the Lower Montney to fluvial-dominated deltaic deposits within the Middle Montney highlight the evolution of a dynamic arid coastline that existed over ~3 million years.

Characterization of natural fracture exposed on bedding planes in Kananaskis, Alberta, Canada

Carolyn M. Furlong¹, Patricia E. Fraino², Per K. Pedersen³

¹MacEwan University, ²Manitoba Geological Survey, ³University of Calgary.

E-mail: furlongc2@macewan.ca

Natural fracture patterns were characterized on three well exposed bedding planes within the Lower Triassic Sulphur Mountain Formation that outcrops along the roadcut at Hood Creek, Kananaskis, Alberta. Fracture analysis was conducted on field photos processed in FracPaQ (a MATLABM toolbox) for 2 m x 3 m rectangular sampling windows on each bed plane. The studied beds occur 2.08 m apart in vertical stratigraphy and are exposed along a 27 m lateral section of the outcrop. Although the three beds consist of siltstone to very fine-grained sandstone and have experienced the same tectonic stresses, the fracture networks differ significantly, suggesting compartmentalization of stress. Bed A has a total of 96 fracture traces, with trace lengths ranging from 0.02–1.73 m (average length 0.31 m) and bed B has a total of 926 fracture traces, with trace lengths ranging from 0.01–1.66 m (average length 0.15 m), whereas bed C has a total of 1981 fracture traces, with trace lengths ranging from 0.01–1.11 m (average length 0.09 m). All beds had a relatively narrow dispersion envelope for dominant fracture orientations, with a strong east–west preferred orientation. Bed A exhibits orthogonal fractures, bed B exhibits conjugate fractures, whereas bed C has a unimodal fracture orientation. Fracture density and intensity increased between bed A, bed B and bed C, with bed A having the lowest average density (84.66/m²) and intensity (4.99 m/m²), bed B having high average fracture density (644.24/m²) and intensity (22.56 m/m²) and bed C having the highest fracture density (1145.73/m²) and intensity (31.09 m/m²). Observations from this study showcase the complexities of fracture networks along closely spaced bedding planes, within a relatively thin stratigraphic interval, which may be oversimplified in existing fracture models.

Mapping an Archean Moho: Analysis of the Superior Province's "tectonic scars" as resolved through gravity modelling

Christopher Galley, Mark Hannington, Erin Bethell, Keaton Strongman

University of Ottawa.

E-mail: gchrist2@uottawa.ca

The Superior Province is Earth's largest Archean craton, forming the core of the North American Shield. It is generally believed to have formed through many Neoproterozoic accretionary events, creating an east-west trending patchwork of subprovinces spanning Manitoba to Quebec. Although there appears to be some continuity between the subprovinces, a discontinuity exists along the Kapuskasing Structural Zone (KSZ) that formed during a major tectonic event at ca. 1900 Ma. This event caused the eastern Superior to rotate relative to the western Superior and mapping the locations where they once joined is challenging and relies heavily on geophysical datasets (i.e. gravity and magnetics) due to the masking effects of the thick Phanerozoic cover filling the Hudson Bay Lowlands. Mapping subprovince boundaries below the Phanerozoic cover has relied heavily on magnetic data which is sensitive to upper crustal features. However, a gap in the magnetic data over James Bay has created ambiguity and the details cannot be mapped with gravity data alone. This study models the gravity data to distinguish between variations in upper-crustal density, representing compositional differences between subprovinces, and the geometry of the Moho that contains evidence of deformation events. The results of a three-dimensional gravity inversion model will better constrain the sub-Phanerozoic boundaries and the mechanisms of deformation across the KSZ and will result in an updated geologic map of the Superior Province as well as a reconstructed model of the Superior pre-1900 Ma.

Magnetic inversion modelling and remote geological mapping of sediment-hosted seafloor massive sulphide deposits, Escanaba Trough, northeast Pacific Ocean

Christopher Galley¹, John Jamieson¹, Amy Gartman², Isobel Yeo³, Masako Tominaga⁴, Maurice Tivey⁴, Carlos Braga¹, Laura Moore⁵, Sharon Walker⁶

¹University of Ottawa, ²United States Geological Survey, ³National Oceanographic Centre Southampton, ⁴Woods Hole Oceanographic Institute,

⁵Oregon State University, ⁶National Oceanic and Atmospheric Administration.

E-mail: gchrist2@uottawa.ca

Mid-ocean ridges, the Earth's most extensive volcanic system, exhibit unique characteristics in sediment-dominant environments. Thick sediment cover insulates the crust and channels subsurface hydrothermal fluids along pathways that can lead to the formation of distinct crustal alteration patterns, exceptionally large mineral deposits, and specialized chemosynthetic-based ecosystems. This talk presents an interdisciplinary investigation into the tectonics of the Escanaba Trough, a heavily sedimented axial valley at the southern Gorda Ridge in the northeast Pacific Ocean. A primary challenge in such environments is overcoming the masking effect of thick sediments on basement structures that control magmatic and hydrothermal activity. We address this by employing three-dimensional (3D) magnetic modeling of high-resolution near-seafloor magnetic data collected by an autonomous underwater vehicle (AUV). The 2022 surveys with AUV Sentry provided data for 3D magnetic susceptibility models, refining our understanding of the geometry of sub-sediment laccoliths and hydrothermal alteration. In conjunction with a new 1:100 000 scale lithostratigraphic map, we outline the tectonic controls on the emplacement of Escanaba Trough's three main volcanic centers, characterize the geometry of its spreading segments, and provide volumetric data on the distribution of sub-sediment volcanism in the southern Gorda Ridge.

Melt extraction and percolation processes in the White Hills Peridotite, St. Anthony Complex, Newfoundland

V.B. Garcia¹, B. O'Driscoll¹, A.M. Hinchey², B. Oller³, G.S. Santos², D.M. Marin², J.M.D. Day³

¹University of Ottawa, ²Geological Survey of Newfoundland and Labrador, ³University of California San Diego.

E-mail: vgar091@uottawa.ca

The oceanic mantle has been shown to have a heterogeneous composition with respect to a range of elemental and isotopic tracers. However, most observations come from dredged (abyssal) peridotites or from ocean floor basalts proxies. The exposed mantle sections of some ophiolites are therefore an ideal laboratory to observe in-situ relations between different oceanic mantle lithologies. The White Hills peridotite of the St. Anthony Complex (StAC), some 400 km NE of the classic Bay of Island Ophiolite Complex in western Newfoundland, contains an extensive mantle exposure that has been understudied. The StAC comprises > 80% harzburgite with localized ~1 m wide dunite channels. Both orthopyroxenite and clinopyroxenite veins occur subparallel to the main foliation, with the former being more common. Massive chromitite pods are also present. Petrographic relationships reveal replacement textures on orthopyroxene rims by olivine and clinopyroxene common in harzburgite and dunite channels, and locally developed disequilibrium textured spinel. Calculated degrees of melt depletion in harzburgites (from whole-rock rare-earth elements; REE) range from 7–13%, in agreement with mineral-chemistry estimates from spinel (5–9%) and olivine (5–13%). The harzburgite REE and the spinel mineral chemistry also indicate significant overlap with a mid-ocean ridge basalt mantle composition. Contrastingly, the dunite channels and pyroxenite veins show a distinct supra-subduction zone-like signature. The clinopyroxene compositions in the latter two lithologies show a positive correlation between Na and Cr, unexpected for magmatic differentiation under equilibrium conditions. Therefore, we further explored the conditions of formation of the clinopyroxene using thermodynamic modelling. Our calculations reproduced the analyzed compositional trends reasonably well, following an assimilation-fractional crystallization model with an initial boninite melt and varying amounts of spinel assimilation. The modelled conditions suggest a melt-dominated environment with implications for melt percolation, refertilization and melt-rock reactions in the oceanic mantle.

Utilization of ultramafic mine tailings for CO₂ capture through aqueous mineral carbonation

Sara Gardideh

Research Associate.

E-mail: sara.gardideh@gmail.com

Mineral carbonation has attracted significant attention as a promising method for the permanent sequestration of carbon dioxide. Owing to its long-term storage stability and the widespread availability of reactive minerals, it is considered one of the most effective CO₂ mitigation strategies. Integrating mineral processing for primary metal recovery with carbonation of mine tailings represents an emerging approach that may significantly reduce sequestration costs, as tailings are already finely ground and readily available. This study investigates low-pressure carbonation of ultramafic tailings under moist, gas-solid reaction conditions. Carbonation efficiency was evaluated using a systematic design of experiments combined with response surface methodology. Key parameters examined include particle size (0–75 µm), temperature, water-to-solid ratio, buffer conditions, catalyst presence, and reaction time. The tailings, primarily composed of serpentine, were subjected to a two-stage thermal regime consisting of high-temperature pre-treatment (550–750°C) followed by carbonation at low to moderate temperatures (0–50°C). The relatively mild reactivity of serpentine was interpreted in terms of structural constraints, including the mismatch between CO₂ molecular dimensions and the octahedral-tetrahedral lattice framework. Thermal activation was found to be essential to dehydroxylate serpentine and transform it into meta-serpentine, a phase characterized by isolated SiO₄ tetrahedra linked to octahedrally coordinated magnesium. This transformation enhances Mg²⁺ availability, a key limiting factor in carbonation reactions. Unlike previous studies focused solely on optimizing activation temperature, this research evaluates the influence of thermal pre-treatment on subsequent aqueous-phase carbonation under low-pressure, flue-gas-like conditions. The results indicate that optimal carbonation occurs in mineral assemblages containing amorphous phases formed during dehydroxylation. Furthermore, the study highlights the role of carbonic anhydrase as a biocatalyst in accelerating CO₂ hydration and promoting magnesium carbonate precipitation.

Potential origins and Neoproterozoic–Palaeozoic palaeogeography of some peri-Gondwana terranes

Andreas Gärtner, Anja Sagawe, Mandy Zieger-Hofmann, Johannes Zieger, Ulf Linnemann

Senckenberg Natural History Collections Dresden.

E-mail: andreas.gaertner@senckenberg.de

For decades, the U–Pb zircon age has been a widely applied tool in the fields of sedimentary provenance analysis and palaeogeographic reconstruction. The high and steadily increasing number of published igneous, metamorphic, and detrital zircon age data allows for more precise provenance studies and thus, fosters an increased level of detail in palaeogeographic reconstructions. Although an increasing number of zircon databases is published, surprisingly few studies use them for comprehensive provenance analyses and palaeogeography compared to global long-term tectonic phenomena like mantle cycles or crustal evolution. Consequently, the substantial potential of igneous, metamorphic and detrital zircon age data for palaeogeographic reconstructions at larger scales remains underestimated. An initial compilation of pre-Mesozoic zircon age data ($n > 8400$, $n > 325\,000$) characterizes the circum-Atlantic (s.l.) zircon provinces, i.e. Amazonia, Baltica, Sub-Sahara Africa, the West African Craton, Europe, Grenville Province, and a number of peri-Gondwanan terranes. As the zircon age data was being compiled, it became evident that the peri-Gondwanan terranes of modern North America and Europe are distinguished by individual zircon age patterns that exhibit significant variations over time. These characteristics facilitate the identification of potentially changing external sources during specific temporal periods in the geological history of each terrane. Furthermore, a comprehensive palaeogeographic reconstruction is contingent upon a meticulous description of magmatic barcodes, metamorphic episodes and detrital zircon age fingerprints for each region of interest, including their potential hinterlands. The objective of this study is to present an

initial overview of the typical igneous, metamorphic, and detrital zircon age patterns observed in the circum-Atlantic areas and to draw initial conclusions on their likely position at different times.

Charlevoix meteorite impact revisited: New shatter cones point to an Ordovician giant

Jean-Michel Gastonguay¹, Nicolas Pinet², Joshua Davies³, Livia Standjofski-Figollis³, Antoine Godet², Morgann Perrot⁴

¹Centre d'études collégiales en Charlevoix, ²Natural Resources Canada, Geological Survey of Canada, ³Université du Québec à Montréal, ⁴McGill University.

E-mail: jean-michelgastonguay@cecccharlevoix.qc.ca

On Earth, impact craters are often difficult to discover from geomorphology alone, as most are deeply eroded. Nonetheless, during a hypervelocity asteroid collision, the immense shockwave propagating through the target leaves diagnostic traces, especially shatter cones, a distinctive conical fracture pattern preserved within rocks. Those shatter cones can withstand hundreds of millions of years of erosion, and their presence today is considered indisputable proof of an extraterrestrial collision. It has been shown that the distribution and distance of the shatter cones from the center of the impact are a function of the original crater diameter, itself a function of the kinetic energy of the impactor. Moreover, the presence or absence of shatter cones in sedimentary sequences can help constrain the age of an impact. Our team has conducted field work within the Charlevoix astrobleme (Québec, Canada), mapping shatter cones to better estimate the original crater diameter and better constrain its age. Newly discovered shatter cones, 2.5 km further away from the center than previously observed, suggest that the impact released about 75% more energy than previously calculated. We also found shatter cones abundant within intact beds and among clasts of the Saint-Irénée Formation (Trenton Group), largely composed of limestone dismembered by mass-wasting. In contrast, shatter cones are absent from the overlying siliciclastic rocks of the Cap-Martin Formation (Utica Shales), the youngest unit in the region. A younger age remains possible and is being evaluated (U–Pb on zircons from a suevite). Charlevoix may thus be the largest preserved of the 21 recognized craters of the Ordovician impact spike. On solid-surfaced Solar System bodies, crater size-frequency distributions are well known: many small craters, few large ones. With only a small fraction of Ordovician crust exposed today, odds are low that Charlevoix was the largest impact overall during this interval of climate upheaval.

Preliminary tectono-magmatic model for the Sirmac LCT-pegmatites in the Frotet-Evans greenstone belt, Superior Province, Quebec

Mathieu Géliot¹, Stéphane De Souza¹, Michel Jébrak¹, Aurélien Eglinger², Rocio Pedreira Pérez¹, Daniele Pinti¹, Vincent Van Hinsberg³, Kim Berlo³, Joshua Davies¹

¹Université du Québec à Montréal, ²Université de Lorraine - Nancy, ³McGill University.

E-mail: geliot.mathieu@courrier.uqam.ca

Archean LCT-pegmatites in the Superior Province of Quebec form dyke swarms hosted in supracrustal rocks of the Eeyou Istchee James Bay area. Their origin, geometry, timing, and mode of emplacement remain poorly understood. The Sirmac deposit is located in the Frotet-Evans greenstone belt and consists of three main mineralized dykes; the largest measures 600 x 30 m and has a resource estimate of 0.27 Mt grading 1.4% Li₂O (NI 43-101, 2023). The mineralized dykes are hosted by sandstone, conglomerate, and basalt metamorphosed at greenschist to amphibolite facies conditions, which are locally overprinted by biotite, tourmaline, and hornblende. The host rocks display a N-dipping foliation hosting a shallow plunging stretching lineation. The crosscutting dykes show a NW-SE trend, exhibiting mainly steeply dipping dykes, though shallow-dipping ones are also observed. The absence of tectonic or magmatic foliations in the dykes suggests that they may fill extensional fractures. The mineralized pegmatites are zoned and characterized by (1) coarse quartz-spodumene cores; (2) heterogranular zones of quartz-feldspar-spodumene with accessory muscovite, tourmaline, biotite, apatite, garnet, and beryl; and (3) a border aplite facies with garnet and apatite. Locally, muscovite-rich aplite cut them. These overall characteristics of the pegmatites are best explained by their emplacement in a late-orogenic D₃ transpressional regime. The pegmatites show increasing Li₂O, Cs and (Rb/Sr) ratio from aplites to the spodumene-rich pegmatites. Bulk Li₂O and Cs contents reach 3 wt.% and 500 ppm, respectively. Muscovite-rich barren pegmatites have also been identified, but further research is required to establish the relationship between these and the mineralized ones in terms of timing and origin. Textural similarities, as well as clustering of the mineralized pegmatites suggest that they may have been emplaced during one main magmatic event. However, additional studies are necessary to ascertain the tectono-magmatic parameters controlling the emplacement of barren muscovite-rich versus mineralized dykes.

The complex history and nature of the northeast Atlantic

Laurent Geoffroy

University of Western Brittany.

E-mail: laurent.geoffroy@univ-brest.fr

The mechanisms involved in the opening of the NE Atlantic appear to be complex due to a number of factors. The initial rheological and structural heritage of the Archean and Proterozoic continental masses and the Caledonian axis played a major role. From the Devonian onwards, the NE Atlantic region east of Greenland became unstable, with significant episodic deformations in both pure extension and strike-slip, with or without magmatism. In the Cretaceous period two continental rifts were individualized, one west of Greenland and the other following the Rockall-Vöring axis. The continental breakup with the onset of oceanic lithosphere spread from the Paleocene to the Eocene northward along the Labrador-Baffin axis. East of Greenland, the extension shifted westward relative to the Jurassic–Cretaceous rifting axis following a ca. 65 myr halt of deformation. Tertiary extension followed a regional magmatic event with onset of plateau basalts. Although the most common explanation is the impact of a sub-

lithospheric thermal anomaly, this volcanism is very dependent on the pre-structuring of the NE Atlantic lithosphere in the broad sense. The complete continental rupture that followed is very difficult, if not impossible, to date, whether in southern Baffin Bay or along the NE Atlantic axis. The rupture mechanism is there associated with the formation of passive volcanic margins. The internal and external zones of these margins, which can be wide, generate linear magnetic anomalies similar to those found in oceanic crust domains. In addition, these margins may be associated with exhumation of the lower continental crust, heavily intruded by magma, over long distances. In this context, the reality of the extension of the oceanic lithosphere in Baffin Bay and especially in the NE Atlantic remains an unresolved issue, as is the true significance of the Greenland-Faroe transverse ridge, including Iceland.

Mechanisms of continental extension over 1.3 billion years

Laurent Geoffroy¹, Christian Schiffer², Jordan Phethean³, Charles Aubourg⁴

¹University of Brest, ²University of Uppsala, ³University of Derby, ⁴Université de Pau et des Pays de l'Adour.

E-mail: laurent.geoffroy@univ-brest.fr

In southwestern Greenland, the Mesoproterozoic (ca. 1.28 to ca. 1.16 Ga) Gardar Rift is considered to be analogous to the active East African Rift System. This would suggest long-term stability in the thermomechanical behaviour of the continental lithosphere over more than 1.3 Ga. We revisit this comparison by presenting new tectonic and geophysical data following a three-year research program. We compare these new data with those from well-documented Cenozoic rifts, such as the East African Rift System. There appear to be considerable differences between the Gardar rift and modern volcanic rift systems, notably (1) the duration of extension, (2) the ratio between magma-induced crustal dilatation and tectonic extension, (3) the overall tectonic context, and (4) the nature and origin of syn- and late-tectonic magma. The Gardar Rift also differs markedly in its structural characteristics from the 1.1 Ga Midcontinent Rift in North America. We observe a radically different mode of lithospheric extension at Gardar with insignificant crustal thinning. We clarify the global tectonic context that governs it. We discuss the implications of these results in terms of geodynamic context and the evolution of the physical properties of the continental lithosphere over time. Such a comparison can help determine which parameter—differential stress, mantle heat flow, rheology and strain rate—has a predominant influence on lithospheric deformation.

Tracing fluid infiltration using atoll microstructures? The record from the ultra-high pressure Maksyutov Complex

Freya R. George¹, Daniel R. Viete², Simon C. Kohn¹

¹University of Bristol, ²Johns Hopkins University.

E-mail: freya.george@bristol.ac.uk

Atoll garnets—characterized by outer rims separated from their cores by rings of inclusions—are relatively uncommon petrographic structures but have long been recognized in a diverse suite of metamorphic settings. Their formation has been attributed to a similarly diverse suite of models, and when formed in subduction zone settings they may provide insights into processes including fluid infiltration and dissolution, cyclic high-pressure metamorphism, subgrain coalescence, and/or kinetically controlled growth rates. Here, we present atoll-bearing samples from the Maksyutov Complex in the southern Ural Mountains, where radial fractures around quartz inclusions were first described almost 20 years before coesite in crustal rocks was recognized elsewhere as evidence for UHP metamorphism. These variably retrogressed high-pressure eclogites and blueschists, which preserve evidence of peak temperatures of ~660°C at ~24 kbar and ca. 380 Ma, contain microstructures that evidence the progressive formation of atoll structures. Compositional mapping using electron microprobe analysis and laser ablation-inductively coupled plasma-mass spectrometry indicate that both non-atoll garnets and cores of complete atolls exhibit both typical prograde and oscillatory zoning, and that incipient atoll formation is associated with a marked change in the major, minor, and trace element composition from which rim garnet grew. Notably, stepwise rims are associated with increases in the HREE-LREE, Sc, P, and Mg content, and marked decreases in Ca, Fe, and V. We couple our elemental approaches with Fourier transform infrared spectroscopy to investigate whether these are externally-fluid buffered compositional changes and numerical modelling to constrain timescales of garnet dissolution associated with atoll formation.

Understanding mineralization at the Bigstone Cu-Zn deposit, Flin Flon Domain, northern Saskatchewan

Kacia George, Kevin Ansdell, Camille A. Partin

University of Saskatchewan.

E-mail: jiv409@mail.usask.ca

The Bigstone Cu-Zn deposit represents an important potential source of critical metals essential for the modern clean energy transition. Bigstone is hosted within the Northern Lights Assemblage of the Hanson Lake block in the Paleoproterozoic Flin Flon Domain in northern Saskatchewan. It is interpreted to be a bimodal felsic-mafic volcanic hosted massive sulphide system (VHMS), southwest of the developing McIlvanna Bay mine, and has an Indicated Resource of 2.38 Mt with a grade of 1.83% Cu, 0.98% Zn, 0.28 g/t Au, and 10.82 g/t Ag (Foran Mining Corp NI 43-101). Despite extensive drilling and geochemical work, the timing, and controls on sulphide mineralization remain unclear due to successive deformation events and metamorphic overprinting during the Trans-Hudson Orogen. Consequently, this raises uncertainty as to whether Cu-Zn mineralization reflect primary VHMS deposition or later remobilization. Here we report petrographic observations integrated with mineral-scale compositional data from the novel Laser Induced Breakdown Spectroscopy (LIBS) technique of selected drill core samples from the main Cu-Zn zones, in collaboration with Foran Mining, to evaluate the style and evolution of the Cu-Zn mineralization at the Bigstone deposit. Petrographic analysis focuses on sulphide mineral textures, cross cutting relationships, and mineral assemblages, whereas LIBS data provides complementary mineral and elemental maps at a 50-μ scale. We observe that chalcopyrite is locally overgrown by pyrrhotite and subsequently overprinted by sphalerite and later pyrrhotite ± pyrite ± arsenopyrite.

phases, all of which post-date peak regional metamorphism and are localized along faults and deformation related fabrics. Post metamorphic gangue minerals, expressed by contrasting chlorite and garnet dominated assemblages, appear to strongly control the resulting sulphide mineral textures. These observations indicate the preserved textures are epigenetic in character and lack identifiable primary mineralized synvolcanic textures, highlighting the importance of microscale textural analysis for interpreting mineralization in deformed VHMS systems.

Jacques Martignole, or the state-of-the-art approach to understanding the Grenville Orogen

Félix Gervais¹, Aphrodite Indares²

¹Polytechnique Montréal, ²Memorial University of Newfoundland.

E-mail: felix.gervais@polymtl.ca

Building an understanding of the Grenville Orogen has a long history reflecting evolving approaches and paradigms for plate tectonics. Since the early seventies and for more than 40 years, new advances have often been associated with contributions by Jacques Martignole, a pioneer in applying state-of-the-art techniques to unravel Grenvillian tectonics and tackle the 'anorthosite problem'. His Ph.D. thesis, which was published in 6 scholarly papers, is literally a scientific masterpiece - a blend of scientific rigor and artful representations. To decipher the emplacement mechanism of the Morin anorthositic massif, he conceived a creative way (to our knowledge never reproduced since) for illustrating the spatial distribution of lithologies, foliation orientation and strain gradient that, combined with stereonet, allowed him to draw complex 3D geological models for the massif and surrounding gneisses. Integration of these geometrical data with advanced (for the 1970s) geochemical and metamorphic studies led to an avant-garde tectonic model for anorthosite emplacement. Later, recognizing the complexities of applying conventional thermobarometry to high-grade gneisses, he pushed forward the advancement of thermodynamics fundamentals. In the 1990s he was an active leader in the Lithoprobe project and added multifaceted field-based contributions with emphasis on age, deformation and metamorphism in western Grenville Province and beyond. Finally, by looking back at the career of Jacques Martignole one realizes how our science has rapidly evolved. For Morin anorthosite, he was inspired in the 70's by the most advanced analog modeling of tectonic processes available, the gravity-driven tectonic models of Ramberg. In the 1990s, in contrast, his models were clearly inspired by the recognition of the importance of horizontal forces driven by plate tectonics. Despite the rapidly evolving fields of metamorphic petrology and numerical modeling of geological processes, his approaches still remain an inspiration for tackling complex geological problems such as Grenvillian tectonics.

Age and kinematics of Acadian multi-phase deformation, Dover Fault, Newfoundland

Sam N. Ghantous¹, Eric J. Thiessen¹, Kyle P. Larson²

¹Memorial University of Newfoundland, ²University of British Columbia Okanagan.

E-mail: sngbantous@mun.ca

The ca. 400 Ma Acadian orogeny involved the ribbon continent Avalonia accreting to the eastern margin of Ganderia. In Newfoundland, this tectonic boundary is preserved in the Gander Zone and consists of eastward increasing metamorphic grade and strain within the left-lateral Wing Pond Shear Zone (WPSZ) and right-lateral Dover Fault Shear Zone (DFSZ), where this study is focused. New detrital zircon data confirm continuity of the Gander Group's Jonathan's Pond formation and WPSZ garnet $\pm$ staurolite schists, with maximum depositional ages of ca. 500 Ma. Within the WPSZ and DFSZ, an older phase of deformation is cross-cut by ca. 470–430 Ma low-strain felsic dykes and sills, closely correlative in time with accretion of western Ganderia to Laurentia. These dykes and sills are oriented parallel with high-strain host foliations that strike northeast, indicating significant Silurian to Devonian reworking and strain partitioning into host schists and gneiss. These observations imply an older Penobscot or Salinic orogenic footprint is present as (sub)greenschist-facies fabrics and overprinted by later higher-temperature events. Schists in the WPSZ record Acadian prograde metamorphic monazite growth ca. 420 Ma, and peak metamorphic (Grt + St + Ms) monazite growth ca. 410 Ma. This peak metamorphic age is synchronous with in situ muscovite Rb/Sr ages that define left-lateral fabrics in a mylonitic granite. Metapelites in the DFSZ record peak metamorphic assemblages of Chl + Ms $\pm$ And, consistent with greenschist facies conditions. Muscovite that defines right-lateral kinematics in mylonitized leucogranite within the DFSZ yield Rb/Sr ages ca. 395 Ma. Granitoid rocks and beryl-pegmatites retain ca. 430 Ma primary muscovite Rb/Sr ages in low-strain phenocrysts whereas muscovite that defines mylonitic shear bands date distinctly younger shearing events ca. 410 Ma and 395 Ma, linked to peak and retrograde metamorphism. The methods used herein are excellent tools to unravel the amphibolite to greenschist facies evolution of micaceous shear zones in orogenic terranes.

Anomaly thresholds for indicator minerals: From guts to probabilities!

Réjean Girard

IOS Géosciences Co.

E-mail: rejean@iosgeo.com

Unless an entire survey returns not a single indicator mineral grain, the exploration geologist faces an important question, i.e., what should I consider as an anomaly worth following up? Decisions are usually taken on a "gut feeling" based on the premise that samples with high counts are anomalous. This can be misguided, leading to needless exploration expenses. In homogeneous sediments, grain counts in aliquots (samples) will not be uniform and are ruled statistically by a Poisson-process. All samples will have non-zero probabilities of yielding elevated grain counts as well as yielding zero counts. In a non-homogeneous medium, such as in a regional survey, counts will be ruled by the Conway-Maxwell-Poisson discrete probability law, in which the degree of freedom is related to the material heterogeneity. If grain counts (which are integers) are normalized, they become fractional numbers and then are ruled by the Erlang continuous-probability law. The regional background signal is expected to show lower degrees of freedom,

whereas a localized source is expected to follow a distribution with higher degrees of freedom. Consequently, if grain counts in a sample set show the latter pattern it can be assumed that grains from local sources were added to the regional background. The crossover of the respective probability density functions can then be used to derive an anomaly threshold. The grain counts in a sample can then be converted into a probability of including locally derived minerals, and anomaly or “heat” maps can be constructed accordingly.

Duration of Neoproterozoic S-type magmatism: Implications for crustal evolution and rare metal pegmatite formation

Antoine Godet¹, Jamie Cutts¹, Matthijs Smit², Marc Legault³, Carl Guilmette⁴, Victoria Maneta¹, Guillaume Mathieu¹

¹Natural Resources Canada, Geological Survey of Canada, ²University of British Columbia, ³Université du Québec en Abitibi-Témiscamingue,

⁴Université Laval.

E-mail: antoine.godet@nrcan-mcan.gc.ca

Neoproterozoic peraluminous (S-type) granites are the terminal magmatic products of Archean craton assembly and are frequently linked to rare-metal pegmatites. Quantifying the duration of this magmatic pulse is essential to constrain mid-crustal thermal regimes and the timing of ore-forming processes. We integrate garnet Lu–Hf and U–Pb zircon–monazite geochronology, together with field observation, whole-rock chemistry and trace-element mapping, to estimate the lifespan of S-type magmatism of the Decelles Batholith (southeastern Superior Craton, Canada). The batholith is largely composed of magnetite- and white muscovite-bearing granite suites sourced from the partial melting of Pontiac Group metasedimentary rocks, with subordinate biotite-hornblende hybrid granitoid rocks interpreted as mixtures between sanukitoid-related and S-type sources. Garnet Lu–Hf ages span 2667.5 ± 3.9 to 2656.0 ± 7.1 Ma, constraining the onset of pluton crystallization. U–Pb ages for zircon and monazite from barren to spodumene-bearing pegmatitic dykes define a broader magmatic-pegmatitic window of ca. 2668–2620 Ma (ca. 50 myr), recording early and late stages of batholith evolution. Sharp oscillatory to locally sector zoning in Li, P, Sc, Ti, Y, Zr, REE, Hf, Th, and U in garnet and low-U, oscillatory zoning and low Th/U ratios in zircon and monazite support a magmatic origin for the three chronometers. Together, these data record a long-lived mid-crustal thermal anomaly that sustained protracted S-type magmatism and LCT pegmatite formation. The results demonstrate that magmatic garnet petrochronology, coupled with accessory-mineral U–Pb dating and trace-element mapping, can robustly bracket the duration of S-type magmatism and provide transferable benchmarks for the thermal evolution and rare metal endowment in Neoproterozoic crust.

A new tool for locating Li-reserves: High helium isotope anomalies from ⁶Li

Juliette Gomes¹, Vincent van Hinsberg¹, Daniele Pinti²

¹McGill University, ²Université du Québec à Montréal.

E-mail: juliette.gomes@mail.mcgill.ca

Lithium-cesium-tantalum (LCT) pegmatites produce about a quarter of the world's lithium. One of the main hurdles to production of Canadian lithium (Li) is locating Li-enriched pegmatites. Due to the incomplete understanding of their formation processes, exploration of Li-pegmatites is dependent on traditional prospecting methods, particularly boots-on-the-ground field work. These field methods primarily determine whether pegmatites are present without directly determining their Li-mineralization nor economic viability. Other exploration methods rely on geochemical signatures, such as K/Rb and other trace element ratios, to identify evolved pegmatites. However, these signatures may be an indicator of late-stage fractionation, but they do not guarantee deposit-grade Li-mineralization. Here, we present helium isotope anomalies as an alternative signature indicating the presence of Li-enrichment. Neutron capture by ⁶Li produces ³He, a stable isotope that is less abundant in crustal rocks compared to ⁴He. Over time, this creates a ³He/⁴He anomaly greater than normal crustal levels ($R/R_a = 0.02$, where $R = ^3\text{He}/^4\text{He}$ and R_a is the atmospheric ratio). To verify that ³He anomalies are present in Li-minerals, helium was extracted from spodumene ($\text{LiAlSi}_2\text{O}_6$), a dominant LCT-pegmatite ore mineral in Quebec, and Li-tourmaline. The minerals were ground and incrementally heated to release helium, and the isotopic composition was subsequently analyzed with the Thermo-Scientific HELIX-MC mass spectrometer at the Geotop Noble Gas Laboratory. High ³He-anomalies were found in the spodumene and Li-tourmaline samples; the most extreme sample, a ca. 600 Ma pegmatite spodumene from Araçuaí, Brazil, has a ³He/⁴He ratio (R/R_a of $15\,000 \pm 576$), about 141 times greater than the solar wind and 762 386 times greater than crustal levels. These anomalies in common Li-minerals indicate a strong potential for using He-isotopes as a vectoring tool in exploration for Li-pegmatite. Moreover, the extreme nature of the ³He enrichment further suggests that the anomaly envelope would be spatially extensive and persist despite extensive dilution.

Ediacaran basin evolution and unroofing of the Avalon Zone, Newfoundland: Constraints from detrital zircon U–Pb geochronology and Lu–Hf isotopes

Nicolas Gómez¹, David Lowe¹, Chidera Ikechukwu¹, Andrea Mills²

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador.

E-mail: ngomezplata@mun.ca

The Avalon Zone of Newfoundland is characterized by Neoproterozoic arc magmatism and a coeval to succeeding sedimentary record spanning ca. 620 to 535 Ma. Ediacaran strata comprise two juxtaposed basin systems, a deep-marine depocenter in the St. John's Basin and a shallow-marine succession in the Bonavista Basin, both overlain by deltaic to fluvial strata. This study presents new detrital zircon U–Pb geochronology, Lu–Hf isotopes, and trace element geochemistry from Ediacaran sedimentary units to refine models of basin evolution and terrane-scale provenance change. The oldest unit, the Connecting Point Group (> ca. 620–605 Ma), contains the highest proportion of pre-800 Ma zircon and displays mixed juvenile and evolved isotopic signatures, reflecting contributions from arc magmatic and reworked crustal sources. From ca. 590 to 580 Ma, sedimentation was

influenced by the Gaskiers glaciation. During the glacial advance, provenance in both basins became predominantly local, although juvenile signatures dominated the Bonavista Basin and moderately evolved values in the St. John's Basin. Deglacial strata record the re-establishment of broader sediment routing and more diverse sediment sources. This isotopic divergence persists into post-glacial successions deposited between ca. 580 and 565 Ma, coincident with declining volcanic input and progressive denudation of older sedimentary successions, first evident in the Bonavista Basin and later in the St. John's Basin. By ca. 560 to 550 Ma, reworking of underlying sedimentary strata and regional unroofing promoted deltaic sedimentation and loss of basin compartmentalization. Uppermost fluvial units deposited between ca. 550 and 535 Ma show a systematic shift toward older detrital sources resembling those of the Connecting Point Group. Collectively, these data document the tectono-sedimentary evolution of West Avalonia from Neoproterozoic arc growth and post-arc extension to foreland-style basin development, demonstrating progressive reorganization of sediment routing systems in response to glaciation, magmatic waning, and hinterland uplift.

Sediment provenance during the Gaskiers glaciation (Newfoundland): Insights from multi-proxy detrital U–Pb geochronology

Nicolas Gómez¹, David Lowe¹, Andrea Mills²

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador.

E-mail: ngomezplata@mun.ca

The identification of glacial influence in ancient active volcanic arc basins is challenging because tectonism can overprint climatic signals and obscure provenance changes. The Neoproterozoic Avalon Zone of Newfoundland preserves thick volcanic-sedimentary successions containing glaciogenic strata of the Gaskiers glaciation (ca. 589–580 Ma), providing an opportunity to evaluate sediment routing, source connectivity, and mineral preservation during glacial cycles. Here, we integrate detrital zircon, apatite, and titanite U–Pb geochronology with trace element geochemistry and Lu–Hf and Sm–Nd isotopes from the Ediacaran lower Rocky Harbour Group exposed on the Bonavista Peninsula. Detrital zircon maximum depositional ages closely approach depositional ages, indicating very short (< 1 myr) lag times between sediment generation and deposition and confirming the presence of two Gaskiers diamictite horizons, the Mercantile and Trinity diamictites, separated by ca. 9 myr. Zircon age spectra from the underlying glaciomarine Monk Bay Member are narrowly unimodal at ca. 580 Ma, whereas coeval glaciofluvial members and the diamictites display broader Tonian–Ediacaran distributions with minor Mesoproterozoic and Archean components, consistent with an expansion of sediment catchments during deglaciation. Zircon trace element compositions indicate dominant magmatic arc sources with minor within-plate affinities, whereas zircon ϵ_{Hf} values are more juvenile in the Monk Bay Member than in the diamictites and conglomeratic units. Detrital apatite and titanite further refine source-to-sink reconstructions. Apatite age spectra shift from dominantly ca. 660–630 Ma grains in the glaciofluvial strata to ca. 600–580 Ma grains in glaciomarine and diamictite units, suggesting preferential dissolution of unstable apatite under acidic periglacial weathering and advance of glaciers across the West Avalonian catchment. Titanite preserves Archean to Tonian ages, records polycyclic recycling from the Connecting Point Group and older cratonic sources and indicates later hydrothermal and low-grade metamorphic overprints at ca. 540 and ca. 400 Ma.

Hysteresis evidence for non-steady state carbon cycling during the Early and Middle Jurassic

Muditha Goonetilleke¹, Ricardo L. Silva¹, Luis V. Duarte²

¹University of Manitoba, ²University of Coimbra.

E-mail: goonetim@myumanitoba.ca

The prolonged decoupling (ca. 85 myr) between organic and inorganic $\delta^{13}\text{C}$ records during the Neoproterozoic prompted recognition of the oceanic organic carbon pool as a key regulator of carbon-cycle dynamics. This extended offset implies a non-steady-state behaviour of the global carbon cycle and has been attributed to a large marine dissolved organic carbon (DOC) reservoir. However, the magnitude and duration of this event would require an exceptionally large and persistent DOC reservoir, raising questions about its feasibility. This leads to the question of whether relatively short-lived expansion of the marine DOC reservoir alone could generate temporary decoupling between organic and inorganic $\delta^{13}\text{C}$ records. We hypothesize that variations in the oceanic DOC reservoir operating at orbital timescales are sufficient to drive transient departures from steady state and generate decoupling between organic and inorganic $\delta^{13}\text{C}$ records for a few million years or less. To test this hypothesis, a hysteresis analysis was performed between carbonate $\delta^{13}\text{C}$ and $\Delta\delta^{13}\text{C}$ (carbonate-organic) using published and newly compiled datasets from the ca. 1 myr Early Jurassic T-OAE (Yorkshire, UK) and a ca. 400 kyr Middle Jurassic event in the Lusitanian Basin (Portugal). Preliminary hysteresis analysis results of both the Early Jurassic T-OAE and the Middle Jurassic (Bathonian-lowermost Callovian) sections show counterclockwise loop geometries with gradients close to unity (i.e. $m \approx 1$). This suggests non-steady-state behaviour of the carbon cycle and a lagged response between the inorganic and organic reservoirs in the ocean. The near-unity slopes further imply potential buffering of the organic $\delta^{13}\text{C}$ variations in the ocean. Together, these results suggest that dynamic ocean organic carbon feedback is involved in both study intervals, although the mechanisms, magnitude, and persistence remain uncertain. Robust evaluation of such feedback requires robust proxies and highly parameterized Earth system models capable of explicitly resolving reservoir sizes, isotope mass balance, and feedback-driven carbon-cycle dynamics.

New fossil discoveries from the Carboniferous Parrsboro Formation at McKay Head, Nova Scotia: Revisiting a historic fossil site in the Cliffs of Fundy UNESCO Global Geopark

Caleb J. Grant¹, Matthew R. Stimson², Olivia A. King³, Luke F. Allen⁴, Brian L. Hebert², Graham A. Young^{2,4}, Bailey C. Malay², Andrew MacRae⁵, John Calder⁶, Spencer G. Lucas⁷, Alexia Hannberg⁸

¹Cliffs of Fundy UNESCO Global Geopark, ²New Brunswick Museum, ³Carleton University, ⁴University of New Brunswick Fredericton, ⁵Saint Mary's University, ⁶Halifax, Nova Scotia, ⁷New Mexico Museum of Natural History and Science, ⁸University of New Brunswick Saint John.

E-mail: geoscience@fundygeopark.ca

Trace fossils often provide additional lines of evidence including the presence of animal life when body fossils are absent. The McKay Head locality within the Cliffs of Fundy UNESCO Global Geopark has coastal outcrops of Carboniferous sedimentary rocks of the Parrsboro Formation bounded in the north by a splay of the Portapique Fault, within the larger Minas Fault Zone. The section is also faulted against younger Jurassic rift valley sediments of the McCoy Brook Formation and North Mountain Basalt. In the 1800s, these shorelines were explored by Sir J.W. Dawson, who discovered invertebrate ichnofossils that he would later name “*Protichnites carbonarius*”, following the discovery of similar shaped, but larger trackways from Ontario and Quebec discovered by Sir W.E. Logan. Dawson compared the tracks to those of modern horseshoe crabs (*Limulus polyphemus*) and concluded that both trackways were likely made by ancient xiphosurans (horseshoe crabs). Here, the type specimen deposited at the Redpath Museum in Montreal is re-examined, together with new specimens observed from this historical fossil locality. These and associated ichnofossils have broader ichnotaxonomic implications for trackways interpreted as those of xiphosurans. A rare body fossil probably belonging to the xiphosuran *Belinurus* was recovered from the fossil site, allowing direct comparison of body and ichnofossils. The presence of xiphosurans suggests that, at minimum, some degree of brackish conditions was likely present and that xiphosuran activity has implications for the paleoecology of the Parrsboro Formation. It also adds new datapoints to the faunal record of the Martimes Basin of Atlantic Canada. This project lays the groundwork for renewed research at other historical fossil localities within the Geopark.

Building capacity through collaboration: Empowering local businesses in the Cliffs of Fundy UNESCO Global Geopark

Caleb Grant, Devin Trefry, William Bollwerk

Cliffs of Fundy UNESCO Global Geopark.

E-mail: geoscience@fundygeopark.ca

UNESCO Global Geoparks (UGGPs) have a unique opportunity to connect the visiting and local public with the wonders of the natural world. However, in Canada, UGGPs are often characterized by vast and variably accessible landscapes. With limited staff resources distributed across large rural regions, Canadian Geoparks frequently face the challenge of meaningfully engaging both visitors and residents at multiple geosites simultaneously. To address these challenges, the Cliffs of Fundy UGGP developed a Certified Geopark Experience Program during the summer of 2024, officially launched in 2025. This initiative was designed to empower local business owners as key stakeholders, fostering pride, ownership, and stewardship within the Geopark community. Through the certification program, participating businesses can incorporate official Geopark branding and geosite-specific interpretation to elevate their offerings, while benefiting from international recognition and promotion under the UGGP network. The program's structure was loosely modeled after Nova Scotia Provincial Parks' regulatory framework, ensuring that all certified experiences align with the Geopark's code of conduct and maintain high standards of quality, safety, and insurance compliance. Geopark staff also provide participating businesses with ongoing guidance, interpretive resources, and scientifically accurate information about relevant geosites to ensure consistent, factual storytelling and high-quality visitor experiences. Early adopters include two local tour companies now offering guided experiences at over 15 geosites across the Geopark—including several remote and previously inaccessible locations. This early success has not only expanded the Geopark's capacity and reach but also sparked interest in extending certification to locally made products in future phases. Feedback from participants highlights the added value of integrating geoheritage education into tourism experiences, which has been praised for deepening visitor engagement and inspiring greater community participation in the program.

The trace and minor element “fingerprints” of gold from ancient, Al Maraziq mines in Yemen and Middle East gold artifacts encompassing the time of fabled King Solomon and the Queen of Sheba

John D. Greenough¹, Leanne Mallory², Charles Fipke³, Sudip Shrestha¹, Mark Button¹, Michel Lamothe⁴

¹University of British Columbia Okanagan, ²Okanagan College, ³C.F. Mineral Research Ltd., ⁴Université du Québec à Montréal.

E-mail: john.greenough@ubc.ca

We report on the Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICP MS) and Scanning Electron Microscope, Energy Dispersive Spectrometry (EDS) composition of native gold from Iron Age, quartz vein gold mines in Yemen (Al Maraziq region) and four ancient mines in Africa. Analyses are compared with gold artefacts from archaeological sites in the Levant, Mesopotamia, and Egypt. The 18 artefacts are dominantly Au (95 to 70 wt.%) and Ag (14 to 0.0025 wt.%) but highly heterogeneous and inclusion-rich compared to the native gold. Artifact element patterns (preliminary) from exploratory statistics indicate groupings as follows. Lithophile elements (Na, Al O, Si + Mg) appear dominantly controlled by silicate inclusions, but they may also be dissolved in gold during ancient processing. The association of Ca, Cl, K, +Mg, +S may reflect natron flux additives containing evaporite (carbonate, sulphate, and chloride) minerals and contaminants. The grouping of Sn, Cr?, Ni, Zn and Mn suggest the use of bronze production methods in gold ore processing. An association of chalcophile elements (Cu, Fe, As, and Pb) may reflect sulphide mineral additives or contaminants; these elements occur at higher concentrations in the artifacts than in the native gold samples. Similarly, the platinum group elements occur at higher concentrations than in the native gold and may come from sulphide minerals. Perhaps only Au/Ag ratios provide some crude

information on the deposit source of artifact Au. Native gold from two of the African placer mines is characterized by low Ag indicative of extensive weathering and/or biological precipitation which increases gold fineness. Thus, five artifacts with high Au/Ag ratios (145–540) might have been produced from weathered placer gold. Nine artefacts have Au/Ag ratios (5.0–15.3) overlapping those of gold from the Yemen mining camp, the African hydrothermal gold sample and one African placer gold sample.

Reconstructing oceanic deoxygenation during the Toarcian oceanic anoxic event using thallium isotopes: A regional study

Holly Grierson, Natasha Bell, Alexandra Kunert, Brian Kendall

University of Waterloo.

E-mail: hgrierson@uwaterloo.ca

The Toarcian Oceanic Anoxic Event (T-OAE) was associated with a large igneous province emplacement that triggered an environmental chain reaction, including an expansion in ocean anoxia/euxinia, and caused a marine mass extinction. To better infer the extent of deoxygenation, we employ a relatively new paleoredox proxy: stable thallium (Tl) isotopes. Based on observations from modern anoxic and euxinic marine environments, the Tl isotope signatures ($\epsilon^{205}\text{Tl}$) of ancient seawater are likely to be recorded with negligible fractionation by underlying anoxic sediments, an advantage over other commonly applied isotope systems (Mo, U). Using black shales from multiple localities in Alberta, Canada, we combine redox sensitive trace metal (RSTM) concentrations and Tl isotopes to expand existing paleoredox data from the area to examine regional $\epsilon^{205}\text{Tl}$ trends and variability due to differences in depositional conditions (e.g. hydrographic restriction). The RSTM concentrations and ratios indicate locally anoxic-euxinic environments without evidence for severe basin restriction, making these sediments useful for inferring seawater Tl isotope signatures and changes in seawater RSTM budgets. The RSTM enrichments show a sharp decline during the T-OAE (marked by a negative carbon isotope excursion), indicating expanded ocean anoxia/euxinia that decreased seawater RSTM inventories. A recovery of RSTM enrichments following the event suggests contraction of ocean anoxia/euxinia. Consistent with a previous study, our $\epsilon^{205}\text{Tl}$ results reveal ocean deoxygenation began before onset of the T-OAE, and persistence of relatively low- O_2 water masses following the event. Combining with the RSTM data, we infer that there was only a partial recovery to more oxygenated conditions after the T-OAE, because the Tl isotope data indicate that oxic environments conducive to Mn oxide burial were not widespread. Additionally, the stratigraphic position of the T-OAE within one core is higher than expected from previous stratigraphic correlations, illustrating that Tl isotopes can aid regional chemostratigraphic correlations around OAEs.

Origin of the Revelstoke pegmatite field in British Columbia, Canada

Lee A. Groat¹, Tarryn K. Cawood¹, Daniel Hnatyshin², Jakob G.O. Kneale³, Madison Dean¹

¹University of British Columbia, ²Natural Resources Canada, Geological Survey of Canada, ³Oxford University.

E-mail: groat@mail.ubc.ca

The comparatively recent economic interest in pegmatites has coincided with a revolution in our theories of how they form. For example, for many years the most accepted idea was that pegmatites resulted from fractional crystallization of granitic magmas. However, the lack of parental granites in many pegmatite fields, coupled with innovations in geochronology, suggested that some pegmatites could form directly from the partial melting of metasedimentary and metavolcanic protoliths, or anatexis. However, we do not know how to determine (1) if a pegmatite is a residual melt of granite magmatism (RMG) or a direct product of anatexis (DPA); (2) how partial melts are concentrated to form pegmatite dykes; and (3) if individual pegmatite bodies and groups or fields formed as a single event or as a series of pulses. In central British Columbia the 50 km² Revelstoke pegmatite field (RPF) includes more than 100 lithium-rich and barren pegmatites extending from Boulder Mountain in the north to Mount. Begbie in the south. Our recent progress suggests that the RPF will be an excellent place to find answers to the above questions. In a RMG model, the nearest potential parent to the RPF is the Ladybird granite suite (LBG), exposed ~50 km to the S and situated structurally above the RPF; previous work has suggested a genetic link between the LBG and migmatites in southeastern BC. In contrast, our Mount. Begbie fieldwork revealed abundant migmatite and perhaps melferite (high strain melt migration pathways), which could be a precursor to the pegmatites in a DPA model, possibly concentrated via a “suction pump model”. We are currently using field mapping, petrology, whole rock geochemistry, geochemical modelling, geochronology, and isotope geochemistry to answer the questions outlined above. Deposit models developed from this research will aid in exploration for critical mineral-bearing pegmatites.

The Archean Troilus Au-Cu-Ag deposit: A metamorphosed magmatic-hydrothermal/VMS system (Quebec, Canada)

Pierre-Arthur Groulier, Nicolas Guest, Remy Klick, Kyle Frank

Troilus Mining Corp.

E-mail: pierre-arthur.groulier@troilusmining.com

The world-class Troilus Au-Cu-Ag deposit (13.01 Moz Au equivalent), which consists of four zones (Z87, J, X22, and SW), is located in the Frotet-Evans greenstone belt (Quebec, Canada). More than 2 Moz Au and 70 kt Cu were produced from an open pit operation from 1996 to 2010 in zones Z87 and J. The deposit was originally described as a volcanic-hosted Archean porphyry before being interpreted as the result of overprinting orogenic events. After extensive exploration efforts and ~360 000 m of drilling since 2018, a deposit reclassification seems warranted; a hybrid magmatic-hydrothermal/VMS Au-Cu-Ag(Zn-Mo) deposit with local orogenic overprint is proposed. New field and core observations, combined with comprehensive deposit-scale 3D modelling, point to an early mineralizing event (ca. 2.79–2.78 Ga) during the transition from effusive tholeiitic-transitional volcanism toward explosive intermediate to felsic calc-alkalic volcanism. The hypabyssal polyphase Troilus intrusion and a swarm of felsic porphyry dykes play a central role in the repartition of the mineralization, which appears dominantly as deformed disseminated pyrite-chalcopyrite-

pyrrhotite grains ($\pm$ sphalerite $\pm$ molybdenite) and veins hosted within specific units including brecciated volcanic rocks and tuffs, high Fe-Ti basalts, within and near felsic dykes and within a tonalitic phase of the Troilus intrusion, and to the formation of large-scale hydrothermal cells. Key alteration minerals are biotite, sericite, albite, magnetite, calcic minerals (carbonate, epidote, amphibole), and aluminosilicates (i.e. garnet and andalusite). The main deformation event D₁ is recognized as an amphibolite grade dextral transpressional event responsible for the development of the dominant S₁ transposition foliation, steeply northwest-plunging L₁ mineral and stretching lineations and asymmetric rootless F₁ folds. A retrograde greenschist D₂ event has also been recognized, which is interpreted as an orogenic Au overprint and presents as discordant quartz-tourmaline-chlorite veins. Gold is strongly associated to sulphide minerals and can be visible in veins crosscutting the foliation.

New paleomagnetic results from the 148 Ma Notre Dame Bay Magmatic Province, Newfoundland, indicate moderate Jurassic apparent polar wander for North America

A. Gusti Guna¹, Phil J.A. McCausland², Alexander L. Peace¹

¹McMaster University, ²Western University.

E-mail: pmccausl@uwo.ca

Recently published paleomagnetic results and paleopole analyses have opened a debate on a possible “monster shift” or rapid apparent change in paleopole position for North America during the Jurassic, or alternatively, that the Late Jurassic paleomagnetic results from eastern North America may be derived from an uplifted, tilted margin that has since subsided, resulting in far-offset paleopole positions. These interpretations have implications for North American motion with respect to surrounding cratons, and the rifting and development of the North Atlantic margin. In this work, we report paleomagnetic analyses of 52 sites sampled from a radial lamprophyre dyke swarm and central intrusion of the 148 Ma (Tithonian) Notre Dame Bay Magmatic Province (NDBMP) in northeastern Newfoundland, emplaced during initial rifting of the southern North Atlantic. After stepwise removal of a viscous remanent magnetization aligned with the present-day geomagnetic field, dual-polarity stable characteristic remanence magnetization directions are revealed (NW, down and SE, up), carried by pseudosingle-domain magnetite. Structural attitudes of the subvertical radial dykes are consistent with the NDBMP retaining paleohorizontal, with no regional margin tilting since emplacement at 148 Ma. The NDBMP (south) paleopole, based on 42 normal- and 5 reversed-polarity site mean directions, is Lat 015, Longitude 67.5°S, with A95 = 7°. The paleopole falls along a Jurassic path for North America, between previously published Late Jurassic paleopoles, indicating only moderate Jurassic apparent polar motion. Late Jurassic paleomagnetic results from West Greenland dykes span a large age range and are subject to reconstruction of Greenland to North America. Lamprophyre dykes in New York have a single polarity and may have too few sites to have averaged out paleosecular variation. The new NDBMP paleomagnetic result is robustly determined, having spanned at least one polarity reversal, and is tightly constrained at 148 Ma, representing North America in the Late Jurassic.

Temporal and petrogenetic evolution of the Terra Nova Intrusive Complex, northern Victoria Land, Antarctica

Giun Han¹, Yoonsup Kim¹, Jong Ik Lee², Youn-Joong Jeong³, Seung-Gu Lee⁴

¹Chungbuk National University, ²Korea Polar Research Institute, ³Korea Basic Science Institute, ⁴Korea Institute of Geoscience and Mineral Resources.

E-mail: yoonsup@cbnu.ac.kr

The multi-pulse magmatic process plays a crucial role in orogenic evolution by forming igneous complexes that act as key geological tracers of tectonic events, making it essential to characterize the geochemical nature of magmas at different stages to identify temporal variations in magmatic activity and their links to tectonic processes. To address this issue, petrographic and geochemical analyses were conducted, including whole-rock Sr–Nd isotope studies and zircon U–Pb dating, on the host granitoid rocks and mafic enclaves from Inexpressible Island and Vegetation Island within the Terra Nova Intrusive Complex (TNIC), northern Victoria Land, Antarctica. The study area presents well-developed magma mixing and mingling structures, evident from outcrop to microscopic scales. Petrographically, samples were classified into the host granitoid rocks, mafic enclaves, and mafic dykes. The host granitoid rocks primarily consist of biotite, plagioclase, K-feldspar, and quartz, along with mafic clots (2–3 mm) composed of hornblende, biotite, and titanite, whereas mafic enclaves and dykes, ranging from tens of centimetres to metre scale, are dominated by hornblende, biotite, plagioclase, and quartz. Zircon U–Pb geochronology reveals a two-stage magmatic emplacement in the study area: the first pulse at ca. 516 Ma and the second at ca. 500–483 Ma. All the samples in the study area belong to the sub-alkaline, high-K calc-alkaline series, exhibiting geochemical signatures indicative of subduction-related magmatism. The geochemical and isotopic data suggest a progressive transition from strong crustal assimilation (~20%) in early-stage magmas to hybridization with crustal melts (~30–50%) in the latter stage. These findings highlight the multi-stage nature of TNIC magmatism controlled by metasomatism of subcontinental lithospheric mantle, crustal assimilation, and fractional crystallization, providing a quantitative framework for understanding the evolution of subduction-related granitoids and emphasizing the role of magma mixing and differentiation in continental arc settings.

Classification of refractory Au-Co-Ni-As-Sb-Bi mineralization associated with the peralkaline Deloro pluton, Ontario, Canada: A fresh look at the first gold district in the Canadian Shield

Jacob Hanley¹, Mackenzie Blight¹, James Brenan², Peteris Rozenbaks², Brandon Boucher³, Mateo Dorado-Troughton⁴

¹Saint Mary's University, ²Dalhousie University, ³University of New Brunswick, ⁴Ontario Geological Survey.

E-mail: jacob.hanley@smu.ca

Gold mineralization in the Deloro mining district, Belmont domain, Central Metasedimentary Belt (CMB), Grenville Province, Ontario is spatially associated with the ca. 1245 Ma, peralkaline Deloro pluton (DP). The DP was formed during one of the oldest episodes of igneous activity in the CMB

and is a crescent-shaped, composite intrusion comprised of early peralkaline hypersolvus granite, hypersolvus syenite, and granophyric granite phases thought to be produced by fractionation of a mafic magma emplaced during episodic extension. Gold mineralization at the former Ackerman mine (production 1869–1938) and in the Deloro-Gatling Five Acre-Cook mining area (1866–1961) occurs along the western margin of the DP. Gold occurs within N-S-trending quartz-ankerite-arsenopyrite veins along the deformed, heterolithic intrusive contact between the DP and country rocks (marble, amphibolite, and clastic metasedimentary rocks). Gold (as Au-Ag alloy; ~90% Au) occurs mainly within polycrystalline arsenopyrite as inclusions along annealed grain boundaries and fracture infillings, with accessory pyrite, chalcopyrite and various Bi + Te $\pm$ Pb $\pm$ S sulphosalt and alloy phases. LA-ICP-MS mapping of arsenopyrite shows oscillatory and sectoral growth zones enriched in (but often decoupled, not correlated) Au-Co-Ni-Sb-Bi-Te-Se, consistent with metal associations observed in assay data. Aqueous-carbonic fluid inclusions in vein quartz are consistent with orogenic gold deposits. However, the metal association is atypical for orogenic gold deposits and is likely linked to the diversity of lithologies involved in metamorphic fluid production. Cumulative compositional curves for Au-Ag alloy are most consistent with skarn gold deposits, lacking the high proportion of low fineness gold in orogenic, epithermal, and intrusion-related gold settings. Similarly, Au:Bi and Au:Te ratios in assays are inconsistent with orogenic and intrusion-related gold settings. These characteristics, combined with evidence for carbonatization of the DP along country rock contacts and mineralized skarn bodies within the DP near the deposits, emphasize the likely role of contact metamorphic fluids in the formation of the gold deposits.

Epithermal Au-Cu-As-Sb-Hg mineralization in the northeast Cobequid Highlands, Nova Scotia: Evidence for incursion of evaporated seawater into an active hydrothermal mineralizing system in the Late Devonian–Early Carboniferous

Jacob Hanley¹, Kevin Neyedley¹, Ryan Sharpe², Mostafa Fayek², Brandon Boucher³

¹Saint Mary's University, ²University of Manitoba, ³University of New Brunswick.

E-mail: jacob.hanley@smu.ca

Low-sulphidation (pyritic) epithermal Au-Cu-As-Sb-Hg mineralization in the northeastern Cobequid Highlands occurs within silicified and sulphidized Late Devonian to Early Carboniferous bimodal volcanics and represents a novel yet poorly characterized target for critical metals exploration in Nova Scotia. Trace element mapping (by LA-ICP-MS) and $\delta^{34}\text{S}$ analysis (by SIMS) identified 3 stages of pyrite in mineralized veins. Type 2 (epithermal pyrite crystal cores) is enriched in Co-Ni-Cu-Ag-Hg-Cd-Bi-Sb ($\pm$ Au, As), with $\delta^{34}\text{S}$ (VCDT) values between -1.5 and +2.0‰. Type 3 (crystal rims) is enriched in As-Sb-Mo-Cu-Se ($\pm$ Au, Ag, Co), records the dominant stage of Au enrichment, and has $\delta^{34}\text{S}$ values between -3.0 and +1.0‰. Core to rim transitions (type 2 to 3) show a marked shift to lower $\delta^{34}\text{S}$ values, consistent with fluid boiling. Late-stage, metal-poor type 4 pyrite occurs as late overgrowths on type 3 pyrite rims, yielding very high $\delta^{34}\text{S}$ values (+17.9 to +23.8‰), formed during incursion of a fluid containing sulphur derived from the reduction of seawater sulphate. Quartz-carbonate vein textures and associated primary fluid inclusion characteristics demonstrate a shallow (< 250 m; lithostatic) epithermal system that experienced rapid, episodic boiling (“flashing”), consistent with pyrite $\delta^{34}\text{S}$ characteristics of types 2 and 3 pyrite. The latest stage fluid inclusions, hosted in massive carbonate-barite vuggy infillings in epithermal vein centers, contain a high salinity, Ca-Mg-rich marine brine (“bittern”), consistent with S isotope systematics of the late type 4 pyrite overgrowths. Further support for evaporitic brine introduction is provided by oxygen and sulphur isotope analyses of other vein minerals, including ^{34}S -enriched ($\delta^{34}\text{S} = +19.4$ to +20.8‰) late-stage barite, and a pronounced decrease in $\delta^{18}\text{O}$ in zoned epithermal quartz and calcite. The results require an overlying evaporitic basin during the waning stages of magmatism, and suggest that epithermal boiling and basinal fluid introduction into underlying hydrothermal mineralizing systems may have triggered or enhanced metal deposition.

Characterization of siderite and diagenetic processes in the Mesozoic Jeanne d'Arc Basin, offshore Newfoundland, Canada

Brette S. Harris¹, Eric M. Hutton¹, Noah Slaney¹, Jaimee Hodgson¹, Simone Booker², Erin Adlakha², David G. Lowe¹, Hilary J. Corlett¹

¹Memorial University of Newfoundland, ²Saint Mary's University.

E-mail: bretteb@mun.ca

Siderite formed during early diagenesis and burial reflects evolving physicochemical conditions and progressive cementation in marginal- to shallow-marine reservoir systems. To advance understanding of siderite paragenesis and its significance in reconstructing diagenetic and fluid-evolution histories, this study examines early Cretaceous intervals from the Jeanne d'Arc Basin, offshore Newfoundland, Canada. An integrated analytical approach employing hyperspectral imaging, petrography, scanning electron microscopy (SEM), electron probe microanalysis (EPMA), and micro-X-ray fluorescence (μXRF) mapping was used to document the compositional and textural development of siderite through diagenesis. Siderite occurs in several textural forms, including nodular, pore-filling, and grain-binding cements, each showing systematic variation across diagenetic facies and burial depth. Elemental variations in Fe, Mg, Mn, and Ca define compositional trends interpreted to reflect shifts in fluid composition and redox conditions during progressive burial. Diagnostic textural relationships such as deflection of laminae adjacent to cemented zones, changes in grain-contact geometry, and truncation or replacement of earlier authigenic phases distinguish early eodiagenetic concretions and cements from later mesodiagenetic replacements and pore-filling generations. Preliminary evidence indicates multiple siderite precipitation events with distinctive chemical and microtextural characteristics, suggesting variable redox regimes during burial. Continued analyses integrating petrography, EPMA, SEM-EDS, and high-resolution μXRF datasets guided by hyperspectral imaging will refine the evolving paragenetic model and evaluate the potential of siderite as an indicator of fluid pathways, redox evolution, and reservoir quality within early Cretaceous reservoirs.

Tectonic implications of upper mantle and mid- to deep-crustal features in the Grenville Province portrayed in satellite gravity and aeromagnetic depth slices

Lyal B. Harris

Institut National de la Recherche Scientifique.

E-mail: lyal.harris@inrs.ca

Enhanced aeromagnetic images reveal spectacular structural and intrusive features in the upper Grenville Province crust in Quebec and Labrador, complementing surface mapping. Aeromagnetic and satellite gravity depth slices portray hitherto undocumented regional mid-crustal to subcontinental lithospheric mantle (SCLM) structures: (i) Long-wavelength satellite gravity along the SE margins of the Archean Superior Province and Paleoproterozoic SE Churchill Province (SECP) portrays an intracontinental or back-arc rift—the jigsaw puzzle-like fit of laterally continuous SCLM domains on the Opatika and Ashuanipi subprovinces' margin indicates Archean SCLM continues beneath the Grenville Province. In the Superior, ca. 2.2 Ga Otish and ca. 1.8 Ga Mistassini basins and the ca. 2.17 Ga Biscotasing dyke swarm occur on the NW rift margin; ca. 1.66–1.47 Ga anorthosite intrusions crop out overlying facing rift margins in Labrador. (ii) Preserved SECP structures beneath allochthonous terrains in Labrador and NW-SE Archean-Paleoproterozoic Waswanipi-Saguenay and Mont Laurier basement deformation corridors preclude regional ductile lower crustal or SCLM flow proposed in 'hot orogen' models. An abrupt change in pseudogravity marking the NW-SE contact between Quebecia and Labradoria occurs over the basement continuation of an Archean shear zone in the adjoining Superior Province. (iii) Localization of pre-metamorphic mineralization, deformation, and pluton emplacement in ca. 1.4 Ga arc assemblages (e.g. Bondy Gneiss Complex) in thinned Laurentian continental crust above the fore-mentioned deep crustal structures and their ca. 1.21–1.18 Ga granulite-facies deformation (Elzevirian orogeny) occurred in proximity to the Laurentian margin. Anorthosites emplaced following Elzevirian crustal thickening between ca. 1.17–1.14 Ga is located in gaps in continuous or between Archean SCLM domains, suggesting they formed by mantle delamination or dripping. Smaller ca. 1.08 Ga 'CRUML' anorthosites were emplaced along the southeastern SCLM domain margin peripheral to the St Lawrence Estuary (delamination/dripping or back-arc rifting?). Deep crustal and SCLM structures played an important role in localizing mineralization during Grenvillian (s.l.) and younger events.

The fluid provenance and ore mineralization history of the Ecton copper mine, northern England

Ryan Harris¹, Brian O'Driscoll¹, Aaron J. Lussier^{1,2}

¹University of Ottawa, ²Canadian Museum of Nature.

E-mail: rharr028@uottawa.ca

Mississippi-Valley type (MVT) ore deposits are significant global sources of lead and zinc. These deposits are the result of relatively low temperature hydrothermal fluids precipitating ore minerals in cavities and veins, typically occurring in regionally significant ore districts that contain multiple deposits. The MVT deposits of the South Pennine Orefield, northern England, are historically important, producing large amounts of lead, zinc and fluoride, predominantly during the 19th and 20th centuries. Located in this orefield is Ecton Mine, with an extensive history of copper mining dating back to the Bronze Age. The high abundance of copper makes Ecton anomalous, and many aspects of the mineralization (such as fluid composition, emplacement temperature, and structural controls) remain unclear, particularly within the regional MVT context. Working with samples from the Deep Ecton mine, obtained through various museum collections, petrographic, cathodoluminescence, SEM, EPMA, LA-ICP-MS, and sulphur isotope data are used to characterize the fluid provenance and mineralization processes leading to the formation of the Ecton orebody. Analysis of marcasite and pyrite textures using element mapping and trace element data show multiple generations of crystallisation, recognized by chemical zoning of Cu, Ni, and Co in single crystals. These observations suggest either changes in fluid chemistry during precipitation, or multiple fluid pulses. The samples also contain Ni-rich minerals like gersdorffite, and relatively Ni-rich pyrite (up to 17.5 wt.%), showing that the hydrothermal fluid was enriched in elements not present within other MVT deposits of the South Pennine Orefield. The new sulphur isotope data, however, overlap with previously reported values for the region with relatively light $\delta^{34}\text{S}$ values (avg. -15.9‰). If the Ecton deposit is genetically related to the South Pennine Orefield, then the source of the Cu, Ni, and Co remains an open question.

Fill the gaps in the natural record — phase equilibrium enhanced machine-learning for petrological applications

Philip Hartmeier¹, Pierre Lanari¹, Jacob Forshaw²

¹University of Lausanne, ²University of British Columbia.

E-mail: philip.hartmeier@unil.ch

Geothermobarometry and phase equilibrium modelling are fundamental to investigating metamorphic reactions and relating them to larger-scale geological processes. To successfully apply such physical models of metamorphism, it is crucial to capture the complexity of natural systems during calibration. In thermobarometry, this challenge is usually addressed by identifying a relevant simplified exchange system (e.g. Mg-Fe²⁺ exchange or Ti incorporation) or by calibrating a more complex simultaneous fit of compositional variability in multiple components from a large dataset. Due to the difficulties associated with sluggish sub-solidus kinetics in both natural and experimental settings, the application of this second approach is successful in magmatic systems but challenging in metamorphic ones. In our recent study, we used biotite from a large dataset of metamorphic sequences to calibrate a neural network, a machine learning algorithm, to predict the P-T conditions of biotite crystallisation. Biotite analyses from the compilation of Pattison and Forshaw and their framework of mineral assemblage sequences provide a large dataset (~2000 analyses) with the required independent constraints for P-T. As modern machine-learning algorithms are notoriously data-hungry, we employed a transfer-learning approach: large simulated datasets (~45 000 simulations) generated through phase equilibrium modelling were used for pre-calibration, after which the models were fine-tuned using the natural data. We tested the final model against an independent dataset compiled from the literature that was unseen during calibration and

model selection. The results indicate that the neural network functions as a potential biotite single-crystal thermometer, yielding an uncertainty of $\pm 45^\circ\text{C}$ (root mean square error of prediction). This level of precision is comparable to the estimated uncertainty of Ti-in-Bt thermometry when applied to the same dataset.

Electrical resistivity and geochronology of the Hope Bay greenstone belt and Bathurst Block

Rasmus Haugaard¹, Ademola Adetunji¹, Mike Hamilton², Ruth Orlóci-Goodison³, Nicholas Wray⁴, Ross Sherlock¹

¹Laurentian University, ²University of Toronto, ³Université Laval, ⁴Agnico Eagle Ltd.

E-mail: rashaugaard@gmail.com

Neoproterozoic greenstone belts are crucial in understanding crustal evolution and related ore-forming processes. To address this, a lithospheric-scale perspective involving the whole of the crust and continental upper mantle is needed. We combine new U–Pb age constraints with deep-crustal magnetotelluric results from the Neoproterozoic Hope Bay greenstone belt and its bounding Bathurst Block granitoid rocks (NE-Slave craton, Nunavut). The work reveals the timing of emplacement of extensive synvolcanic intrusions linking Hope Bay belt felsic extrusive rocks with part of the Bathurst Block granitoid rocks. The electrical architecture is relatively resistive down to at least 40 km depth, only disrupted by a significant ~100 km long, NNE–SSW-striking, crustal conductor oblique to the N–S striking greenstone belt and the flanking granitoid rocks. Two subvertical low resistive structures connect this major conductor to the surface near the Boston orogenic gold deposit. The origin of the conductor remains unknown, but its oblique nature could indicate that it represents a later (Paleoproterozoic?) crustal event.

Zircon is only half the story: Rethinking provenance with detrital chromite

Rasmus Haugaard¹, Shreya Mukherjee², Pedro Waterton²

¹Laurentian University, ²University of Copenhagen.

E-mail: rashaugaard@gmail.com

Detrital zircons have been the go-to mineral in reconstructing the timing of geological events as well as establishing the composition and source characteristic of Earth's continental crust. However, zircons crystallize predominantly in felsic magmas, creating an information bias in provenance studies because a significant proportion of the continental crust is composed of mafic-to-ultramafic magmatic rocks. Constraining the source and flux of mafic-ultramafic magmas to the crust therefore requires a different detrital mineral. Chromite is an early crystallizing phase in mafic-to-ultramafic magmas and is very robust in the sedimentary environment. Unlike zircon, chromite chemistry changes systematically during partial melting making it an excellent petrogenetic indicator in provenance studies. Using examples from the Archean clastic rock record in the Slave and Superior cratons, we demonstrate the applicability of detrital chromite in provenance studies as it relates to the composition, timing and formation of the chromite source, key factors in identifying the role of mafic-to-ultramafic contribution to continental crust building and the evolution of the lithosphere. Due to the often-poor preservation potential of mantle-derived rocks at Earth surface, detrital chromite can record crustal sources that are no longer preserved today. By complementing the detrital zircon record, detrital chromite offers a powerful new tool for reconstructing crustal evolution, with broad applicability to crustal terranes spanning the Hadean-Archean to the Phanerozoic.

Neoproterozoic non-plate to plate tectonic regime transition evidenced in the central Superior Craton

Xin He¹, Jian Zhang¹, Guochun Zhao¹, Shoufa Lin², Qihang Wu¹, Xiao Wang¹, Wei Wang³

¹The University of Hong Kong, ²University of Waterloo, ³China University of Geosciences.

E-mail: superherbeyida@163.com

The transition from non-plate to modern plate tectonic regimes is a pivotal yet unclear event in the early Earth's history. The Neoproterozoic Abitibi terrane of the Superior Craton preserves a critical record for this transition. This study integrates field investigation, petrology, whole-rock geochemistry, Sm–Nd isotopes, and zircon U–Pb–Lu–Hf trace element analysis on the tonalitic-trondhjemitic-granodioritic (TTG) gneisses, sanukitoids, and associated metavolcanic rocks. Our results reveal a gradual tectonic regime transition in the Abitibi terrane, from an early vertical tectonism dominated by mantle plumes (ca. 2750–2700 Ma) to a later horizontal plate tectonic system driven by subduction- and collision (ca. 2710–2660 Ma). This transition is petrologically marked by a magmatic evolution from reduced, low-H₂O TTGs derived from oceanic plateau basalts (ca. 2750–2700 Ma) to hydrous, oxidized sanukitoids formed by the partial melting of subduction-modified oxidized metasomatized mantle (ca. 2710–2660 Ma). This finding is broadly consistent with the regional geophysical and structural data, indicating that synchronous vertical and horizontal tectonism (ca. 2710–2700 Ma) jointly governed the Neoproterozoic tectonic evolution of the Abitibi terrane. By combining global geological records, we propose that the transition from non-plate to plate tectonic regime occurred diachronously across different cratons during the Meso- to Neoproterozoic (ca. 3.2–2.5 Ga), marking the global onset of plate tectonics.

Statistical reasoning and decision-making under uncertainty in geoscience

Drew Heasman

SMCG Services.

E-mail: dheasman@smcg-services.com

Geoscience increasingly relies on large and complex datasets, yet the presence of more data does not necessarily lead to more reliable interpretations or better decisions. This presentation examines recurring statistical pitfalls and cognitive biases that influence geological research and mineral exploration, often in subtle but consequential ways. Examples include the misuse of percentages without appropriate context, survivorship bias in discovery and production datasets, misuse of compositional data, overfitting in predictive models, and the conflation of correlation with causation. The discussion also highlights foundational statistical principles that are particularly relevant to geoscience, including base rate neglect in anomaly detection, regression to the mean in drill results, the implications of small sample sizes in geochemical surveys, and the exploration, exploitation trade-off in target selection. Rather than treating data science as a purely technical toolkit, this talk frames it as a framework for disciplined reasoning under uncertainty, complexity, and incomplete information. Emphasis is placed on strengthening quantitative practice by identifying where intuitive reasoning can fail and where formal probabilistic and algorithmic thinking improves robustness. By grounding these concepts in geological case studies, the presentation aims to provide geoscientists with a clearer understanding of the assumptions embedded in their analyses and with practical strategies for improving the rigor and defensibility of data-driven interpretations.

Out-of-equilibrium growth recorded by mineral inclusions in chromite with implications for their suitability as melt proxies

Hadrien Henry¹, William D. Smith², Mathieu Rospabé³, Anastassia Y. Borisova¹, Georges Ceuleneer¹

¹Centre National de la Recherche Scientifique, ²Commonwealth Scientific and Industrial Research Organisation, ³Institut Français de Recherche pour l'Exploitation de la Mer.

E-mail: hadrien.henry@get.omp.eu

Silicate inclusions in chromite crystals sometimes occur at high population densities and even share a common shape preferred orientation. These inclusions seem to be arranged in a two-dimensional grid and have been observed in the different geological contexts where chromite crystals nucleate. The ubiquity of this microstructure (that we refer to as Waffle-Iron Pattern, WIP) together with the exotic mineralogy of the included silicates raises questions about their origin and the invariant petrogenetic process they recorded. Using crystallographic data acquired on WIP-bearing chromite crystals from extensively characterized samples of different geological contexts; we demonstrate a systematic host/inclusion crystallographic orientation relationship. We show that WIPs result from syn-growth epitaxial nucleation of silicates onto initially skeletal chromite crystals, thus, are markers of cryptic and transient out-of-equilibrium magmatic systems. This finding provides a simple optical criterion to identify chromite grains who grew rapidly and offers a solution to the paradox of assumingly evolved inclusions hosted in assumingly primary crystals. The implication is that chromite-hosted silicate inclusions may not be reliable proxies for the early stages of magmatic systems. This work calls for similar investigations in other mineral systems and on the evolution of WIPs during textural evolution.

Tungsten and tin producing districts geographically correlate with marine sedimentary phosphorite-containing stratigraphy

Alan Hildebrand

Terrext Research Ltd.

E-mail: ahildebr@ucalgary.ca

Tungsten and tin producing districts have many metallogenic characteristics well established by field studies and sample analysis but are relatively rare and scattered globally implying a set of specific required geologic circumstances in their metallogeny. This is particularly true of the vein/stockwork and porphyry-type deposits with associated greisen-type alteration (a.k.a. greisen-type deposits). The association with late-stage (often S-type) granitoid rocks in orogenic belts is clear, but that setting is not sufficient for the occurrence of W and Sn mineralization. These W and Sn deposits ubiquitously contain fluorine-containing minerals (e.g. fluorite and topaz) and enhanced transport of these elements by fluorine complexing in solution (to create these deposits) is widely suggested and the mechanism is well demonstrated by laboratory scale experimentation. Geographically restricted and scattered sources of fluorine would explain the geographic distribution of W and Sn districts and may be a missing part of the W and Sn deposit metallogeny. A geographic correlation exists between W and Sn districts and the locations of (often) Paleozoic marine phosphorite stratigraphy. The phosphate mineral typical of these phosphorites is francolite - a carbonate-rich variety of fluorapatite with variable fluorine concentrations. The phosphate minerals in Paleozoic phosphorites often have significant fluorine concentrations of 3–4% (close to stoichiometric). Occurrence of marine phosphorites in the S-type granitoid source rocks, or the opportunity for other granitoid types to interact with marine phosphorites, may be necessary enabling components in the metallogeny of W and Sn greisen-type deposits and more indirectly of W and Sn skarn-type deposits.

Comparative geochemical and facies analysis of sediment cores from Coronation and North Pangnirtung fjords, Baffin Island: How deglaciation may affect ecosystem services related to carbon sequestration

John Michael Hilliard, Thomas Young, Hilary Corlett

Memorial University of Newfoundland.

E-mail: jmhilliard@mun.ca

Climate change is accelerating deglaciation, especially in Arctic fjords, and significant changes in local microbial assemblages and their ecosystem services related to carbon sequestration have been observed in glacial forefields following retreat in numerous locations. This presents an urgent need to constrain how deglaciation may augment carbon cycling as global temperatures continue to rise. Nestled in Baffin Island, Nunavut, at the easternmost stretch of the Canadian archipelago, are Coronation and North Pangnirtung fjords. These two adjacent fjords sit beneath the Penny Ice Cap, a remnant of the Laurentide Ice Sheet. The distinguishing feature between these two fjords are their heads: Coronation fjord features a marine-terminating, tidewater glacier, whereas North Pangnirtung's glacier has fully retreated. The fjords, their proximity, coupled with otherwise similar mineralogy and environmental context, provide an interesting case study into how deglaciation may impact carbon cycling in similar glacial fjords. To address this, two giant gravity cores (GGC) containing modern sediment were collected near the head of each fjord. These cores were analyzed with X-ray fluorescence (XRF) data contextualized by computed tomography (CT) scans to better characterize trends in carbon fluxes to the sediment bed. XRF profiles of bulk bromine concentrations and molybdenum anode ray scattering ratios indicate that inventories of marine organic carbon (MOC) correlate with total organic carbon (TOC) downcore, suggesting MOC may be the primary driver of TOC fluxes to the sediment. The CT scans in the Coronation core show interbedded clays down the entire core, while the North Pangnirtung core features a horizon at 4 m depth where similar sedimentation structures are interrupted by a continuous, heavily bioturbated facies stretching to the surface, and XRF data indicates TOC/MOC inventories increase across this horizon of high bioturbation. These findings suggest that deglaciation may lead to increased TOC/MOC retention and bioturbation in the sediment beds of Arctic fjords.

Eo- to Neoproterozoic crustal assembly of the Saglek Block, Labrador: Insights into early North Atlantic craton evolution

Alana M. Hinchey¹, Sally Pehrsson², Monika Kusiak³, Antoine Godet², Ivan Yip¹, Ethan Milkowski⁴, Brendan V. Dyck⁴

¹Geological Survey of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada, ³Institute of Geophysics Polish,

⁴University of British Columbia Okanagan.

E-mail: alanahinchey@gov.nl.ca

The Saglek Block of northern Labrador represents one of Earth's oldest preserved continental nuclei and forms the northern segment of the Nain Province within the western North Atlantic Craton. New field observations, integrated with published U–Pb zircon and monazite, refine the multi-stage evolution of this Eoarchean to Neoproterozoic crustal domain. The block is dominated by tonalite-trondhjemite-granodiorite (TTG) orthogneisses of the Uivak complex (ca. 3.75–3.72 Ga), interleaved with > ca. 3.8 Ga Nulliak supracrustal assemblages and intruded by Paleoproterozoic granitoids (ca. 3.6–3.3 Ga). These early crust-forming events record repeated juvenile additions and reworking of mafic protoliths, consistent with early TTG genesis in a hydrated basaltic crust. Structural and geochronological relationships indicate at least four Archean tectonothermal episodes. An Eoarchean high-grade event ($\geq$ ca. 3.6 Ga) produced early gneissosity and recumbent folding preserved locally in low-strain domains. The dominant tectonic episode occurred at ca. 2.8–2.7 Ga, generating pervasive gneissic foliation, granulite-facies metamorphism, and widespread partial melting during crustal thickening and lateral flow. Late Neoproterozoic transcurrent shearing at ca. 2.6–2.5 Ga overprinted earlier fabrics and localized high-temperature deformation along crustal-scale shear corridors. Collectively, these data document over one billion years of episodic crust formation, reworking, and stabilization between > ca. 3.8 and ca. 2.5 Ga. The Saglek Block preserves a vertically extensive section of Archean continental crust, recording early TTG crust formation, supracrustal incorporation, granulite-facies reworking, and late transpressional modification. Its polyphase history provides critical constraints on the assembly and long-term stabilization of the Labrador segment of the North Atlantic Craton and offers an important analogue for early continental growth processes globally.

Reassessing the age and tectonic affinity of metasedimentary sequences in the Long Range Inlier, western Newfoundland

Alana M. Hinchey¹, Diane R. Skipton¹, Ludovico Scorsolini¹, Daniela Mendoza Marin¹, Nicole Rayner², Ivan Yip¹

¹Geological Survey of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: alanahinchey@gov.nl.ca

The Long Range Inlier of western Newfoundland exposes Grenvillian basement within the Humber margin of the Appalachian orogen and preserves thin, discontinuous metasedimentary sequences of uncertain affinity. These rocks have variably been interpreted as pre-Pinwarian basement (> ca. 1550 Ma) or as Neoproterozoic–Paleozoic Laurentian cover. New U–Pb detrital zircon data from three samples constrain their maximum depositional ages and provenance, necessitating a revision of existing stratigraphic interpretations. Two samples of psammite from Sequence A (associated with marble and quartzite) yield contrasting maximum depositional ages of 996 ± 26 Ma and 554 ± 15 Ma. The younger age supports correlation with the Cambrian–Ordovician Laurentian cover sequence (Labrador-Port au Port groups), whereas the older signature reflects dominantly Paleoproterozoic and Mesoproterozoic detritus derived from proximal Grenvillian and older basement sources. These contrasting detrital populations suggest deposition in localized, basement-controlled basins rather than within a laterally extensive passive-margin system. A sample of psammite from Sequence B (interlayered with quartzite), previously mapped as part of the Long Range Gneiss Complex and interpreted as Pinwarian in age, yields a maximum depositional age of 906 ± 7 Ma. This postdates the Rigolet phase of the Grenville orogen and indicates derivation from post-Grenvillian

sources. The data support either (1) development of a ca. 900 Ma extensional basin, potentially linked to post-orogenic rifting (e.g. Asgard Sea), or (2) deposition as part of the Laurentian cover succession. These results demonstrate that metasedimentary rocks of the Long Range Inlier record a more complex, polyphase depositional history than previously recognized and highlight the importance of detrital zircon geochronology in resolving basement-cover relationships along the Laurentian margin.

Geologists in national parks: Geoscience outreach at Pukaskwa and Fundy National Parks

Joanna Hodge

Canadian Federation of Earth Sciences.

E-mail: hodge.joanna@gmail.com

In 2022 the Canadian Federation of Earth Sciences and Parks Canada piloted the Geologist in Residence (GIR) program at Pukaskwa National Park on Lake Superior near Marathon, Ontario. The program places a volunteer geoscientist or geoscience educator in the park for two weeks in August with the aims of promoting and encouraging public engagement with the geology of the park and providing Parks Canada interpreters with basic geological knowledge that they can then share with visitors. Programming is mutually determined by the GIR volunteer and the Parks Canada Interpretation Officer and Volunteer Coordinator, guided by access to park locations and the volunteer's interests and expertise, and tailored to the interests of the participating public. The program is now in its fifth year and since its inception geoscientists and geoscience educators have successfully delivered outreach programming including guided hikes, drop-in sessions, informal walk-and-talks, and formal presentations to more than 300 visitors from all over North America, Parks Canada staff, and community members from the Biigtigong Nishnaabeg First Nation. Given the success of the GIR program at Pukaskwa National Park, CFES and Parks Canada are pleased to announce the expansion of the program to Fundy National Park in New Brunswick. Fundy received approximately 370 000 visitors in 2025 and is one of the most popular national parks in Canada. It is also geologically diverse. With the rocks telling stories of Proterozoic mountain building, Paleozoic erosion and sedimentation, and recent glaciation and deglaciation, combined with the world's highest tides in the Bay of Fundy, the park provides multiple opportunities to engage with visitors at the intersection of their interests and the knowledge and expertise of the volunteer geologist. We are excited to expand our highly successful Geologist in Residence program to a second national park and broaden the reach of our public geoscience engagement.

Carbonate cement and fault associations in the Hibernia Oil Field, Jeanne d'Arc Basin, offshore Newfoundland: A hyperspectral approach

Jaimie L. Hodgson, Noah A. J. Slaney, Brette S. Harris, Eric M. Hutton, David G. Lowe, Hilary J. Corlett

Memorial University of Newfoundland.

E-mail: jilhodgson@mun.ca

Carbonate cements are persistent throughout various Mesozoic clastic reservoir formations of the Jeanne d'Arc Basin and include early and late diagenetic phases. Determining the distribution and controls of these cements is an important challenge for future extraction and injection projects throughout the basin. Visually distinguishing between cemented and uncemented intervals in core is challenging leading to over sampling or missing key cemented intervals. Hyperspectral data may be used to identify carbonate cemented intervals prior to sampling, ensuring various carbonate intervals are adequately accounted for and provide early insight into the distribution of carbonate zones. With a focus on the Hibernia Oil Field, the largest producing field of the Jeanne d'Arc Basin, a series of six wells from across the basin through the Ben Nevis, Avalon, Catalina, and Hibernia formations are sampled for further petrographic and geochemical analysis of carbonate cementation. This study focuses on late diagenetic cements and cross-cutting relationships to provide insight into their association with faults and fractures at core scale. Detailed petrographic analysis of these samples is used to determine mineralogy, diagenetic phases, and geochemical composition of the various cements. Late diagenetic cements, studied in greater detail, will be compared to faults and fractures seen within the core, and then related to larger-scale faults from 3D seismic data to determine potential correlations between precipitation and fault associated fluid mobilization. Thus, this study aims to provide insight into the spatial distribution of late diagenetic carbonate-cemented intervals in the Hibernia Field, with a focus on fault associations. Targeted petrographic analysis will be used to further our understanding of the spatial-temporal relationships between faulting, late diagenetic carbonate cementation, and fluid flow histories through the primary reservoirs of the Hibernia field.

On Ice Ages and climate change over three billion years

Paul F. Hoffman

University of Victoria.

E-mail: paulfhoffman@gmail.com

The number and extent of large continental ice sheets is a measure of global climate having a 3.0-billion-year geological record. For 90% of that time, no large continental ice sheet existed, suggesting that 'nonglacial' is the Earth's default climate state. For 7.5% (225 Myr), a small number of mid- to high-latitude ice sheets existed. Such 'paraglacial' states became more frequent since ca. 450 Ma, showing there is more to climate history than Solar brightening. For 2–2.5% (60–75 Myr), ice sheets existed on virtually all continents, but not all areas. Such 'panglacial' states (aka 'Snowball Earth') result from runaway ice-albedo feedback that drove sea-ice to the equator, which thickened to form 'sea-glaciers' that flowed under their own weight, eliminating thin ice. Continental icesheets were fed by water vapour sublimated off the equatorial sea-glaciers and returned in outlet glaciers. Panglacial states self-reverse because CO₂ consumption is diminished but supply is not. Two panglacial states occurred in tandem during the Cryogenian Period: the older started ca. 717 Ma and lasted 56 Myr; the younger ended at ca. 635 Ma and lasted ≥ 4.0 Myr. Earlier, during the Great Oxidation, strong

paleomagnetic evidence for a near-equatorial ice sheet on Kaapvaal craton implies a third panglacial episode ending ca. 2420 Ma. This Makganyene glaciation may be coeval with the Polisarka glaciation of Baltica, and with either the Ramsay Lake or Bruce glaciation of the Huronian. The most remarkable feature of the long-term glacial record is the 1.5 billion years (ca. 2250 to 750 Ma) when there is no evidence of a large icesheet anywhere. In contrast, no fewer than four glacial epochs occurred between ca. 2250 and ca. 2440 Ma. Marine clay formation ('reverse' weathering) is a potential explanation for prolonged warmth, since enhanced weathering (higher CO₂) would be needed to balance CO₂ sinks and sources. But the glacial gap's timing remains unexplained.

Charles Darwin's prophecy regarding selective survival on Snowball Earth

Paul F. Hoffman

University of Victoria.

E-mail: paulhoffman@gmail.com

All living things are descended from the survivors of the tandem Cryogenian Snowball Earths. Who they were is of more than geological interest. Most fossil assemblages from before and after those freeze-ups are marine, so it has generally been assumed that survival depended on marine refugia. This assumption is challenged by the estimated 300-year timescale for initial sea-ice advance across the tropical ocean, the perpetual darkness that descended over $\geq 99.9\%$ of the global ocean for millions of years, and temperatures several degrees below the freezing point of modern seawater, due to hypersalinity and thick ice. In Chapter 11 of *The Origin of Species*, Charles Darwin (1859) proposed a different scenario—ecosystem relocation in response to climate change—expanding on earlier work by young Edward Forbes. Darwin begins by noting that the flora and fauna of mountaintops are quite similar, even where they are far apart. Those high in the Alps and Pyrenees are indistinguishable from those at sea level in the Arctic. Darwin's parsimonious explanation was that during glacial times, the biomes lived together in the temperate lowlands. When the glacial period ended, they divided between those that relocated upslope or northward. The separation occurred so recently that no subsequent evolutionary divergence is apparent. At the start of the glacial period, pre-adapted polar and alpine biomes descended to the temperate valleys and plains, whose previous occupants moved southward, displacing tropical biomes which perished, having nowhere warmer to go. In the extreme case, Darwin wrote, "we should have a uniform arctic fauna and flora". Darwin didn't know about Snowball Earth, but his prophecy was that Ediacaran and Paleozoic diversity radiated from a pre-adapted polar–alpine subset of pre-Cryogenian life. This scenario is consistent with phylogenomic evidence that major groups of modern marine phytoplankton occupied benthic freshwater habitats before an Ediacaran marine radiation.

The gold district of east-central Newfoundland: Geology, structure, and the evolution of a basin

Ian W. Honsberger¹, Hamish A.I. Sandeman², Cameron Peddle³

¹Natural Resources Canada, Geological Survey of Canada, ²Geological Survey of Newfoundland and Labrador, ³New Found Gold Corp.

E-mail: ian.honsberger@nrcan-nrcan.gc.ca

The east-central Newfoundland Appalachians host a multi-million-ounce orogenic gold deposit along the Appleton Fault Zone, a northwest-dipping deformation zone that transects the core of a structurally bi-vergent, compressionaly reactivated basin dominated by fault-bound Early Ordovician to Early Devonian clastic sedimentary rocks. The basin started forming turbidites of the Davidsville Group during Early Ordovician rifting along the Ganderian margin. Continued subsidence is marked by the widespread occurrence of Late Ordovician black shale of the Main Point Formation. Black shale detritus in unconformably overlying pebbly wacke and conglomerate signify exhumation and/or uplift and erosion of the Main Point Formation in a terrestrial-proximal setting accompanied by the emplacement of ca. 453–446 Ma gabbro dykes. Such dyke emplacement may reflect local extension corresponding to late-stage rifting in the Iapetan Tetagouche—Exploits backarc basin to the present day southwest of the Davidsville basin. Deposition of Wenlock limestone breccias at the base of the Indian Islands Group record shallow marine channelized sedimentation that transitions to Wenlock to Lochkovian terrestrial, shallow water siltstones and sandstones upward in the section. Such shallow marine to terrestrial deposition is associated with Pridoli bimodal magmatism that is attributed to within-plate extension (D₁) immediately preceding the Acadian orogeny. A prominent S₂ cleavage penetrates the Ordovician to Early Devonian clastic sedimentary rocks, with an apparent lack of earlier structures in the Ordovician units; therefore, S₂ is interpreted to be related to Early Devonian Acadian compression (D₂) during far-field Avalonian collision with composite Laurentia. The S₂ cleavage is recumbently folded, attributed to Acadian orogenic collapse (D₃), and late-stage dextral shearing reflects post-Acadian strike slip (D₄). Devonian orogenic gold mineralization was focused in the multiply-extended, Ordovician–Silurian Davidsville basin during Acadian and younger thrust/reverse fault reactivation, highlighting the rheological and structural importance of extensional sedimentary-magmatic environments to the formation of younger orogenic gold deposits.

Thallium and lead isotope systematics of exhalative iron formations from the Bathurst Mining Camp, NB

Allison C. Howes^{1,2}, Matthew Leybourne², Shelby T. Rader³, Heather Jamieson², Peir Pufahl², Jan Peter⁴

¹St. Francis Xavier University, ²Queen's University, ³Indiana University Bloomington, ⁴Natural Resources Canada, Geological Survey of Canada.

E-mail: ahowes@stfx.ca

Thallium isotopes ($\epsilon^{207}\text{Tl}$) have been utilized as a redox proxy and for exploration vectoring in ancient and modern sedimentary environments. However, iron formations (IF) have yet to be evaluated using this non-traditional stable isotope system. Exhalative IF are often spatially and temporally associated with volcanogenic massive sulphide (VMS) deposits and are important paleoenvironmental archives that can retain primary information about seawater conditions. Here, we report new whole-rock geochemical and Tl and Pb isotopic composition data for Ordovician exhalative IF from the Bathurst Mining Camp (BMC) in northeastern New Brunswick, Canada. Abundances of Tl, Mn, K, Rb, Cs, Cu, Zn, Pb, and As

in Brunswick No. 12, Brunswick No. 6, and Austin Brook IF are elevated compared to that from Gilmour Brook and Old Stump IF. The $\epsilon^{205}\text{Tl}$ values for the sample suite range between -6.9 and +3.2 and $^{206}\text{Pb}/^{204}\text{Pb}$ values are between 18.199 and 19.011. Thallium abundances in IF increase (up to 5.2 ppm) and $\epsilon^{205}\text{Tl}$ values are the most negative with increasing proximity to the Brunswick No. 12 VMS deposit. Correlations between $\epsilon^{205}\text{Tl}$ and Cu, Zn, and Pb in Gilmour Brook and Old Stump indicate that sulphide minerals are a control for thallium isotope fractionation due to a lesser influence from VMS. The most radiogenic Pb isotope compositions are from the Gilmour Brook and Old Stump IF ($^{206}\text{Pb}/^{204}\text{Pb} = 18.276\text{--}19.011$), which indicates a more predominant detrital signature since Old Stump IF are not directly linked to a corresponding VMS deposit. Our data suggest that the lighter Tl isotope fractionation in IF reflects the preferential fractionation of ^{205}Tl into VMS mineralization rather than into the proximal IF. We highlight that although thallium isotopes have been used as a redox proxy in other sedimentary systems, fractionation processes in exhalative systems are more related to hydrothermal mineralization.

The Science Communication Career Test Drive program – developing a talent pipeline of science communication professionals

Lesley Hymers

Mining Matters.

E-mail: lhymers@miningmatters.ca

Mining Matters is an informal Earth science and mineral resources education organization, serving a range of audiences including teachers, students and the public, across Canada. On occasion, we collaborate with post secondary institutions to engage faculty, and students in work integrated learning projects to develop educational materials for implementation into our programs. Recently, Mining Matters partnered with McMaster University to participate in the Science Communication Career Test Drive program, an academic-industry partnership initiative led by the McMaster Faculty of Science in collaboration with the School of Interdisciplinary Science and the Science Careers and Experience Centre. The purpose of the program is to create meaningful, work-integrated learning experiences for students in Life Sciences interested in pursuing careers in science communication and related fields. During the Winter 2026 semester Mining Matters was invited to submit a science communication challenge to students in SCICOMM 3P03 (Communicating Science for Public Audiences), a course lead by Dr. Katie Moisse, in which students work in teams to address a real-world communication challenge provided by an employer partner. Mining Matters submitted four mining and environment themed challenges, focusing on a variety of technical topics and aimed toward a range of audiences for consideration. A challenge focusing on communicating the complexities of mine reclamation was ultimately selected for implementation. Three other challenges exploring the regulatory regime of the mine life cycle, the use of cyanide in gold ore processing, and mining companies and net zero, were selected for implementation in the SCICOMM 2A03: Foundations in Science Communication. More than 200 third-year students worked to develop proposals. A short list was presented for consideration. The students will be meeting with Mining Matters representatives in early March to provide input and feedback to projects which will serve to inform the final projects that will be presented later in the semester.

On the post-Gaskiers stratal evolution, redbed sedimentation, and new occurrences of Ediacaran macrofossils from the Musgravetown Supergroup, northwestern Bonavista Peninsula, Avalon Zone, Newfoundland

Chidera V. Ikechukwu¹, David G. Lowe¹, Michael G. Babechuk¹, Nicolás C. Gómez¹, Andrea J. Mills²

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador.

E-mail: cikechukwu@mun.ca

Strata of the upper Rocky Harbour and Crown Hill groups preserve a late Ediacaran record of sedimentary, tectonic, and ecological responses to the Gaskiers postglacial transition. This study integrates facies and architectural analyses, U–Pb zircon geochronology, and Lu–Hf isotopes in zircons to reconstruct postglacial stratal evolution, constrain the onset of redbed sedimentation, and evaluate paleoenvironmental responses during Ediacaran postglacial basin evolution. Five facies associations document this transition: (i) ice-proximal glacial diamictite deposits; (ii) shallow-marine shelf-to-prodelta successions; (iii) storm-flood and river-dominated delta-front systems; (iv) delta-plain deposits; and (v) distributive fluvial systems. Stacking patterns indicate sustained clastic progradation and marine regression, consistent with enhanced sediment flux likely driven by glacioisostatic rebound and/or the onset of regional uplift and exhumation. Shallow-marine Ediacaran macrofossils, including *Aspidella*, occur on bedding planes deposited near storm-wave base within (ii) and predate the onset of redbed sedimentation, which first appear within (iii). A tuff and overlying lithic-feldspathic arenite from (iii) yield U–Pb zircon maximum depositional ages (MDAs) of 573 ± 7 Ma and 571 ± 7 Ma, respectively, constraining the onset of postglacial redbed sedimentation to ca. 572 Ma, broadly coeval with or following the onset of the Shuram carbon isotopic excursion. Detrital zircon age spectra are dominated by Ediacaran and Cryogenian, with minor Mesoproterozoic and Paleoproterozoic populations. The ϵHf values (–6.1 to +11.8) indicate mixing of juvenile arc-derived and evolved basement sources, reflecting broad sediment catchments during glacio-isostatic rebound coinciding with increasing rates of postglacial chemical weathering and sediment flux. Sediment sources likely included bimodal volcanic rocks that contributed nutrients (e.g. P) to postglacial seas, enhancing biological productivity and facilitating the proliferation of Ediacaran biota and oceanic oxygenation. Redbeds from (iii) may provide a primary record of the onset of enhanced shallow marine oxygenation, and ongoing Fe-oxide petrography and geochemistry will test this hypothesis.

Tectonostratigraphic evolution and clastic provenance of the Cambrian–Ordovician Cow Head Group, Humber Zone, western Newfoundland

Jorge Iturralde, David Lowe

Memorial University of Newfoundland.

E-mail: dlowe@mun.ca

The Upper Cambrian–Lower Ordovician Cow Head Group of western Newfoundland is a deep-marine carbonate-clastic succession on the Laurentian passive margin, with limestone megaconglomerate indicating sedimentation influenced by deformation and seismicity. The basal Miaolingian succession comprises facies association 1 (FA1), characterized by amalgamated sheets of limestone conglomerate originating from subaqueous debris and hypercontracted flows, implying episodic carbonate platform margin collapse. Evidence of reflected turbidity currents and/or tsunami-related currents in a confined slope basin setting is indicated by oscillatory bedform stratification here and in the overlying facies association 2 (FA2). FA2 consists of tabular turbidites incised by channels and scours filled with limestone conglomerate of debris, hypercontracted, and concentrated flow origins, representing the establishment of a slope channel-levee succession. Coeval distal turbidites with scour-filling debrites of FA3 record sedimentation at the fringes or base of this slope depocenter. These strata are capped by boulder megaconglomerate at the Cambrian–Ordovician boundary, recording catastrophic rock fall, with large extrabasinal boulders suggesting carbonate platform collapse (FA4). Capping the succession are facies recording lower energy depositional conditions in the Early Ordovician, characterized by low-concentration turbidity currents in a generally unconfined slope setting (FA5). These facies associations record the transition from a Miaolingian platform margin fault scarp basin, to a confined slope during the Furongian, succeeded by basin-margin collapse at the Cambrian–Ordovician boundary, and relatively quiescent slope sedimentation during the Early Ordovician. Paleocurrent data suggest a south-facing submarine paleoslope oriented at a high angle to the east-facing Laurentian passive margin. Detrital zircon data from Furongian FA2 suggest recycling of earlier Paleozoic shelf units and erosion down to Ediacaran igneous rift-related rocks. Together, these facies and provenance results imply localized transverse fault reactivation along the Laurentian margin during the Late Cambrian, perhaps linked to dynamic stress field changes during the onset of subduction in the Taconic Seaway.

Petrology of pelitic migmatite in xenoliths from the Eastern Shore dykes, Meguma terrane, Nova Scotia: Devonian ultra-high-temperature metamorphism in Appalachian lower crust

Rebecca A. Jamieson¹, Sandra M. Barr², Chris E. White², Deanne van Rooyen², Donnelly B. Archibald³

¹Dalhousie University, ²Acadia University, ³St. Francis Xavier University.

E-mail: beckyf@dal.ca

The Meguma terrane, eastern Canadian Appalachians, is notable for its regional low pressure - high temperature (LP-HT) metamorphism and voluminous peraluminous magmatism at ca. 380–370 Ma. Xenoliths hosted by the Eastern Shore lamprophyre dyke swarm are the only samples of what lay beneath it when the dykes were intruded at ca. 370 Ma. Previous studies reported high-grade mineral assemblages, but the petrological context was not well documented. Renewed interest in the provenance of the Meguma terrane and the nature of its lower crust has sparked re-examination of these important samples. More than half of the available samples are pelites and pelitic migmatites, with other metasedimentary lithologies and mafic igneous rocks comprising the rest. In pelitic compositions, a precursor phase of granulite-facies metamorphism in the kyanite field is inferred, possibly preceded by muscovite dehydration melting. Most pelitic samples now consist of an intimate mixture of highly peraluminous quartz-poor leucosome and relict phases, including kyanite, interpreted as residual from the precursor mineral assemblage. The leucosome mineralogy includes ternary feldspars, garnet, spinel, sillimanite, corundum, sapphirine, and rutile, with rare Al-orthopyroxene. Biotite is uncommon and texturally late in leucosomes, although biotite + sillimanite melanosomes are locally developed. Garnet is typically surrounded by spinel + plagioclase reaction rims. Leucosome in the xenoliths is interpreted as residual following prolonged melt extraction, which could account for the scarcity of quartz. The observations are consistent with biotite dehydration melting at ultra-high-temperature (UHT) conditions, ca. 950°C and 12 kbar. The available geochronological data suggest Devonian metamorphism of late Neoproterozoic to Cambrian protoliths, but sample heterogeneity leaves many details unclear. In addition to documenting unusual UHT metamorphism in Appalachian lower crust, the results place additional constraints on interpretation of seismic profiles from the region and on models for the thermal evolution of the Meguma terrane.

Key steps in the early history of odontodes: Evolutionary novelties in the face of environmental pressure

Melina Jobbins¹, Ricardo L. Silva¹, Zerina Johanson², Kirstin Brink¹

¹University of Manitoba, ²Natural History Museum (UK).

E-mail: melina.jobbins@umanitoba.ca

Teeth are viewed as a key innovation underpinning the evolutionary success and radiation of vertebrates. For the past two decades, understanding the origin of teeth has become a focus point in early vertebrate research. Although research has allowed us to reconstruct how they first developed, questions around why they initially evolved remain a mystery. Here, we demonstrate that early odontode (teeth, scales, and dermal denticles) traits evolved stepwise alongside major environmental change events in the Ordovician and Silurian and that these traits became key innovations only later during fish radiation in the Devonian. In this review, we synthesize approximately 40 myr of early odontode history (scales, oral/pharyngeal denticles, teeth, replacement, and dental patterning) and correlate these milestones with published $\delta^{13}\text{C}$ records for the Ordovician–Silurian. Using the novelty-innovation framework, we discuss how recurring environmental disruption, changing marine chemistry, and evolving nutrient regimes could have shaped the contexts in which odontode novelties accumulated. Beyond existing developmental explanations for the origin of teeth, this synthesis adds

an environmental dimension, suggesting that global ecological disruption and evolving ocean chemistry may have also modulated when dental novelties emerged and later became innovations.

New constraints on the Late Jurassic paleogeography and thermal history of the Flemish Pass basin using detrital apatite geo- and thermochronology

Emily Johns-Buss¹, Luke Beranek¹, Eva Enkelmann²

¹Memorial University of Newfoundland, ²University of Calgary.

E-mail: egjohnsbuss@mun.ca

The Flemish Pass basin is located ~500 km east of St. John's, Newfoundland, and formed during Triassic to Cretaceous rift development that led to the opening of the North Atlantic Ocean. The Flemish Pass basin contains syn-rift, Upper Jurassic to Lower Cretaceous strata and a series of oil discoveries have been made within Tithonian incised valley to deltaic successions. Previous depositional and detrital zircon provenance studies suggest these Tithonian strata were fed by WNW-directed river systems with headwaters in adjacent highlands. However, the identities and geographic distribution of potential parent rock sources within these regions remain elusive. We present new detrital apatite fission-track (AFT), U–Pb age, and trace element geochemical results for 24 borehole samples (9–89 grains per sample) of Tithonian strata from the northern Flemish Pass basin. Apatite geochemistry allows the discrimination of parent rock lithologies, and combined with U–Pb age, these geochemical proxies provide useful provenance information which are often indistinguishable using detrital zircon U–Pb methods. For example, apatite grains derived from low- to medium-grade metamorphic parent rocks identified two distinct source signatures for Tithonian strata that distinguish northern and southern source regions within the Flemish Cap. Detrital metamorphic apatite grains in strata from the southernmost sample site, mostly yield Mesoproterozoic U–Pb ages compared to Ediacaran to Cambrian U–Pb ages in strata from the northernmost sample site. Both metamorphic U–Pb age populations are observed in strata from the sample site located geographically in-between the other two. The AFT system is sensitive to temperatures ranging from 60–120°C and provides information on the post-depositional burial and thermal history of the Flemish Pass basin. The AFT results indicate that Tithonian strata likely did not reach temperatures over 60°C until burial in the Cenozoic with samples currently residing at or close to their maximum burial temperature.

New insights on inherited fault reactivation during Mesozoic development of the Newfoundland and West Iberia conjugate rift margins

Emily Johns-Buss¹, Luke Beranek¹, Fernando Ornelas Marques², Eva Enkelmann³

¹Memorial University of Newfoundland, ²Universidade de Lisboa, ³University of Calgary.

E-mail: egjohnsbuss@mun.ca

Plate tectonic models for the Newfoundland and West Iberia conjugate margins predict discrete phases of lithospheric extension during the Mesozoic breakup of supercontinent Pangea and opening of the North Atlantic Ocean. These extensional phases resulted in stepwise progression of margin-parallel architectural domains that developed during Triassic to Early Cretaceous lithospheric stretching, Early to mid-Cretaceous hyperextension, mantle exhumation, and crustal breakup, and mid-Cretaceous mantle breakup processes. The exhumation of Appalachian and Variscan basement rocks along crustal-scale normal faults is predicted to correspondingly shift oceanward during rift-margin development. However, there have yet to be regional studies to examine the spatial patterns and rates of rift-related exhumation across the conjugate margin pair. New zircon (U–Th)/He thermochronological results from exhumed Variscan granites in the Central Iberian Zone (CIZ) of central Portugal were integrated with published apatite fission-track data to identify cooling histories from ~200–60°C along the West Iberian margin. Triassic to mid-Cretaceous accelerated cooling phases represent bedrock exhumation during discrete lithospheric stretching events and filling of the Lusitanian basin. When compared to our thermal models for exhumed basement rocks along the Newfoundland margin, the results indicate that cooling histories are younger for rock samples located closer to the rift-axis, however, inherited Appalachian–Variscan faults along both margins likely impacted the spatial distribution of cooling and controlled Mesozoic deformation. For example, latest Permian to Jurassic cooling occurred throughout the CIZ, but Cretaceous cooling was controlled by the reactivation of late Paleozoic faults. In contrast, latest Permian to Jurassic cooling in eastern Newfoundland was mostly concentrated along an Appalachian suture zone and no Cretaceous and younger cooling is observed.

Building geological maps and models in Minecraft for use in early education

Alexis Johnson, Colin Farquharson, Alison Malcolm

Memorial University of Newfoundland.

E-mail: alexisj@mun.ca

Minecraft is currently the most played video game of all time, being especially popular amongst children. In Minecraft, players explore worlds made up of cubic blocks and engage in activities such as exploring, mining, and building. The cubic geometry of Minecraft worlds is similar to that of models used in geoscience. Using the connection between Minecraft worlds and geoscience models, we use Minecraft to create educational materials focused on geoscience directed towards younger students. The goal of creating these materials is to generate interest in geoscience by using Minecraft as a tool and creating a connection between a game that students already know and understand to the world of geoscience. Geological and geographical data are used to build geologic maps of Newfoundland, Canada, and additional smaller regions in Minecraft. These maps are filled in with information regarding the geology of key sites on the maps. These Minecraft worlds can be used as simple introductions to different geological concepts which students can freely explore. Code has also been written to generate gravitational maps from Minecraft worlds. This code is being used to design lab

exercises for grade school students to teach them about density, gravity, and geophysics. These labs involve using the gravity maps to locate gravitational anomalies and use these anomalies to find and mine ore in Minecraft. This work can easily be expanded to create Minecraft worlds of new areas, and to teach many more geological concepts.

CO₂ storage potential in the Whale and South Whale basins

Alexis Johnson, Alison Malcolm, J. Kim Welford

Memorial University of Newfoundland.

E-mail: alexisj@mun.ca

Increased CO₂ emissions into the atmosphere are having large-scale negative effects on the global environment. To combat these increasing emissions, CO₂ can be removed from the atmosphere and stored in the subsurface. A common method of storing CO₂ is to structurally trap supercritical CO₂ in deep, porous rock formations capped by impermeable caprocks. Research is being done to assess the feasibility of storing CO₂ in the Whale and South Whale basins, offshore Newfoundland. These basins are relatively close to shore and are shallow compared to other offshore basins, meaning storage in these basins would likely be more economical than in other basins. This research is being done using a combination of seismic interpretation, well log analysis, physical core analysis, and reflectivity modelling. A pre-existing 2D seismic survey of this region has been used to map out the key rock formations in this region and used to identify structures relating to the potential to trap fluids. The well logs, along with core samples of these wells, have been studied to determine the average geophysical properties of the main formations. Tests done on core samples included measuring their porosity, permeability, density, and seismic velocity. Results from the seismic interpretation and geophysical analysis were used to build reflectivity models of this region, to assess the feasibility of monitoring injected CO₂. This research has shown that there are multiple porous rock formations in this region that have the size and physical properties suitable for storage, and that they are consistently capped by an impermeable shale. However, the large-scale structural trends of this region indicate potential migration of fluids into shallower areas, which are less viable for storage.

Revised bedrock geology of the Caledonian Highlands, southeastern New Brunswick

Susan Johnson¹, Ayalew Gebru¹, Adrian Park¹, Sandra Barr², Chris White², Steven Rossiter¹

¹New Brunswick Department of Natural Resources, ²Acadia University.

E-mail: Susan.Johnson@gnb.ca

The Caledonian Highlands encompass an area of over 3700 km², extending along the northern Bay of Fundy from Saint John to Alma in southeastern New Brunswick. The Neoproterozoic and Cambrian succession in the highlands represent one of several Avalonian terranes in the northeastern Appalachian orogen, along with northern Nova Scotia and southern Cape Breton Island, southeastern Newfoundland, and southeastern New England, USA. Since the last bedrock mapping in the highlands was conducted in the early 1990s, a wealth of new data had become available; however, no attempt had been made to incorporate these data into a regional stratigraphic framework and revised bedrock geology maps. Towards this aim, a multi-year collaborative project was initiated in 2015 and is now in its final year, which included bedrock mapping, geochronology, geochemistry, and mineral deposit studies. Neoproterozoic volcanic, volcanoclastic, and epiclastic rocks that were previously divided into the Broad River Group (ca. 620–615 Ma) and Coldbrook Group (ca. 550 Ma), now include a third older package of volcanic rocks named Lumsden Group. The Lumsden Group is intruded by a coeval suite of granodiorite, tonalite and trondhjemite of Cryogenian age (ca. 687 Ma), and is host to the Lumsden base-metal deposit, similar in age and metallogeny to the Stirling deposit on Cape Breton Island in the Avalonian Mira terrane. In the structurally complex and strongly deformed eastern highlands we have expanded the distribution of marine sedimentary rocks of the Cambrian Saint John Group, indicating that the Avalonian overstep sequence is more extensive in this area than previously thought. We also suggest that a sequence of uppermost Coldbrook Group rhyolite/basalt and a newly delineated unit of latest Ediacaran mafic volcanic and fluvial sedimentary rocks associated with the Saint John Group represent a stratigraphic interval that is missing in the western highlands, where the Coldbrook and Saint John groups were defined.

Investigating the tectonic significance of ultramafic rocks in the eastern Harrison Lake area, southwestern BC

Gabrielle Jones¹, Dan Gibson¹, Dejan Milidragovic², Jim Ryan²

¹Simon Fraser University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: gaby_jones@sfu.ca

The potential for permanent carbon capture via carbonate mineralization within hydrated ultramafic rocks to mitigate CO₂-induced global warming necessitates the identification and characterization of large volumes of these rocks in Canada and globally. Significant quantities of serpentinized ultramafic rocks occur within the North American Cordillera and are often interpreted as dismembered ophiolites, implying the preservation of oceanic lithosphere between accreted terranes (i.e. suture zones). However, the emplacement of ultramafic rocks within convergent margin settings may result from a range of igneous and tectonic processes, including accretion of supra-subduction zone or mid-ocean ridge ophiolites, or intrusion of ultramafic-mafic magmas. Detailed multi-disciplinary studies involving targeted bedrock mapping, geochemistry, and geochronology are required to understand the nature of ultramafic bodies. The eastern Harrison Lake area hosts a significant volume of variably serpentinized ultramafic rocks. However, paucity of modern geochemical and geochronological data and the obscuring effects of polyphase deformation, metamorphism, and magmatism have hindered the petrogenetic and tectonic interpretations of these rocks. Preliminary field work undertaken in 2025 indicates these ultramafic rocks comprise variably serpentinized (< 2–100% serpentinized), medium- to coarse-grained dunite with local Cr-spinel schlieren. Contacts with country rock (metavolcanic rocks, gabbro, chlorite schist, chert, and pelite) are generally under cover, recessively weathered, and spatially associated with increased serpentinization in dunite that indicate faulted contacts. In the Old Settler Peak area, dunite is in sharp contact with a

potentially genetically related intermediate-SiO₂ to mafic intrusion. Preliminary whole-rock geochemistry results of the Harrison Lake ultramafic rocks, including high MgO/SiO₂ (0.93–1.23 wt.%) and low Al₂O₃/SiO₂ (0.01–0.05 wt.%) ratios, are consistent with olivine-dominated mineralogy and overlap with forearc peridotite compositions from literature. Future work for the Harrison Lake area will involve additional detailed mapping, whole-rock and mineral chemistry, and geochronology analyses of the ultramafic rocks and surrounding country rock to better understand their petrogenetic and tectonic history.

U–Pb geochronology of the polymetamorphic Grenville Front Tectonic Zone: A window into the lower crust of the Archean Superior Craton

Marine Jouvett¹, Carl Guilmette¹, Antoine Godet², Jérémie Darveau¹, Christiaan Laureijs¹, Myriam Côté-Roberge³

¹Université Laval, ²Natural Resources Canada, Geological Survey of Canada, ³Ministère des Ressources naturelles et des Forêts.

E-mail: marinejouvett1@gmail.com

Archean lower to middle crust occurrences are rare witnesses of early deep tectonic processes, and their petrochronological histories provides key insights into the architecture of cratons at depth, thermal conditions, fluid production, and mobility during cratonization. The parautochthonous Grenville Front Tectonic Zone (GFTZ), located southeast of the Archean Superior Craton, represents a window into the lower crustal units of the adjacent Pontiac Subprovince, brought to the surface and partially reworked by the Proterozoic Grenvillian orogeny. However, the timing of basin deposition, Archean metamorphism and the extend of the Grenvillian overprint remains poorly studied. The area consists of granulite-facies metatexite paragneisses ranging from ky-sill-gt-melt metapelites in the north to medium-pressure opx-gt metawacks in the south, as well as metamafic units, and mafic and felsic intrusions. New U–Pb geochronology performed on zircon and monazite highlights that the whole area preserves a Neoproterozoic history, with the few oldest detrital zircons preserving Mesoarchean records. The maximum depositional age is estimated at ca. 2700 Ma and was followed by metamorphic zircon formed from ca. 2690 Ma to 2620 Ma. The Lac Bay intrusive suite on the west of the GFTZ is dated at ca. 2700 Ma, pointing toward syn-deposition TTG. Monazite reveals protracted metamorphic record from ca. 2680 Ma to 2620 Ma. Nonetheless, a recrystallization gradient is recorded by younging monazite southward during the Grenvillian overprint (1001 ± 1 Ma). Our results, along with Lu–Hf on garnet and Rb/Sr on biotite from companion works, provide new constraints on the nature and extent of the Grenvillian thermal overprint, and highlights that the restitic granulite-facies rocks in the parautochthonous GFTZ presents Archean assemblages but underwent polymetamorphism with a subtle diffusion southward during the Grenvillian orogeny.

New insights into diversity of the pennate diatoms from the Late Cretaceous central Arctic Ocean

Irena Kaczmarek, James M. Ehrman

Mount Allison University.

E-mail: iehrman@mta.ca

Contemporary diatoms are one of the most significant participants in global carbon, oxygen and silicon cycling. Extrapolating from the diatom-rich deposits in the past, they likely played an equally significant role in paleo-ecosystems, including the Arctic and Antarctic Oceans. Despite being one of the most consequential events in the evolutionary history of diatoms, the emergence of pennates remains poorly understood both in terms of its timing and their ancestry. Here, we present results of our re-examination of several diatom-rich Late Cretaceous (Campanian) samples from the Canadian expedition to study the Alpha Ridge (CESAR) in the central Arctic Ocean. We recovered greater than anticipated species richness and increased known Cretaceous pennate diatom flora by 25%. All taxa encountered belong to the earlier diverged araphid pennates. Only one species found was previously known to science. One new genus (*Cesaria*) and three species (*Cesaria palaios pennata*, *Kannoa archaia*, and *K. simswilliamsorum*) are formally proposed. For six others, the taxonomic affinity ranges from species to family and remains tentative but foretells still greater species diversity to be discovered in other samples. We postulate that the plasticity of the structural characters present in the new *Cesaria* frustules serves as an example of a valve-design that could have been advantageous among the earliest pennates. Extinct *Kannoa* species show overall structural similarity to extant *Asteroplanus* and *Asterionellopsis* usually recovered as the earliest pennate diatoms in molecular phylogenies. Our unnamed species show affinity to broadly defined *Rhaphoneidaceae*. All our diatoms are relatively small and delicate and could easily go unnoticed among the abundance of accompanying large and heavily silicified polar and non-polar centric diatoms. If our assumptions regarding their taxonomic affinity based on morphological similarities to extant taxa are correct, the species diversity recovered suggests evolutionary roots of these many taxa are even older than the material examined here.

Petrographic and geochemical analyses of 4.3 Ga metamorphosed pillow basalts from Nuvvuagittuq Greenstone Belt

Si Kaur, William Minarik

McGill University.

E-mail: s.i.b.kaur@mail.mcgill.ca

The composition of the primordial crust and its formation is not well constrained due to the constantly evolving nature of Earth's surface. However, places like the Nuvvuagittuq Greenstone Belt in Quebec can provide insight into the geological processes involved in crust formation on the ancient Earth. The Nuvvuagittuq Greenstone Belt, located in the northeastern Superior Province, and has rocks dating as far back as ca. 4.3 Ga. This outcrop of Hadean crust has been pervasively metamorphosed up to four times to amphibolite facies yet has remarkably preserved the pillow shapes formed during the eruption of the lava on the primordial ocean floor. This provides a unique opportunity to understand and constrain the composition of the primitive upper mantle before the extraction of continental crust, which is otherwise quite poorly represented in the geological record. The samples

chosen for this study were originally deposited as pillow basalts in a marine environment and have since been metamorphosed to amphibolite facies. As the exteriors of the pillow basalts would have been hydrothermally altered immediately after their deposition, resulting in formation of phases like clays and chlorides, the extent of preservation of these hydrous phases would be equally examined. A detailed petrographic analysis is conducted to determine the mineral paragenesis and assemblage, as well as the microstructures and textures. Further investigation of hydrothermal alteration textures and mineral phase chemistry is complemented by electron microprobe analysis and whole rock geochemical analyses. The expected results intend to provide insight into the composition of the primordial ocean floor and the controls of the bulk composition on the metamorphic assemblage and mineral composition observed.

Late Cretaceous tectonothermal development of the northern Kootenay Arc and western Selkirk Fan recorded by U–Pb monazite and Lu–Hf garnet geochronology

Collin Kehler, David Pattison

University of Calgary.

E-mail: collin.kehler@ucalgary.ca

The north-south transition from the adjoining structural and metamorphic domains of the western Selkirk Fan into the Kootenay Arc is located approximately 30 km southeast of Revelstoke in southeastern British Columbia. Mapping, structural and petrographic analysis, and geochronology in the vicinity of this interface has uncovered a phase of Late Cretaceous mid-crustal tectonothermal development in a region dominated by a Jurassic tectonic history. Three phases of deformation and metamorphism are present in this area, with the latter two (D₂/M₂ and D₃/M₃) predominating. Jurassic to Early Cretaceous(?) D₂ and associated M₂ metamorphism resulted in the development of km-scale upright F₂ folds, an axial-planar phyllitic to schistose S₂ fabric, and chlorite to garnet zone M₂ metamorphism. This episode of deformation and metamorphism is overprinted by Late Cretaceous km-scale recumbent F₃ folds, an axial-planar L₃ crenulation to schistose S₃ fabric, and Barrovian M₃ metamorphism with successive garnet, staurolite, kyanite, and sillimanite zones. In-situ LA-ICP-MS Lu–Hf garnet dating records ages of M₂ garnet development between ca. 161–140 Ma, with S₂ development initiating prior to ca. 161 Ma based on the preservation of S₂ in garnet of this age. In-situ Lu–Hf garnet and U–Pb monazite dating records Barrovian M₃ metamorphism from ca. 89–71 Ma, with garnet growth initiating at ca. 84 Ma (Lu–Hf garnet) and final staurolite and garnet growth after ca. 82 Ma (U–Pb monazite inclusions in garnet and staurolite). Because M₃ garnet and staurolite preserves and is in turn wrapped by S₃, fabric development and potentially F₃ recumbent folding was ongoing by ca. 84 Ma and persisted after ca. 82 Ma. Late Cretaceous deformation and metamorphism present in the western flank of the Selkirk Fan and northern Kootenay Arc is similar to that observed in the east flank of the Selkirk Fan where it is associated with out of sequence deformation tied to the Purcell Thrust.

Nanoscale dissolution-precipitation and epitaxial nucleation at biotite-tourmaline interfaces

Austin Keirs¹, Brendan V. Dyck¹, Michael Schindler²

¹University of British Columbia, ²University of Manitoba.

E-mail: austin.keirs@ubc.ca

Dissolution-precipitation reactions and structural re-arrangements of crystalline lattices along grain boundaries can both result from metasomatic fluid-rock interactions. The advancement of a dissolution-precipitation front across a two-phase boundary often requires the transport (to the matrix) of components that are less compatible in the product phase. If rates at which these excess components are transported away from the interface is slower than the advance of the front it can lead to local saturation and the formation of metastable interface phases. When these reactions progress near equilibrium, nucleation of interface phases will theoretically be governed by epitaxy, driving the system toward a lower interfacial energy configuration through structural templating from parental grains. Here we document the nanoscale structural and chemical evolution of biotite-tourmaline interfaces in Himalayan banded leucogranites from Langtang, Nepal, to understand how the reaction progresses at the grain interface. Utilizing high-resolution transmission electron microscopy (HR-TEM), selected area electron diffraction, and scanning transmission electron microscopy–energy dispersive spectroscopy, multiple interface phases were identified. First, we observe discontinuous nanoscale precipitates of rutile. Fast Fourier transform analysis of HR-TEM lattice fringes reveals sharp inter-phase boundaries and the alignment of fringes across biotite (022), rutile (110), and tourmaline (102). This structural templating indicates rutile nucleated epitaxially to the parental biotite in an orientation that maximizes coincident-site lattice atomic interactions. Second, we observe diffuse, Al-rich and Fe-rich amorphous regions within the parental biotite. Nanostructures at these interfaces include the apparent disassembly of biotite laths and the precipitation of secondary 2:1 clay minerals and goethite within the amorphous matrix. Whether these nanostructures form during low-temperature alteration mediated by high-ionic-strength solution or represent metastable products formed at the transport-limited interface, there appears to be no strict epitaxial templating. These observations reveal the interplay between interfacial energy minimization and transport-limited reaction kinetics governing fluid-rock interaction at the nanoscale.

Hiding in plain sight: Cryptic post-growth features in granulite facies garnet revealed by transmission electron microscopy

Jillian Kendrick¹, Vincent van Hinsberg², Vladimir Roddatis³, Richard Wirth³, Anja Schreiber³

¹Saint Mary's University, ²McGill University, ³GFZ Helmholtz Centre for Geosciences.

E-mail: jillian.kendrick@smu.ca

Garnet is the quintessential metamorphic mineral, given its myriad uses as an indicator of pressure-temperature (P-T) conditions, petrochronometer, and host to versatile mineral inclusions. However, the usefulness of garnet depends on its preservation from growth during prograde metamorphism through cooling and retrogression. Evidence that its integrity has been compromised may be obvious, including reaction rims and flattened zoning

profiles. However, post-growth features at the nanometre scale may indicate modification to garnet but are not visible by the most commonly used microscopy techniques. Here, we present results from transmission electron microscopy (TEM) of garnet from the granulite facies Kapuskasing Structural Zone. These samples were selected for investigation to determine the cause of their variably reset Lu–Hf ages. Although TEM did not reveal a direct explanation for disturbance to the Lu–Hf system, previously unidentified post-growth features were identified. Despite only minimal petrographic evidence of retrogression, all fractures examined in garnet are filled with chlorite. In one case, chlorite is associated with a cubic Cu–Fe–S phase and native Cu, indicative of a retrograde redox reaction between garnet and fluid. Our investigation also produced the first documented case of α -decay-related damage in natural garnet. A narrow (50–100 nm) zone of damage at the contact between zircon and garnet—locally associated with nanoporosity and small fractures—indicates that garnet is relatively robust to radiation damage. However, this modification to the grain boundary could have implications for elastic thermobarometry. Overall, our results highlight the potentially cryptic nature of post-growth modification to metamorphic minerals and serve as a reminder to exercise caution when inferring prograde growth conditions.

Discovery GeoPark, eastern Newfoundland: A complex geological storyline explained for non-specialists

Andrew Kerr¹, Samantha Mills-Wiseman²

¹Memorial University of Newfoundland, ²Discovery Global Geopark

E-mail: akerr@mun.ca

Discovery Geopark occupies over 1000 km² on Newfoundland's Bonavista Peninsula. Its complete history extends for half a billion years to when the first complex life forms appeared on Earth. Over 40 diverse Geosites are defined here. Some express geological processes and illustrate how geologists think, whereas others showcase rare Precambrian fossils or events related to glaciation and landscape development. The Geopark is a focus for research aimed at Precambrian fossils, but it has potential for other research activities. The park is dominated by sedimentary rocks of late Precambrian (Ediacaran) age. In the eastern section of the park, the arrangement of strata corresponds closely with that of the Avalon Peninsula, including rocks correlated with the famous Mistaken Point Formation, where the oldest known complex organisms are protected through UNESCO World Heritage Status. Discovery Geopark contains these same fossil species, and they are an important component of its geological story line. The western section of the park represents a different sedimentary basin, including unusual sedimentary rocks that record ancient glaciation events preceding the appearance of earliest complex life forms. These are linked to a period in Earth's history called the 'Snowball Earth', when glacial ice sheets perhaps encased all the planet. The modern landscapes of the park bear witness to the power of ice and ocean through numerous and spectacular coastal erosion features. It is important that visitors leave with an appreciation that even though its story is preserved in layers of stone, it is not yet cast in stone. Rather, it is an evolving story for which many key chapters have yet to be outlined, let alone written. The Geopark continues to work with UNESCO and other organizations to maintain and build its status, with emphasis on the involvement of local communities in its development plans.

The other side of Strange Lake: Historical aspects and future considerations

Andrew Kerr

Memorial University of Newfoundland.

E-mail: akerr@mun.ca

The Strange Lake Zr–Y–Nb–REE deposit in Quebec and Labrador (Nunatsiavut) is widely seen as a symbol of Canadian critical minerals potential, but it remains undeveloped. The original discovery was made in the late 1970s in Labrador, where resources were first defined, and where many ideas about origins and controls were formulated. These deposits (known imaginatively as the Main Zone) played an important role in understanding the nature of the deposit and wider potential, although many questions remain. This presentation has an historical emphasis, but some long-standing discussions about the nature and origins of mineralization will also be addressed. The Main Zone deposits in Labrador remain closed to exploration following land claims settlements during the establishment of Nunatsiavut but may be important in the future of this world-class deposit. The Strange Lake deposits are associated with a largely unexposed Mesoproterozoic peralkaline granite ring complex. These near-unique granites contain rare zirconosilicates and REE-bearing minerals occur in pegmatite and aplite variants that have irregular geometry and sporadic distribution. Potentially economic zones are demarcated by contours of grade, rather than lithological boundaries. The Main Zone resource was estimated in the 1980s at some 57 million tonnes of about 3% Zr₂O₃, 0.4% Y₂O₃, 0.3% Nb₂O₅, and about 0.5% REE oxides, but few samples were ever analyzed for REE. The deposit is relatively enriched in the 'heavy REE' (i.e. Gd to Lu) but in absolute terms remains dominated by the 'light REE' (La to Eu). The B-Zone deposit in Quebec was discovered at around the same time but was then only a subsidiary target. The mineralization is closely similar, but the B-Zone host granite is less enriched in Zr, Y, and REE. The larger resource estimates for the B-Zone deposit reflect deeper exploration drilling compared to the Main Zone, where holes rarely penetrated more than 50 m.

Investigating downstream contaminant transport from a legacy tailing impacted wetland site and the sediment erosion protection effect of a thin reactive amendment and protective capping (TRaP) application

Kaitlyn Kerr, Emily E.V. Chapman, Heidi Gavel, David Lewis, Linda M. Campbell

Saint Mary's University.

E-mail: kaitlyn.kerr@smu.ca

Aquatic ecosystems downstream of historical gold mine districts in Nova Scotia show elevated mercury (Hg) and arsenic (As) concentrations in water and sediment samples. This suggests that contaminants are being transported from where they were originally deposited. The project presented here estimates annual downstream contaminant transport, in particulate and dissolved forms, based on discharge measurements from a typical Nova Scotia

wetland site known as Muddy Pond. We also estimated the amount of contaminated surface sediment that could be eroding and moving out of this system yearly. In addition, the project investigated the success of a thin reactive amendment and protective capping (TRaP) material in reducing that transport from the wetland. First, a water budget was developed for the contaminated wetland site, providing information on typical flow conditions including how much water flows downstream from Muddy Pond yearly. To estimate erosion rates, a SEDflume apparatus was used to simulate various shear stresses over aged (12 months) TRaP treated and untreated sediment cores extracted from Muddy Pond.

"Detrital" zircons in sensu stricto eclogite from the Ross orogen, Antarctica

Tachwan Kim

Korea National University of Education.

E-mail: tachwan.kim@knu.ac.kr

We document the incorporation of exceptionally abundant “detrital” zircon xenocrysts in a sensu stricto eclogite of the Antarctic Ross orogen. The studied eclogite is slightly retrogressed, coarse-grained and Zr-rich. Zircon abundance is comparable to that of siliciclastic sedimentary rocks. Zircons show variable size and morphology and comprise heterogeneous inner zones surrounded by Cambrian outer rims. The inner zones yield wide age range (ca. 2.29 Ga to 530 Ma) and REE variability, whereas outer zones record high-P metamorphism at ca. 528 Ma. The age distribution of the former is characterized by bimodal peaks of so-called Pacific-Gondwanan (ca. 700–500 Ma) and Grenvillian (ca. 1.3–1.0 Ga), matching detrital zircon age patterns from Ross-orogen clastic (meta)sedimentary rocks. We concluded that detrital zircons were introduced after gabbro solidification via solid-state mixing at a subduction front, with zircon incorporation occurring no earlier than ca. 546 Ma. These results imply rapid material recycling ($< 18 \pm 8$ myr) from arc magmatism to deep subduction.

The phosphorus face-off: Modelling resource competition and the finite budget of accessory minerals

Carson Kinney, Sabastien Dyer, Chris Yakymchuk

University of Waterloo.

E-mail: ckinney@uwaterloo.ca

Accessory minerals such as zircon, apatite, and monazite are the primary hosts for trace elements and radioactive isotopes, making them essential for reconstructing the thermal and temporal evolution of the crust. However, accurately modelling their stability is complicated by the fact that multiple phases often compete for the same essential structural constituents. For example, phosphorus is required for both apatite and monazite, yet traditional thermodynamic modelling often treats these minerals in isolation or through sequential calculation steps. This can lead to mass balance inconsistencies and an overestimation of mineral stability when multiple accessory phases are present. To address this, we present a new geochemical framework and open-source Python tool, SAMM (simultaneous accessory mineral modelling). Unlike traditional workflows, SAMM utilizes a universal matrix formulation to solve for the modes of all accessory minerals simultaneously. By integrating experimentally derived saturation expressions within a single mass balance equation, the model accounts for the continuous redistribution of elements like P, Zr, and REEs between minerals and melt. We also include the substitution of these elements into major phases (feldspar, amphibole, etc.), further increasing the competition and potential applications to natural systems. This approach captures the competitive “tug-of-war” for shared resources, providing a more realistic representation of how accessory mineral assemblages evolve during metamorphism and partial melting. We demonstrate the impact of this simultaneous approach using metapelitic, metatonalitic, and metabasic case studies. Our results show that accounting for resource competition significantly shifts predicted mineral stability fields compared to sequential models. This approach provides the metamorphic petrology community with a chemically rigorous framework that reconciles geochronologic data with major phase petrogenesis, ensuring that every atom of a trace element budget is accounted for across the entire mineral assemblage.

Carbonatites: Magmas, melts, fluids and mineralization

Bruce Kjarsgaard

University of Alberta.

E-mail: bakjarsgaard@gmail.com

The past 15 years has seen a resurgence of exploration for carbonatite-hosted critical minerals and metals, complimented by numerous scientific studies and publications. However, a number of these publications have recycled ‘old’ (and forgotten) ideas, or presented hypotheses not supported by available data and knowledge. This is certainly the case with respect to a number of key topics including primary magmatic crystallization, mineralization, and hydrothermal fluid precipitation, mineralization in carbonatites, carbonatite magma (plus fluid) generation and evolution, and carbonatite nomenclature. The presentation will provide an overview of carbonatite melt generation via primary low degree partial mantle melts (peridotite, eclogite) and liquid immiscibility from CO_3^{2-} -bearing (‘carbonated’) alkali silicate magmas, and how these carbonatite magmas differentiate and evolve. The contrasting and distinct process of forming residual carbonate crystal plus melt assemblages derived from fractionated carbonated silicate magmas of variable alkalinity is re-examined. Fluids associated with carbonatite magmas have been variably termed carbohydrothermal, carbothermal, or brines, and although CO_2 -rich they are H_2O -bearing and thus by definition, are in fact, hydrothermal fluids. The main economic commodities of interest in carbonatites can be subdivided into two types, based on process, namely magmatic and hydrothermal. The two key commodities of magmatic mineralization include niobium (pyrochlore, rarely ferrocolumbite, and fersmite) and phosphate (apatite, monazite). In this context REE (e.g. bastnaesite) mineralization is sometimes considered to be extremely late stage magmatic. This is contrasted by hydrothermal mineralization including REE, Cu (chalcopyrite, bornite), fluorite, and gold. To further complicate matters, there is also hydrothermal overprinting and

replacement, e.g. ferrocolumbite or fersmite replacing pyrochlore, and precipitation of pyrochlore in fenites. A detailed examination of Nb solubility and the stability of pyrochlore, lueshite, and high Nb-perovskite in sub-systems of CaCO_3 - Na_2CO_3 - NaNbO_3 - H_2O - CaF_2 at 1 kbar is presented to illustrate these processes.

Sphalerite geochemistry as a proxy for the evolution of volcanogenic massive sulphide deposits in the Buchan Roberts Arm belt, Newfoundland, Canada

Tosh M. Klever

Memorial University of Newfoundland.

E-mail: tklever@mun.ca

The Buchans-Roberts Arm lithotectonic belt within the Notre Dame Subzone of the Dunnage Zone in central Newfoundland hosts bimodal-mafic and bimodal-felsic volcanogenic massive sulphide (VMS) mineralization formed within an Ordovician peri-Laurentian arc during Iapetus Ocean closure. Despite a shared tectonic setting, mineralized and barren occurrences across the belt exhibit highly variable sizes, polymetallic (Pb-Zn-Cu-Au-Ag) grades, and mineralization styles. Few mineralogical studies of these occurrences have applied modern microanalytical techniques, leaving controls on metal grade variability and deposit-forming conditions poorly constrained. Sphalerite is investigated as a proxy for the physicochemical conditions of formation and evolution to correlate geochemical variability with deposit size and metal grade. Sphalerite-bearing samples of massive in-situ, stringer zone, and transported massive sulphide clasts are collected from drill core and will be analyzed by reflected-light petrography, electron microprobe analysis (EMPA), and laser ablation inductively coupled plasma mass spectroscopy (LA-ICP-MS) to determine sphalerite mineralogy, minor and trace element chemistry, and sulphur stable isotope compositions. Minor and trace element systematics in sphalerite will be used to constrain temperature, redox conditions (Eh-pH-fO_2), and fluid composition during formation. Sulphur isotope compositions will distinguish seawater-derived and magmatic-hydrothermal sulphur sources and evaluate sulphur cycling within the hydrothermal system. This study will define fluid and physicochemical characteristics that distinguish high-grade VMS deposits within the Buchans-Roberts Arm belt, advancing genetic models of bimodal-felsic mineralization.

Multi-dataset integration of hyperspectral core scanning

Halina Kondrasovas

Veracio Co.

E-mail: halina.kondrasovas@veracio.com

This presentation will discuss the integration of hyperspectral core scanning data with complementary datasets, with particular emphasis on combining hyperspectral mineralogical information with XRF geochemistry to enhance geological interpretation and decision-making. Hyperspectral spectroscopy is a powerful tool for identifying spectrally active minerals and alteration patterns, but its value increases significantly when combined with elemental data, lithological logging, rock property measurements and domain of the geological context. Integrated datasets can improve ore body characterization, highlight alteration systems, and provide cross-validation between techniques, while contextualizing hyperspectral-derived mineral proxies and relative abundance estimates within whole-rock geochemistry. Combining these datasets also helps constrain uncertainty and provides a more robust framework for interpreting mineralogical and geochemical trends across different spatial scales, and mitigating limitations associated with spectrally inactive minerals in certain spectral regions. The integration approach will be outlined, including how hyperspectral and XRF datasets can be visualized and explored within digital interpretation workflows to support correlation, geological interpretation, and the delivery of decision-relevant products. Emphasis will be placed on how structured integration and clear data dissemination practices improve usability, build confidence in hyperspectral-derived results, and support broader industry adoption of hyperspectral core scanning workflows, with practical examples.

An amphibolite-facies hosted intrusion-associated gold setting recording retrogression and rapid exhumation in the Meguma terrane, Nova Scotia

Daniel J. Kontak¹, Richard J. Home², Gorman Sears³, Kyle P. Larson⁴, Alfredo Camacho⁵

¹Laurentian University, ²Consulting Geologist, ³St. Barbara Ltd. Atlantic, ⁴University of British Columbia Okanagan, ⁵University of Manitoba.

E-mail: dkontak@laurentian.ca

The modern mineral-system paradigm for orogenic gold deposits (OGD) suggests formation is coupled to metamorphic devolatilization of appropriate source rocks (i.e. Au- and S-bearing) with egressed fluids ascending to form gold resources. The Cochrane Hill deposit of the Meguma terrane diverges from this model as it is hosted in Ediacaran-Cambrian Goldenville Group rocks that record amphibolite-grade metamorphism (porphyroblastic staurolite -garnet-cordierite-andalusite) related to its proximity to ca. 375 Ma granite plutons. Gold mineralization (~0.475 Moz @ ~1–2 g/t Au) is hosted in ~30 m unit of pelitic rocks characterized by disseminated arsenopyrite (aspy) and visible gold; barren quartz veins rarely occur outside the ore zone. Petrographic studies highlight: (1) porphyroblasts overgrowing the regional fabric (S_1) are overprinted by S_2 fabrics cut by quartz veins; (2) quartz veins are dismembered; (3) arsenopyrite pressure shadows (quartz record continued strain); (3) arsenopyrite hosts resorbed loellingite and pyrrhotite with visible gold; (4) hydrothermal (~400–450°C) vein biotite; and (5) gold cutting garnet is synchronous with albitization of plagioclase (An_{30}). Elemental mapping of arsenopyrite reveals early Au that is mobilized. Stable isotopes ($\delta^{18}\text{O}$ (quartz, muscovite, δD (muscovite, fluid inclusions)) overlap the field for magmatic and metamorphic fluids and thus equivocal, whereas $\delta^{34}\text{S}$ for arsenopyrite ($+12.7 \pm 0.8$, $n = 5$) reflects a sedimentary influence, as does $\delta^{13}\text{C}$ ($-17.2 \pm 2.7\text{‰}$, $n = 6$) for fluid inclusion extracts. Dating of hydrothermal vein phases indicate cooling through respecting blocking temperatures for Rb/Sr muscovite (ca. 374 ± 34 Ma, $Sr_i = 0.7111 \pm 0.002$) and biotite (294.4 ± 1.1 Ma, $Sr_i = 0.7104 \pm 0.003$)

versus $^{40}\text{Ar}/^{39}\text{Ar}$ muscovite (359.1 ± 0.1 Ma). Quartz-hosted fluid inclusions are secondary $\text{H}_2\text{O}-\text{CO}_2$ types that record abundant decrepitate textures. These findings suggest an intrusion-related(?) auriferous gold event ($> 550^\circ\text{C}$) was later retrograded and exhumed at ca. 295 Ma due to its proximity to the Avalon–Meguma terrane boundary fault zone.

Tracking the imprint of late-stage magmatic fluids in an A-type F-rich hypersolvus intrusive setting: The Late Devonian St. Lawrence Granite, Newfoundland

Daniel J. Kontak¹, Zsuzsanna Magyarosi², James Conliffe²

¹Laurentian University, ²Geological Survey of Newfoundland and Labrador.

E-mail: dkontak@laurentian.ca

The St. Lawrence Granite (SLG) is a ca. 372 Ma peralkaline A-type intrusive complex well known for mining of vein fluorite mineralization. Past studies focused on the granite petrology and related fluorite veins, but details in regard to the late-stage magmatic-hydrothermal stage and how this may relate to fluorite mineralization are lacking. Here we report the results of detailed petrographic, mineral chemical, and fluid inclusion studies aimed at unravelling the important transition from the magmatic to hydrothermal stage that occurs in many rare-metal systems given the exceptional preservation of such features in the SLG. Our preliminary work focused on hypersolvus samples (i.e. quartz-one feldspar system) which retain textural evidence of volatile saturation preserved as euhedral quartz $\pm$ albite lining miarolitic cavities with primary fluid inclusions (FI) decorating growth zones in quartz and also hosted in albite. The feldspar retains perthitic textures with uniform bulk chemistries ($\approx \text{Or}_{50}\text{Ab}_{50}$) based on raster-mode SEM-EDS analysis ($n = 50$). That such areas are inundated with FIs indicates textural ripening via coupled dissolution-precipitation (CDP) mediated by a fluid phase. The latter was subsequently replaced by variably textured albite (granular, vein-like, chessboard) that commonly hosts HFE- and REE-phases (e.g. zircon, monazite, bastnaesite) with rare fluorite associated; imaging of opened quartz-hosted melt inclusions also reveal the presence of these latter phases. Primary FIs in miarolitic quartz include V-rich, L-V, and LV-halite with $> 90\%$ the V-rich type. Common are high-aspect irregular-shaped FIs with elongation parallel to quartz growth direction and equant types between such zones. Microthermometry indicates V- and LV-type FIs with variable chemistries based on eutectic melting (-30°C) and final melting of hydrohalite (-20°C) and ice (most $< -2^\circ\text{C}$, few -6°C); homogenization of LV-types is $325\text{--}350^\circ\text{C}$. Our findings support exsolution of a magmatic volatile phase that facilitated CDP reactions and sodic metasomatism with formation of dispersed HFE and REE phases in the SLG.

Mesozoic intraplate magmatism of the Superior province reflects Arctic – North Atlantic tectonic evolution

Egor Koptev¹, Alexander Peace¹, Gillian Foulger²

¹McMaster University, ²Durham University.

E-mail: koptev@mcmaster.ca

Mesozoic intraplate magmatism in the Superior province of the Canadian Shield spanned the Late Jurassic–Early Cretaceous. Its record comprises multiple kimberlite fields and the Monteregian Hills alkaline province. Recent investigations of its geodynamic nature converged on the ‘plume hypothesis’ associating it with Atlantic hotspots and/or African Large Low Shear Velocity province. In this work, we show that association to be geometrically improbable and suggest a plate-tectonic-driven model for this magmatic activity. We use GPlates 2.5.0 to examine spatial relationships between intraplate intrusions and suggested North Atlantic mantle anomalies. We analyze aeromagnetic and field data in Oasis Montaj 2024.1 to characterize structural settings of the intrusions in the Superior province. We reconstruct the Mesozoic evolution of the stress field from tensile fracture orientations in Paleozoic sediments using WinTensor 5.9.2. We analyze fault reactivation potential in intrusion-hosting structures in response to the reconstructed stress regimes using Petex MOVE 2019.1. We demonstrate that the footprint of a hypothetical hotspot responsible for intraplate magmatism in the Superior would need to exceed 3000 km in diameter. We show that the Mesozoic intraplate intrusions of the Superior were emplaced in the limbs of the aborted Proterozoic St. Lawrence rift system. Segments of this system were sequentially reactivated as pull-aparts in a stress-field with the main extension axis rotating counter-clockwise from W-E to NW-SE. Shift from W-E to N-S extension was marked by cessation of magmatism in the NW-SE limb of the rift system and emplacement of the Monteregian Hills plutons in its W-E-trending branch. We suggest that this shift, occurring at 125 Ma, correlates with a major tectonic re-organization in the North Atlantic – Arctic domain, marked by the syn/post-rift unconformity in the Beaufort-Mackenzie Basin, basaltic volcanism on the Alpha - Mendeleev rise, and peak extension rates in the NE Atlantic branch.

In situ S isotope analysis of apatite by LA-ICP-MS/MS

Luis Krampert¹, Bertrand Rottier¹, Crystal LaFlamme¹, Guillaume Barré², Georges Beaudoin¹, Sarah Dare³, Dany Savard³

¹Université Laval, ²Natural Resources Canada, Geological Survey of Canada, ³Université du Québec à Chicoutimi.

E-mail: luis.krampert.1@ulaval.ca

In situ $\delta^{34}\text{S}$ measurements of apatite are currently acquired by complex SIMS analyses. We present a new method to efficiently measure $\delta^{34}\text{S}$ in situ in apatite using LA-ICP-MS/MS. The LA-ICP-MS/MS system avoids interferences by using two quadrupoles separated by a reaction cell, in which S ions react with oxygen and undergo a mass shift. A suite of existing and newly developed apatite reference materials (RMs) of varying S content (175 to 4115 ppm) and $\delta^{34}\text{S}$ (-2.4 to $+28.4\text{‰}$) were collected. The new RMs were characterized by bulk and SIMS S isotope measurements to validate results obtained by LA-ICP-MS/MS and determine optimal analytical conditions. Similar instrument setups at Université Laval and Université du Québec à Chicoutimi were operated using a sample fluence of $4 \text{ J}/\text{cm}^2$, spot diameter of $75\text{--}80 \text{ }\mu\text{m}$, and repetition rate of 15 Hz. The $\delta^{34}\text{S}$ values obtained by bulk and SIMS were reproduced within $< 2\text{‰}$ at both laboratories by LA-ICP-MS/MS and show standard deviations (SD) $< 2\text{‰}$ for relatively S-rich (> 1000 ppm) apatite. For low S apatite, an offset and increase in uncertainty of measured $\delta^{34}\text{S}$ values is observed. This is linked to the larger

proportion of isotopically distinct S within the total S signal, due to remobilization of ambient S in the LA-ICP-MS system during ablation. This effect can be diminished by using RMs of similar S concentration or by applying a regression correction using multiple RMs with different S concentration. The observed SD for low S apatite (500–1000 ppm) after correction is ~3–6‰. Accurate measurements of low S apatite require minimal S background levels, crucial to attain high S signal-to-noise ratios and limit corrections. We demonstrate that LA-ICP-MS/MS can be used effectively to determine the S isotope composition of S-rich apatite (> 1000 ppm) and track physicochemical processes and sources of S.

In situ S isotope and trace element composition of apatite from the Gaspé Copper porphyry-skarn Cu-Mo deposit

Luis Krampert, Bertrand Rottier, Crystal LaFlamme, Georges Beaudoin

Université Laval.

E-mail: luis.krampert.1@ulaval.ca

Magmatic apatite incorporates abundant trace elements and volatiles (Cl, F, OH), including S. Previous in situ $\delta^{34}\text{S}$ measurements in apatite from arc magmas and porphyry systems show a range of ~0–10‰, attributed to fluid saturation or sulphate/sulphide crystallization, which are key controls on porphyry Cu fertility. In this study, we performed in situ SIMS $\delta^{34}\text{S}$ coupled with EPMA and LA-ICP-MS measurements in matrix-hosted apatite from polyphase porphyry intrusions at the Gaspé Copper porphyry-skarn Cu-Mo deposit to investigate the controls on the S isotope signature in apatite. The Gaspé Copper deposit has two intrusive centers: Copper Mountain (CM) and Porphyry Mountain (PM). Apatite at CM and PM displays $\delta^{34}\text{S}$ values with a range of ~1.5–8‰, means of ~4.7‰, and some intra-grain variations exceeding 5‰, with no specific $\delta^{34}\text{S}$ values associated with the pre-, syn-, and post-mineralization intrusions. In some syn- and post-mineralization intrusions, apatite volatile chemistry (F, Cl, OH) indicates fluid saturation, which has no or limited impact on the apatite $\delta^{34}\text{S}$ values. Only a small fraction of apatite at CM exhibits a core-to-rim increase in $\delta^{34}\text{S}$ values (up to 5.7‰) correlating with decreasing Cl content. This pattern may be consistent with S isotope fractionation driven by exsolution of SO_2 -bearing fluids in oxidized melts. However, most investigated grains from intrusions at CM and PM, also show a large range in $\delta^{34}\text{S}$ values without systematic relationship with volatile and trace element compositions. This suggests a minor effect of fluid exsolution on the observed range of apatite $\delta^{34}\text{S}$ values. Apatite S isotope signature is likely controlled by magmatic replenishment and crystallization/redissolution of anhydrite during apatite crystallization. While the $\delta^{34}\text{S}$ values in apatite provide only limited evidence of fluid exsolution and mineralization at the Gaspé Copper deposit, the results illustrate the complex dynamics of S in a long-lived oxidized magmatic system.

Unravelling the tectonometamorphic evolution of the Uvauk high-pressure anorthosite complex, Nunavut: Implications for Precambrian plate tectonic processes

Kelsey Krossa¹, Dan Gibson¹, Sally Pehrsson², Brendan Dyck³

¹Simon Fraser University, ²Natural Resources Canada, Geological Survey of Canada, ³University of British Columbia Okanagan.

E-mail: kelseykrossa@gmail.com

The Uvauk complex is an Archean-Paleoproterozoic, 30 km long by 1–20 km wide, penetratively deformed anorthosite suite that records evidence for multiple overprinting tectonometamorphic events including high-grade metamorphism and deformation. The Uvauk complex, along with the Kramanitar, Daly Bay, and Hanbury Island Shear Zone complexes are grouped together as the “Aqarneq gneisses”, located along Chesterfield Inlet, on the northwestern coastline of Hudson Bay, Nunavut. The Aqarneq gneisses are anomalous for various reasons, including the steeply dipping bounding shear zone, granulite facies mineral assemblages, and the proximity of the complexes to one another and to the Snowbird Tectonic Zone. There is, however, limited data to characterize the complexes and to develop a regionally cohesive tectonic model/geodynamic setting that explains the formation of the Aqarneq gneisses. The overarching theme of this research is to determine the geodynamic setting that produced the Aqarneq gneisses, testing the hypothesis that the Aqarneq gneiss complexes are related in occurrence and formation. Using garnet Lu–Hf and titanite U–Pb geochronology, new dates have been generated for timing of primary crystallization and subsequent deformation of the Uvauk complex anorthosite suite. Petrography and energy-dispersive X-ray spectroscopy have revealed mineral assemblages and exsolution/symplectic textures indicative of eclogite facies metamorphism followed by decompression through granulite facies conditions which had not been previously identified in the study area. These findings provide new constraints for the tectonic processes and geodynamic setting that produced the Uvauk complex and overall Aqarneq gneisses, and in turn, provide new insight into fundamental tectonic processes that occurred in the Archean and Paleoproterozoic.

Petrological features of the magmatic-hydrothermal component of a hybrid Archean Au deposit setting, Wawa, Ontario

Jacklyn Krueger¹, Daniel J. Kontak¹, Jean-Francois Montreuil²

¹Laurentian University, ²RPX Gold Inc.

E-mail: jkrueger@laurentian.ca

The Archean (ca. 2900–2660 Ma) Michipicoten Greenstone Belt (Superior Province) hosts Au deposits attributed to both intrusion-related (e.g. Renabie, Magino) and orogenic (e.g. Eagle River, Island Gold) processes. The Wawa Gold Corridor was a historical orogenic vein-type Au producer (0.120 Moz Au) hosted in the ca. 2745 Ma Jubilee volcanic-plutonic complex; however, recent work has defined an early magmatic-hydrothermal Au (MHG) system as part of this intrusion. Here we report results from preliminary studies initiated to better define the nature of the host intrusion and the posited MHG system which we cautiously suggest may have contributed Au to the later higher-grade orogenic Au vein systems. The polyphase dioritic-to-tonalitic intrusive complex is mainly fine to medium-grained and varies from melano- to leucocratic with minor late-stage leuco-aplitic dykes and coarse mafic pegmatites; hence the system records an evolution to a more felsic and hydrous component. Numerous generations of disseminated and stockwork sulphide minerals (pyrite-pyrrhotite-chalcopyrite) define Au ore (i.e. 14.16 m @ 1.04 g/t Au) in the MHG system that is associated with

biotite alteration and noted to predate fabric development (D_1 – D_3). Drill holes with high modal pyrite related to the MHG event, as established in our working paragenesis supported with SWIR data, suggest that higher than background Au values associated with early pyrite relates to sericite alteration of the host rock. These findings have several important implications: (1) the established presence of a significant zone of Au mineralization in the hybrid setting predating the orogenic Au event; (2) the MHG component should plausibly be incorporated as a potential source of Au in the later orogenic Au event; (3) geological similarities in terms of age, setting, host rocks and alteration with the world class 20+ Moz 2740 Ma Côté Gold-Gosselin Au deposit; and (4) highlights the importance of better defining the nature of early MHG systems.

Quantification of fracture intensity and rockfall hazard along the Niagara Escarpment using drone-based photogrammetry

Catherine Kupiec, Corey Lang, Alexander Peace, Elli Papangelakis, Carolyn Eyles

McMaster University.

E-mail: kupiec@mcmaster.ca

The Niagara Escarpment exposes a lengthy stratigraphy of Paleozoic sedimentary rocks and stretches across southern Ontario, bisecting the city of Hamilton. Erosional processes acting on the escarpment face present considerable geohazard concerns, as 19 major access routes and countless recreational trails in Hamilton cross the escarpment and require ongoing maintenance and costly infrastructure repairs. Understanding these geohazards, such as rockfalls and slope instability, is essential for ensuring appropriate mitigation measures are in place to minimize their impact. The Ancaster member of the Goat Island Formation and the Gasport Formation are the uppermost units exposed in Hamilton, with variably fractured dolostone units undercut by shale. Spatial variability in fracture intensity and density in these lithological units is expected to influence the frequency and size of rockfall events. However, the steep rock faces along the escarpment are inaccessible for traditional hand measurements of fracture characteristics. Instead, a DJI Mini microdrone was used to acquire imagery for structure-from-motion photogrammetry, producing high-resolution three-dimensional models of selected outcrops. Fracture planes were semi-automatically extracted using planar facet segmentation and manually filtered to remove non-fracture surfaces. Fracture traces were analyzed within defined sampling windows to quantify areal fracture intensity (P21) and areal fracture density (P20). Identified areas of elevated fracture intensity were subsequently integrated with municipal geospatial datasets to create a rockfall susceptibility map. These results demonstrate that UAV photogrammetry, combined with semi-automated fracture extraction, provide an efficient and reproducible methodology for documenting and characterizing fracture networks and for informing further geohazard studies along the Niagara Escarpment. The derived fracture intensity values provide a quantitative basis for assessing spatial patterns of rockfall susceptibility along the Niagara Escarpment.

The timing of orogenic gold emplacement constrained by xenotime geochronology: Developments and future directions

Crystal Laflamme¹, Michael Herzog^{1,2}, Chris McFarlane³, Bertrand Rottier¹, Georges Beaudoin¹, Carl Guilmette¹

¹Université Laval, ²Nutrien Ltd., ³University of New Brunswick.

E-mail: crystal.laflamme@ggl.ulaval.ca

Constraining the absolute timing of orogenic and intrusion associated gold mineralization has often been difficult due to the low-closure temperature of chronometers in the alteration assemblage of gold-hosting quartz-carbonate veins. Because orogenic gold mineralization is emplaced during or slightly post-dating peak metamorphism, this makes it difficult to discern the timing of gold emplacement from the cooling of the metamorphic terrane. Xenotime (YPO₄) is an important U–Pb chronometer for orogenic gold mineralization because it is often precipitated in the quartz-carbonate veins and can be spatially associated with gold-bearing sulphide minerals. Further, xenotime contains U–Pb closure temperature well above 600°C, higher than the peak metamorphic assemblage associated with typical orogenic gold districts. Here, we present a methodology employed to locate xenotime in orogenic gold assemblages, determine their REE signatures and then date the grains by LA-ICP-MS. We present a small case study where xenotime REE chemistry and U–Pb is employed to constrain the timing of orogenic gold mineralization and discern it from a remobilisation event. Finally, we present new avenues for xenotime geochronology by combining it with other imaging and isotopic techniques to place robust constraints on the timing of these complex and multi-phased ore systems.

The Slave Province LCT pegmatites: Occurrence and rare metals mineralization

Gideon Lambiv Dzemua¹, Gilles Ngoran², David Lentz²

¹Northwest Territories Geological Survey, ²University of New Brunswick.

E-mail: Gideon_Lambiv@gov.nt.ca

The Slave Province is endowed with numerous lithium-cesium-tantalum (LCT) pegmatites. These pegmatites have demonstrated potential for lithium, tantalum, niobium, tin, and other rare metals. The Slave Province is a random mosaic of Archean metasedimentary and granitic rocks, with slivers of greenstone belts. The metasedimentary rocks include turbidites of greywacke and mudstone, deformed and metamorphosed to greenschist to lower- to medium-amphibolite facies, and are intruded by granite and granodiorite. Metasedimentary units within the aureoles of large granitic plutons are contact-metamorphosed to cordierite-amphibolite facies, with a diagnostic nodular texture characterized by abundant medium to large cordierite porphyroblasts. The LCT pegmatites in the Slave occur as dykes, generally < 10 to 30 m wide and hundreds of metres long. The dykes occur in groups across the craton and are hosted by both metasedimentary and granitic rocks. However, lithium mineralized pegmatites occur mainly in high-grade nodular metasedimentary units. The dykes vary from simple to irregularly zoned, and spodumene is the primary lithium mineral across the craton. Significant amounts of amblygonite-montebrazite occur in the Faulkner Lake Group, which includes the Best Bet and DeStaffany dykes. Other lithium minerals reported in the Slave include lepidolite, triphylite, and zinnwaldite. Non-ore minerals include microcline, quartz, muscovite, and tourmaline.

Spodumene-mineralized dykes are devoid of tourmaline. Mineralized and barren dykes occur together in the same group. Alteration halos are rare and characterized by narrow black tourmaline bands. The pegmatites are variably albitized and greisenized. Albitization is common along the margins of the dykes. Greisenization is common, but generally incipient. Unlike LCT pegmatites in many other Archaean cratons, such as the Superior Province, those in the Slave are not spatially associated with obvious structural features, such as lithological contacts, folds, and greenstone belts. Evidently, their emplacement is probably controlled by far-field forces.

Need for speed — how quickly can metamorphic minerals grow in nature?

Pierre Lanari¹, Jiahui Liu², Renée Tamblyn¹

¹University of Lausanne, ²The University of Hong Kong.

E-mail: pierre.lanari@unil.ch

Metamorphism is a fundamental geological process whereby rocks are transformed by heat and pressure, resulting in the formation of new minerals and textures. This process occurs over a range of spatial and temporal scales, playing a central role in the geodynamic cycle. Metamorphism shapes mountain ranges, drives crustal recycling, and contributes to the formation of economically important resources. Metamorphism also induces dehydration and densification—processes that actively influence plate tectonics and are associated with rapid geological phenomena, such as seismic activity. However, what controls the rate at which metamorphic reactions, particularly mineral transformations, proceed? Field-based petrological observations suggest timescales of hundreds of thousands to millions of years, whereas experimental data often yield much shorter timescales of days to weeks. In this presentation, we will present a case study in which we use data-driven approaches to reveal the evolving conditions and timescales of the gabbro-to-metagabbro transformation under granulite facies metamorphism. This transformation process involves an ultra-fast reaction occurring within a year and is constrained by diffusion modelling based on frozen-in chemical gradients of trace elements across a partially melted corona texture, preserved in metamorphic peritectic garnet. This study offers an insightful perspective on how advances in analytical techniques and the development of user-friendly big data analysis software are crucial for addressing the long-standing question of metamorphic process rates in natural systems.

Geochemical stability assessment of weathered acid-generating tailings

Faridah Alexandra Lankoande¹, Benoît Plante¹, Isabelle Demers¹, Thomas Pabst²

¹Université du Québec en Abitibi-Témiscamingue, ²Norwegian Geotechnical Institute.

E-mail: Faridah.Alexandra.Lankoande@uqat.ca

Acid mine drainage-generating tailings exposed to climatic conditions for several decades often contain large amounts of oxidation products such as iron oxides/hydroxides, sulphates, and high concentrations of metals. The reclamation of fresh tailings with oxygen barriers has proved efficient but can cause the dissolution of the oxidation products when it concerns weathered tailings storage facilities (TSF). This issue leads to environmental contamination for several decades after reclamation. The objective of this study was to assess the geochemical stability of iron oxyhydroxides to optimize the reclamation of weathered tailings. Two methods were used: passivation of the mineral surfaces of iron oxyhydroxides and dissolution of iron oxyhydroxides. A total of eight weathering minicells and eleven batch assays were conducted in the laboratory using sodium metasilicate (passivating agent) and a deep eutectic solvent (DES, complexing agent), respectively. Concentrations of 0.05 mol/L to 2 mol/L and dilutions of 10% to 60% were tested for the sodium metasilicate and for the DES, respectively, with contact times of 24 to 72 h. Leachate analyses by ICP-AES showed that the addition of metasilicate as a passivating agent decreased by 10 to 100 times the calcium and magnesium content in the leachate. Iron levels were low (less than 10 mg/L) because of neutral to basic pH. Sulphate levels were significantly greater in experiments with a higher concentration of sodium metasilicate than in the control, indicating destabilization of sulphate secondary minerals such as gypsum and anhydrite (confirmed by simulation with Vminteq). The addition of DES allowed the dissolution of iron oxyhydroxides with higher concentrations of cations like iron (100 000 times more than the control), zinc, and lead (1000 times more than the control). These results are promising: passivation or dissolution methods could be applied to the weathered tailings before reclamation methods to optimize their remediation.

The Seiland Igneous Province, Norway: Role of volatiles in the emplacement of ultrabasic fertile melts and the formation and disruption of deep-crustal ore deposits

Rune B. Larsen¹, Maria Cherdantseva², Steven Denyszyn³, Marco Fiorentini², Jacob Hanley⁴, Aleksandra Anna Smyrak-Sikora¹, Bjørn Eske Sørensen¹

¹Norwegian University of Science and Technology, ²University of Western Australia, ³Memorial University of Newfoundland, ⁴Saint Mary's University.

E-mail: rune.larsen@ntnu.no

The Seiland Igneous Province (SIP), Norway, represents a complete crustal conduit system (1 to 0.1 GPa) that fluxed thousands of km³ of fertile asthenospheric volatile-rich ultrabasic melts. The 5000 km² SIP is associated with the Central Iapetus Magmatic Province (CIMP) and formed at ca. 570–530 Ma. Four large peridotite complexes (2–10 km in diameter) embrace the main conduit systems emplacing the ultrabasic melts. They are well exposed in a right-way-up position in steep-walled plugs extending 10 km downwards. From edge to core, they comprise: (1) a marginal rheomorphic fusion zone; (2) olivine-clino-pyroxenite cumulates; (3) wehrlitic; and (4) dunitic cumulates. Parental melt modelling implies ultrabasic melts with 16–22 wt.% MgO, emplaced at 1400–1500°C and formed at 1630°C and 7 GPa by partial melting of carbonated asthenospheric peridotite. Abundant hornblende, carbonatite and lamproite confirm the volatile-rich nature of the mantle reservoir, further corroborated by high contents of magmatic sulphides (0.5–5%), as well as volatile-rich phases (8–48 vol.%) in dykes and cumulates. Volatile-rich alkaline melts aided in both deposition and later disruption of Cu-Ni-PGE minerals. We hypothesize that volatile phases lower melt densities and viscosities and are imperative for the rapid fluxing of

dense basic-ultrabasic melts. In 4 drill holes, we observe 5–20 m of cumulates with 0.4 wt.% Ni, 0.14 wt.% Cu and 70 ppb PGE. Tens of metres below, several 1 m thick PGE reefs occur. Typically, grading 1–1.7 ppm PGE+Au. Example grades feature 0.8 g/t Pd, 0.4 g/t Pt, 0.2 g/t Au, and 0.3 ppb Os-rich IPGE. Decoupling of PGE from Cu and Ni-rich horizons occurs in all four drill holes. Some of the mineralized horizons are associated with recharge events. However, the richest Cu-Ni-PGE reefs do not, hence challenge the common models. The PGE-Cu-Ni occurrences typically occur in parasitic side chambers butting the ultramafic conduit system and are tentatively suggested as prospective targets.

Searching for the White Bird

Alison M. Leitch¹, Richard Gillespie², Ernie Leroy², Alfred Marshall², Jason Sylvester³

¹Memorial University of Newfoundland, ²The International Group for Historic Aircraft Recovery, ³University of Guelph.

E-mail: aleitch@mun.ca

Less than two weeks before Charles Lindbergh's historic flight between New York and Paris in May 1927, two famous French aviators, WW1 veterans Charles Nungesser and François Coli attempted the flight in the opposite direction. They flew a modified wood and fabric-covered Levasseur PL.8 biplane, painted white and christened L'Oiseau Blanc (the White Bird). It dropped its undercarriage after take-off and was designed to land on water on a boat-shaped hull. Its flight path, relying on celestial navigation, was a great circle touching the Northern Peninsula of Newfoundland: its last confirmed sighting was over SW Ireland. Since 1984, The International Group for Historic Aircraft Recovery (TIGHAR) has chased stories of its fate and discovered records of 18 witnesses to a plane flying south from the NW Avalon Peninsula and then west over St Mary's Bay, trailing white smoke. They hypothesize, based on local stories of wreckage found, that the plane crashed into a small island while attempting to land in a large, shallow pond ("Gull Pond") in SW Avalon. TIGHAR has investigated the site with divers (hindered by soupy mud), EM (generating multiple false positives) and drone magnetics, which revealed the geological structure under the pond. Our latest attempt to find the wreckage of the aluminum engine and propeller involves a very detailed ground penetrating radar survey over the frozen pond.

Petrogenetic review of NYF pegmatites: Clues from F-rich A-type granitic intrusion sources to evolution

David Lentz¹, Tania Martins², Michael Wise³

¹University of New Brunswick, ²Manitoba Geological Survey, ³Smithsonian Institution.

E-mail: dlentz@unb.ca

Clues to the origin of NYF (niobium-yttrium-fluorine) granitic pegmatites lie with their direct links to mantle-derived (A1) and crustal-derived (A2) anorogenic magmatism. The composition of the four main endmember (silica-saturated, silica-undersaturated, alumina-saturated, and alumina-undersaturated) magmatic systems controlled by the melting equilibria in the mantle vs crustal sources. Water-undersaturated partial melts require high temperatures that yield high solubilities of incompatible high field strength elements (HFSE) including U, Th, Nb-Ta, and REEs. Fluorine-rich assemblages in the sources affect the partial melting equilibria, but these are typically higher temperature than water-rich assemblages. High F in the granitic melts also increases HFSE solubility and the higher temperatures and lower viscosities enhance coalescence of fertile partial melts with mobilization to the upper crustal regime where A-type granites may crystallize or NYF pegmatites of anatectic origin. NYF pegmatites may also originate directly as late derivatives of residual A-type granite melt crystallization, generally displaying chemical signatures that reflect advanced degrees of fractionation. The presence of primary accessory fluorite and (or) F-enriched ferromagnesian phases provides evidence of the F-enriched nature of the parental A-type granite. The low D values for HFSE from source to emplacement in either setting cause co-enrichment, although saturation of a variety of phases affects each of the D values. The magmatic-hydrothermal transition and (or) melt immiscibility also affects partitioning relations drastically; generally, the later two are late during emplacement as they are quite dependant on decreasing pressure. The relative behaviour of H₂O vs HF is affected by the stability of hydrous silicates, but both are generally incompatible. This suppresses liquids and solids throughout decreasing P-T, extending crystal fractionation to lower temperatures. Like aH₃PO₄, aHF is affected by the relative activity of Ca, to fluorite saturation. If not, H₂O and HF differentially exsolve during volatile saturation as does elemental partitioning of MeOH-MeCl-MeF and alkali-metal complexes.

Designing a rock identification mat for multiple audiences

Louise Leslie

GeoLearns. E-mail: louise@geolearns.com

Several approaches to rock identification were tested in both informal and formal settings with various audiences that included teachers, students, and adults from the general public. The informal settings were field trips to a number of pebbly beaches in Nova Scotia that focused on rock identification. On the first few field trips, participants collected pebbles from the beach and sorted them into groups based on criteria that they chose. Participants commonly chose generalized descriptors such as colours and shapes to sort their pebbles. The conclusion drawn from these first few field trips is that the participants needed more prompting in order to make geologically relevant observations. Therefore, one large sorting mat was created, on which the participants could sort pebbles into boxes with descriptors indicated on the mat. This change redirected the participant's attention to characteristic textures that helped them identify rock types and give each rock a name. At about the same time that this rock mat was being developed for field trips, a new project was initiated to create a rock and mineral kit for the classroom. The function of the rock mat was expanded to the classroom using a collection of rock samples for conducting rock identification. The rock mat was introduced at a teachers' workshop before using it in classroom visits with students from grade levels 4 and 7, as well as a Geology 12 class. The rock identification mat has proven to be an effective tool both for a field trip and in the classroom for different grade levels, helping to develop observational skills to recognize the textures needed to identify rocks.

How to build continental crust: Tracing the emplacement of Archean TTG gneisses using field relationships and microstructural signatures

Eunice Chit Yan Leung¹, Sandra Piazzolo², A. Alexander G. Webb³, Thomas Müller⁴, Christoph A. Hauzenberger⁵, Dominik Sorger⁵, Peter Haproff⁶

¹The University of Hong Kong, ²University of Leeds, ³Freie Universität Berlin, ⁴University of Göttingen, ⁵University of Graz, ⁶University of North Carolina Wilmington.

E-mail: eunicey@connect.hku.hk

The mechanisms driving the growth and stabilization of early Archean continental crust remain highly debated. Central to this problem are the petrogenesis and emplacement of tonalite-trondhjemite-granodiorite (TTG) suites, and whether apparent pulses in the Archean rock record reflect episodic magma addition or selective preservation bias. We investigate ca. 3.7 Ga metatonalites of the Itsaq Gneiss Complex adjacent to the Isua Supracrustal Belt in SW Greenland to constrain deformation conditions and emplacement processes in one of Earth's oldest preserved felsic crustal nuclei. This study integrates field observations, whole-rock geochemistry, petrography, and microstructural analysis across multiple tonalitic-granitoid intrusive phases. Microstructural evidence provides a critical and underused constraint on deformation mechanisms, thermal conditions, and syn- to post-emplacement annealing. We observed feldspar grains with evidence of brittle fracturing, minor deformation twinning, and boundary-localized recrystallization textures, but limited intracrystalline strain. Alteration of feldspar is common near later-stage intrusives. Biotite commonly preserves magmatic-to-subsolidus foliation and locally occurs in fracture-fill and reaction zones within feldspar-rich domains. Quartz preserves the dominant strain record and exhibits a heterogeneous microstructural suite: relict grains with undulose extinction and subgrain development; lobate grain boundaries consistent with grain-boundary-migration recrystallization; localized chessboard extinction; and polygonal aggregates with straight to locally faceted grain boundaries and $\sim 120^\circ$ triple junctions indicative of static annealing. These observations indicate ambient deformation near $\sim 500^\circ\text{C}$, below the threshold for pervasive feldspar ductility, with strain partitioned into brittle feldspar networks and accommodating biotite grain boundaries. Quartz microstructural heterogeneity records repeated thermomechanical cycles, not a simple linear progression, reflecting alternating far-field deformation and intrusion-related heat pulses. We infer that strain in the tonalitic core was weaker than along belt-margin domains and was largely syn-emplacement and thermally driven, rather than a single pervasive regional overprint. The results support incremental, pulsed crustal growth with repeated thermomechanical reworking in a rheologically partitioned early Archean crustal system.

Long term effectiveness of reactive amendment treatment for lowering mobile arsenic and methylmercury in legacy tailing impacted wetland sediments under changing redox conditions

David M. Lewis¹, E. Emily V. Chapman¹, Joyce M. McBeth², Linda M. Campbell¹

¹Saint Mary's University, ²University of Regina.

E-mail: david.lewis@smu.ca

Reactive amendment materials can bind and react with contaminants and decrease their mobility, making them a promising option for remediating and restoring legacy tailing-impacted wetlands. We are developing an in-situ thin reactive amendment and protective capping (TRaP) treatment with the goal to decrease the bioavailability, toxicity and mobility of arsenic (As) and mercury (Hg) in impacted wetland ecosystems from historical gold mine tailings in Nova Scotia. Preliminary short-term laboratory tests using zero-valent iron (ZVI) reactive amendment combined with thin protective capping showed promising results. However, understanding long-term treatment effectiveness under changing redox conditions is essential. To address this a one-year sediment column leaching experiment was conducted using intact sediment cores collected from an impacted wetland. A reactive amendment, zero valent iron (ZVI), with and without a protective capping layer was applied to the wetland sediment columns together with surface water from the site to test the effectiveness and longevity of the treatment. The experiment included a 26-week waterlogged phase followed by three 8-week drying events, each separated by two weeks of saturation. Surface water and leachate samples were collected to measure As and Hg concentration and speciation. Sediment samples were collected from the columns after 12 months for spectroscopic analysis (XAS). Dissolved As concentrations in the overlying water of treated columns remained low throughout the 52-week period, including after the drying and reflooding events. After the initial saturated 26 weeks there was also a 92–95% decrease of dissolved MeHg in the overlying water column in treated columns. However, after drying and reflooding, no significant difference in dissolved MeHg was observed between treated and untreated. Overall, results indicate that the TRaP treatment effectively decreases dissolved As and MeHg in surface waters a one-year period, particularly under sustained waterlogged conditions, highlighting its potential for wetland remediation.

Tectono-metamorphic and magmatic evolution during Permian terrane accretion along a ductile shear zone, southern Beishan orogenic collage, Central Asian Orogenic Belt, NW China

Wenxuan Li¹, Shoufa Lin¹, Chris Yakymchuk¹, Cees van Staal²

¹University of Waterloo, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: w54li@uwaterloo.ca

The Beishan orogenic collage in the Central Asian orogenic belt records the terminal closure of the Paleo-Asian Ocean, yet the Permian tectonic processes responsible for final amalgamation remain controversial. We investigate the Nanquan ductile shear zone and associated lithology in the Shiyao Complex, which is located at southernmost part of the southern Beishan orogenic collage, and integrate field and microstructural analyses with petrology, mineral chemistry, phase-equilibria modeling, and U–Pb geochronology to constrain its deformation-metamorphic-magmatic evolution and clarify terrane accretion. The shear zone juxtaposes the Carboniferous Shiyao Complex against the Baidunzi Complex, a Permian continental-arc

terrane underlain by Proterozoic basement, and is characterized by mylonitic foliations, steeply plunging stretching lineations, and asymmetric shear-sense indicators consistent with south-over-north thrusting. Metatolitic gneisses record an early low-temperature, high-pressure episode (560–590°C, 11–13 kbar) overprinted by higher-temperature, medium-pressure metamorphism (630–690°C, 9–11 kbar), whereas amphibolites south of the shear zone preserve high-temperature, low-to-medium-pressure conditions (770–820°C, 5.5–9 kbar). These P-T paths support subduction of fragments from the Shiyao complex to mantle depths followed by exhumation and thermal overprinting during accretion. Zircon geochronology dates main shearing at ca. 278–274 Ma, exhumation at ca. 274 Ma, and cooling during ca. 266 to 260 Ma. Coeval, multi-pulse Permian magmatism within the Shiyao Complex, including ca. 280–260 Ma gabbro, diorite, granodiorite, granite, indicates a transition from syn-collisional to post-collisional regimes. Together, these results identify the Nanquan shear zone as a suture and document a protracted Permian subduction-accretion event followed by post-collisional evolution in the southern Beishan.

Geological evolution of the southern Beishan orogen, Central Asian orogenic belt (NW China): Results of a collaborative mapping project with Cees van Staal

Shoufa Lin

University of Waterloo.

E-mail: shoufa@uwaterloo.ca

The southern Central Asian orogenic belt (CAOB) in northwest China preserves evidence for both early and late Paleozoic orogenies, but the timing of the closure of the Paleo-Asian Ocean remains uncertain. The strong early Paleozoic orogeny, marked by ca. 450 Ma eclogite and a sub-Devonian angular unconformity, has traditionally been interpreted to indicate that the ocean closed by the Devonian, with the late Paleozoic orogeny viewed as intracratonic. However, growing data now demonstrate extensive late Paleozoic subduction and collision. In the Beishan orogen, detailed mapping by Cees van Staal, Shoufa Lin, and their students—PhD students Gabriel Santos, Tong Hong and Wenxuan Li, and MSc students Jordy de Vries and Jiangyu Li—has revealed multiple fault-bounded structural panels (complexes). The ca. 290–280 Ma mafic-ultramafic Liuyuan Complex represents a back-arc-basin ophiolite with a well-preserved sheeted-dyke complex. The ca. 295–281 Ma Ganquan Complex comprises felsic volcanic and volcanoclastic rocks with arc-like geochemical signatures and magmatic zircons showing mantle-like $\delta^{18}\text{O}$ values; zircon ϵHf values shift from -4.2 to +1.9 in the lower part to +1.3 to +7.6 in the upper part, indicating increasingly juvenile sources. The Baidunzi Complex consists of sheared and isoclinally folded metasedimentary rocks and syn-kinematic intrusions transformed into upper greenschist to amphibolite tectonites, including basement orthoquartzite and orthogneiss, Carboniferous–Permian metasedimentary rocks, and a ca. 294–289 Ma metaluminous, calc-alkaline intrusive suite ranging from hornblende diorite to granite with arc affinity. Its geochemical signatures support formation in a subduction-related setting with possible crustal contamination, consistent with development of an Andean-type arc. Together, these results show that the Paleo-Asian Ocean in this part of the orogen closed in the Permian through multi-phase subduction, arc accretion, and collision.

Linking Avalonian–Cadomian and Alleghanian–Variscan orogenic processes of the Appalachians with Gondwanan Europe: Many thanks to Atlantic Canada!

Ulf Linnemann, Andreas Gärtner, Mandy Zieger-Hofmann, Johannes Zieger, Katja Mende

Senckenberg Naturhistorische Sammlungen Dresden.

E-mail: ulf.linnemann@senckenberg.de

The Alleghanian–Variscan orogen of the Appalachian orogen and of Gondwanan Europe form the central mountain belt of supercontinent Pangea in Devonian–Carboniferous time caused by continent–continent collision of Laurussia, Gondwana, and several microcontinents such as Avalonia composite. That orogen contains Avalonian and Cadomian basement units, which share, at least in part, a common geological history. Contemporaneous occurrence of Ediacaran biota which are characterized by "ash-bed preservation", occur both in West and East Avalonia, and in the Cadomian margin of West Africa. Such fossil assemblages associated with Ediacaran tillites suggest a close spatial relation of Avalonia and Cadomia in Late Ediacaran time (ca. 570–540 Ma). Patterns of detrital zircon U–Pb ages relate Avalonia to Baltica and/or Amazonia whereas Cadomia shows a strong relation to Gondwana. From a plate tectonic perspective, several geotectonic events are recorded in the Alleghanian–Variscan orogenic belt, most of which reflect the global supercontinent cycle: (i) dispersal of the putative supercontinent Pannotia, opening of the Iapetus Ocean, and the amalgamation of the megacontinent Gondwana in Ediacaran time; (ii) formation of the Avalonian and Cadomian orogens in the late Ediacaran and early Cambrian as a system of arcs and marginal basins on the peripheries of Baltica, Amazonia, and West Africa; (iii) Cambrian–Ordovician rifting and drifting of the microcontinent Avalonia away from Gondwana and the subsequent opening of the Rheic Ocean; (iv) origin of the short-lived megacontinent Laurussia in response to the collision of Baltica with Avalonia (ca. 450 Ma) and Laurentia (ca. 420 Ma) recorded as multiple processes linked to the development of the Caledonian Orogen, (v) formation of the Alleghanian–Variscan orogenic belt with the closure of the Rheic Ocean (ca. 400 Ma); (vi) opening and closure of the Rhenish Seaway (ca. 390–330 Ma), and (vii) the consequent orogenic processes that resulted in the formation of the supercontinent Pangea (ca. 330–300 Ma).

Upper crustal signature using ambient noise tomography in polyorogenic NW Iberian crust (Variscan–Alpine)

Sergio Llana-Fúnez¹, Gabriela Fernández-Viejo¹, Carlos López-Fernández¹, Jorge Acevedo², Javier Olona², Juan Manuel González-Cortina¹, Patricia Cadenas³, Miguel Gutiérrez-Medina⁴

¹University of Oviedo, ²Terradat Ltd. Spain, ³University of Coimbra, ⁴Instituto Geológico y Minero de España.

E-mail: llanasergio@uniovi.es

The continental crust of the NW Iberian Peninsula was strongly structured during the Variscan orogeny. Currently exposed is a nearly complete half-section of an orogenic belt. From east to west, it includes the foreland basin, the fold-and-thrust belt, the slate belt, and a high-grade hinterland that was strongly granitized during the late stages of collision. The hinterland also comprises a suite of allochthonous tectonic complexes that incorporate the suture zone (remnants of ophiolitic rocks) and overlying exotic units. The two-stage extensional events that led to the opening of the Atlantic Ocean and the Bay of Biscay did not substantially affect the onshore crust, although they strongly impacted the continental margin. It was not until the convergence between Iberia and Europe in the Paleogene that the onshore crust was tectonically reactivated, leading to the development of an orogenic root beneath part of the Cantabrian Mountains, the Alpine belt west of the Pyrenees. We investigate the crustal signature of these two major events onshore using ambient noise interferometry, with data acquired primarily from temporary seismic networks deployed at different locations. Cross-correlation of seismic records between station pairs allowed us to construct a three-dimensional tomographic model covering most of the upper crust. The explored crustal thickness ranges from 8 to 12 km, depending on station spacing within each network. In addition to discriminating syn-orogenic basins from basement units in both orogens, we were also able to determine crustal fabric. In the Variscan slate belt, this fabric is most likely related to strong rock anisotropy in refolded slates. In the fold-and-thrust belt, it is partly inherited from the Variscan imprint and partly related to more recent Alpine fracturing patterns. Ongoing research aims to extend this analysis offshore.

The western Bay of Biscay; ASTRACAN project results on the structure and late evolution of a failed Atlantic arm and subduction system

Sergio Llana-Fúnez¹, Gabriela Fernández-Viejo¹, Carlos López-Fernández¹, Luis Pando¹, Patricia Cadenas², Jorge Acevedo³, Javier Olona³, Juan Manuel González-Cortina¹, Miguel Gutiérrez-Medina⁴

¹University of Oviedo, ²University of Coimbra, ³Terradat Ltd. Spain, ⁴Instituto Geológico y Minero de España.

E-mail: fernandezgabriel@uniovi.es

The southern margin of the western Bay of Biscay, facing the northern coast of the Iberian Peninsula, preserves key physiographic features that record its late tectonic history. Within the central Bay, a relict proto-ridge—interpreted as the failed arm of the North Atlantic opening—extends west to east from a triple junction from 17°W to ~9°W along latitude 44–45°N. To the south of this ridge, evidence of an aborted proto-subduction system is preserved within the present-day passive margin. This includes an accretionary prism buried beneath post-tectonic sediments, and a relict subduction interface imaged by velocity models and deep seismic reflection profiles. New data acquired during the ASTRACAN project (2025) are currently being processed and analyzed to better constrain the tectonic evolution of this margin, particularly the transition from ridge activity to subduction initiation and its subsequent reversion to the current passive margin setting. The dataset includes passive recordings from ocean bottom seismometers (OBSs) and land seismic stations, high-resolution bathymetry along key fault zones, and 15 multichannel high-seismic reflection profiles. These integrated observations will provide new constraints on the geodynamic evolution of a unique domain within the North Atlantic realm.

Ni-Cu(-PGE) prospectivity and petrogenesis of the Coppermine River Group basalts and associated feeder dykes

Matthew Lombardi¹, Brian O'Driscoll¹, Marie-Claude Williamson²

¹University of Ottawa, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: mlomb005@uottawa.ca

Large Igneous Provinces (LIPs) represent large volumes and fluxes of mostly mafic magma emplaced over relatively short timescales. Some LIPs contain economically significant ore mineralization, including concentrations of chromium (Cr), nickel (Ni), copper (Cu) and platinum-group elements (PGE). The interaction between melt and sulphur-bearing country rocks may induce sulphide saturation, facilitating the concentration of chalcophile Ni-Cu(-PGE) elements into dense immiscible sulphide mineral phases. Such sulphide minerals are expected to accumulate in chonoliths and/or feeder dykes associated with the overlying flood basalt successions. The ca. 1.27 Ga Mackenzie LIP in northern Canada is one of the most extensive LIPs on Earth and comprises three main components: the Mackenzie Dyke Swarm, the Muskox layered intrusion and the Coppermine River Group (CRG) flood basalts. The CRG has been explored for mineralization historically, revealing over 160 different showings as of 1972; an example of the economic potential of the CRG is the DOT-47 lode, last drilled in 1968, with estimated reserves of 5.1 Mt at 2.5 wt.% Cu. Despite these results, the region's remoteness limits the potential for economically viable mining. This study investigates the lowermost picritic flows of the CRG (September Creek and Stony Creek members) and their associated feeder dykes, an underexplored region that is considered highly prospective due to the potential for early crustal contamination of magma. We integrate petrographic observations and geochemical analysis with the results of remote predictive mapping of feeder dykes in the study area to assess evidence for crustal contamination and sulphide mineralization in the September Creek and Stony Creek members. Preliminary findings are encouraging, revealing fine-grained disseminated Cu-rich sulphide minerals (chalcocite) and native copper. Our study will provide new constraints on magma-crust interactions within the CRG and contribute to a broader understanding of the Mackenzie LIP's metallogeny and potential as a target for new discoveries of critical minerals.

A “sed-strat” perspective on West Avalonian climate conformity and tectonic divergence from the Gaskiers glaciation to the Avalonian orogeny

David Lowe¹, Andrea Mills², Nicolas Gomez¹, Chidera Ikechukwu¹, Santiago Serna Ortiz¹, Grace Khatrine¹

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador.

E-mail: Daveglowe25@gmail.com

The Avalon Zone of Newfoundland preserves a mosaic of fault-bounded Late Ediacaran basin successions formed within a linked continental arc system. On the Bonavista Peninsula, mapping distinguishes two such successions—the Bonavista Basin (BVB) and the St. John's Basin (SJB)—yet their continuation southward onto the Avalon Peninsula remains unresolved. Here, we integrate new mapping, facies analysis, and detrital zircon U–Pb geochronology to track their stratigraphic evolution across the eastern Avalon Zone. Shallow-marine to deltaic BVB strata extend onto the eastern Avalon Peninsula (ca. 590–550 Ma Big Head Formation and Hodgewater Group), where they contrast sharply with coeval deep-marine deposits of the SJB to the east (Conception and St. John's groups). Both basin successions record the ca. 590–580 Ma Gaskiers glaciation, but from contrasting depositional perspectives. In the SJB, the Mall Bay and Gaskiers formations preserve glacial influence in deep-water settings. In the BVB, the periglacial Monk Bay and lower Big Head formations record a shallow-marine response, including glacially influenced southeast-facing shoreface parasequences. Overlying these strata and the deglacial Trinity diamictite, postglacial shallow-marine to deltaic deposits (upper Rocky Harbour Group and Hodgewater Group) document transgression and isostatic rebound—signals subdued in the coeval deep-marine SJB succession. Tectonic divergence intensified during the Avalonian orogeny. In the SJB, deformation began ca. 557–550 Ma with deltaic progradation (St. John's Group and lower Signal Hill Group), evolving into braided fluvial, alluvial fan, and lacustrine growth strata along the Avalonian thrust front by ca. 545–530 Ma (upper Signal Hill Group). In contrast, the BVB records subtler tectonic overprinting, characterized by earlier deltaic progradation from ca. 575–540 Ma (upper Rocky Harbour and Crown Hill groups), potentially influenced by postglacial rebound. Both successions were ultimately overlain by widespread alluvial redbeds by ca. 540–535 Ma, marking basin integration across the eastern Avalon Zone.

Tourmaline from the Li-bearing Leduc pegmatite in the Grenville Province, Mont Laurier Terrane – a complex post-crystallization history

Aaron J. Lussier^{1,2}, Isabelle Komendat², Glenn Poirier^{1,2}

¹Canadian Museum of Nature, ²University of Ottawa.

E-mail: alussier@nature.ca

The granitic Leduc pegmatite occurs within Archean paragneiss of the Grenville Province in the Mont Laurier Terrane near Val-des-Monts, Québec. It is the only known Li-bearing pegmatite in the region and has been intermittently mined since the late 19th century. The exposed pegmatite body has dimensions of approximately 15 x 10 x 5 m. It is well-zoned, showing a prominent quartz core, intermediate zone (containing fluor-elbaite, fluor-schorl, microcline (amazonite), lepidolite-zinnwaldite, and smokey quartz), and a heterogeneous wall zone (peristerite, schorl, and regions of graphitic texture). Recent excavations have produced an abundance of high-quality tourmaline specimens, most originating from the intermediate zone into the core. Of interest to collectors, these multi-coloured crystals range in size from centimetres to decimetres and occasionally yield gem-quality material. Tourmaline composition is mostly constrained along the fluor-elbaite to fluor-schorl solid solution. With growth, crystals follow a common colour sequence - light green → pink → green/blue → dark green → black. Tourmaline minerals are versatile petrogenetic tools, with details of host rock emplacement and evolution being determined from compositional (major/trace elements and isotopic) changes as a function of crystal growth. The tendency of tourmaline compositions to remain unchanged after crystallization is fundamental to this petrogenetic functionality. Within Leduc tourmalines, however, abundant textural and compositional evidence suggests the operation of a series of complex dissolution and replacement reactions. Here, these textures and regions are investigated with high-resolution WDS/EMP/MS mapping, along with SEM and Mössbauer spectroscopy. The resulting maps show a complex sequence of alteration of the primary major and trace element compositions, though crystallographic orientation is maintained. In addition to overall enrichment in Fe, trace elements are selectively enriched (e.g. Mg, Ni²⁺, Ti⁴⁺, Sr, V³⁺, and HREE) or depleted (e.g. LREE, Ge⁴⁺, Pb²⁺, and Bi³⁺), with all showing a highly disequilibrium distribution within reacted areas.

Titanite destabilization mechanism during pseudomorph formation in the Ice River Alkaline Complex, southeastern British Columbia, Canada

Aaron J. Lussier^{1,2}, Paula C. Piilonen¹, Glenn Poirier^{1,2}

¹Canadian Museum of Nature, ²University of Ottawa.

E-mail: alussier@nature.ca

Pseudomorphs after cm-scale titanite crystals were observed to be common features in a recently discovered Ti-bearing pegmatite dyke intruding altered nepheline syenite of the late-Paleozoic Ice River Alkaline Complex. These form by the reaction: titanite + HCO₃⁻ + 2H₂O → calcite + anatase + H₄SiO₄ + (OH)⁻. The pegmatite dyke is mineralogically complex (consisting of at least 28 different phases, 13 of which are HFSE- and/or REE-bearing), and both textural and chemical evidence suggests the mobilization of Ti on the local scale within the pegmatite unit. Within the pseudomorph volumes, primary titanite material is commonly preserved, wherein a prominent, linear reaction front is observed at the contact margin with pseudomorph products. At the reaction front, both chemical and textural details of titanite destabilization can be investigated. Three distinct regions are typically observed along such fronts, where titanite is: (1) primary and unreacted; (2) chemically altered but (mostly) crystallographically coherent; and (3) predominantly dissolved and replaced. Using WDS/EMP/MS mapping, LA-ICP-MS and TEM/EDS, the mechanism of titanite breakdown is

characterized. Although major elements show little variability across the reaction front, trace elements are observed to either decrease discontinuously (e.g. Mn, YREE, Nb, Ta, Pb, Th, U, and F), increase discontinuously (e.g. Sc, V, Zr, and Hf), or show minimal change (e.g. Na, Mg, Ni, Cu, Zn). Such behaviours suggest the operation of element exchange mechanisms during the initial phase of decomposition. Toward the transition between regions (2) and (3), the crystallographically directed dissolution of titanite is observed; here, the precipitation of calcite appears to occur first, suggesting that Ti initially migrates away from the advancing reaction front. Corresponding TEM investigations also reveal the formation of abundant TiO₂ nanoparticles during titanite breakdown and subsequent nanoparticle aggregation.

Vectoring towards different styles of mineralization in an orogenic gold district using gold grain geochemistry and PLS-DA: Evidence from the Meadowbank district, Nunavut

Wasiq Lutfi¹, Georges Beaudoin¹, Isabelle McMartin²

¹Université Laval, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: wasiq.lutfi.1@ulaval.ca

Orogenic gold deposits and showings at the Meadowbank mine complex (Agnico Eagle Mines), Nunavut, are hosted by Archean Woodburn Lake group volcanic and sedimentary rocks. Gold mineralization is primarily hosted by deformed magnetite-chert banded iron formations (BIF) containing pyrrhotite ± pyrite and minor chalcopyrite, arsenopyrite, galena, and sphalerite at the Goose, North and Third Portage deposits, whereas it is hosted in quartz-pyrite ± galena veins in sericite and carbonate-altered volcanoclastic rocks at the Vault deposit. In contrast, gold in regional showings occurs mainly in quartz veins with minor sulphide and carbonate minerals, BIF, and chlorite. This study examines the geochemistry of gold grains to compare the major orogenic gold deposits with the showings to develop improved vectoring strategies for mineral exploration in glaciated terrains. Biplots show inverse Ag-Cu relationships and positive Ag-Sb-Hg correlations in all gold grains; however, gold grains from a showing hosted in felsic intrusive rocks (Sheba) exhibit lower Au-Cu and higher Ag-Hg-Sb-Pb contents. Partial Least Squares Discriminant Analysis (PLS-DA) indicates that components t1 and t2 explain 42% and 32% of the total variance, respectively. The Goose, North and Third Portage deposits, and the Anuri prospect predominantly plot at negative t1 scores, although Third Portage also show small positive t1 values. The Sheba prospect quartz-pyrite veins hosted in schist plot at negative t1 scores, whereas gold in pyrite-sphalerite-galena breccia in intrusive felsic rocks plot at positive t1 values. Overall, there is a good agreement in gold grain chemistry between orogenic gold deposits and similar orogenic-style showings whereas gold grains in intrusion-hosted sulphide bearing breccia show a distinct signature. Differentiation of gold grain populations and derived dispersal trains in glacial sediments will help improve mineral exploration strategies in this glaciated region.

Benthic foraminiferal indices indicate recent shifts in nutrient levels along Abu Dhabi's coastline

Kathryn MacDonald, Hilary Corlett

Memorial University of Newfoundland.

E-mail: kamacdonald@mun.ca

After the 1958 discovery of oil in the Persian Gulf, the coastal city of Abu Dhabi, UAE, underwent rapid industrialization, urbanization, and coastal development. In this study, benthic foraminiferal indices and geochemical trends in intertidal push cores from Al Qantur Lagoon, located 40 km from Abu Dhabi city, are analyzed to evaluate if anthropogenic impacts are influencing the foraminiferal population. Foraminiferal indices are proxies for environmental conditions first developed for use in temperate and tropical shallow marine settings and have not been used in the Persian Gulf since the hypersaline and warm marine conditions may impact the indices' values. Results of our study show correlation between the Foraminifera in Reef Assessment and Monitoring Index (FI), Foram Stress Index (FSI), and sediment geochemistry, suggesting that use of indices is effective. Recent benthic foraminifera were separated and identified to the generic level from subsampled 25 cm and 27 cm push cores which, based on published sedimentation estimates, cover between 1160 to 2021 and 1090 to 2021, respectively. Foraminifera taxa counts were used to calculate FI and FSI values, which show fluctuations and then an overall decreasing trend in the upper 15 cm, suggesting increasing nutrient availability and organic matter enrichment in recent assemblages. The overall lowest FI values are in the upper 5 cm of both cores, and lowest FSI values are in the upper 5 cm for Core 3, which is consistent with foraminifera experiencing nutrient pollution. Geochemical analysis of the sediment from the push core sites experiencing lower bioturbation intensity reveals increasing nutrient proxy (P/Ca) values in the upper 15 cm. Increasing P/Ca suggests increasing nutrient availability, supporting interpreted trends from foraminiferal indices. Overall, both foraminiferal indices and geochemical trends suggest recent increases in nutrient availability and organic matter enrichment, consistent with nutrient pollution effects on coastal environments.

Allanite: A window into the evolution of REE mineralization in alkaline-silicate igneous systems

Zsuzsanna Magyarosi¹, John M. Hanchar², Sebastian Kommacher², Wanda Aylward²

¹Geological Survey of Newfoundland and Labrador, ²Memorial University of Newfoundland.

E-mail: zsuzsannamagyarosi@gov.nl.ca

The REE and HFSE mineralization in southeastern Labrador is hosted by Mesoproterozoic metaluminous to peralkaline granites and syenites of the Fox Harbour Belt and pegmatites to the south. Allanite is the main REE-bearing mineral, locally accompanied by fergusonite and/or chevkinite. In metaluminous rocks and pegmatites, allanite is a primary magmatic mineral but records two subsequent metasomatic alteration events. Primary magmatic allanite, preserved with bright cores in back-scattered electron (BSE) imaging within some grains, is typical of allanite from extensional tectonic settings, characterized by enrichment in REE, Fe, and Ti and depletion in Al relative to allanite from synorogenic settings. The first metasomatic event is represented by darker mantles seen in BSE images surrounding primary magmatic cores, or entire magmatic cores in more

extensively altered grains. This allanite is associated with Cl enrichment and increased Ca, Mg, Co, and Mn contents, indicating alteration by a Cl-rich fluid. The second metasomatic event is represented by strongly altered rims around earlier allanite, containing inclusions of REE $\pm$ Ca fluorocarbonates and minor thorite, reflecting interaction with a low-temperature, oxidizing fluid enriched in F and CO₂. Relative to primary magmatic allanite, altered allanite displays a decrease in LREE and an increase in HREE contents and an overall decrease in total REE contents. The REE released during allanite alteration were mostly incorporated into secondary fluorocarbonates, suggesting limited REE mobility. In the peralkaline rocks, the allanite is interpreted to be secondary after chevkinite, likely forming during the second metasomatic event. The widespread distribution and consistent nature of both alteration events throughout most of the alkaline magmatic system suggests a predominantly closed system involving late-magmatic fluids derived from the cooling magma. Zircon and fergusonite are interpreted to have crystallized during late-magmatic metasomatic activity associated with the later F-rich fluids, indicated by their close spatial association with strongly altered allanite rims and the spongy, inclusion-rich textures of zircon.

The petrogenesis of Devonian peraluminous plutons in southwestern Newfoundland

Kiersty M. Malay¹, Donnelly B. Archibald², James Conliffe³, James L. Crowley⁴

¹Memorial University of Newfoundland, ²Saint Francis Xavier University, ³Geological Survey of Newfoundland and Labrador, ⁴Boise State University.
E-mail: kmmalay@mun.ca

The Couteau Brook and Peter Snout plutons in southern Newfoundland are complex composite intrusions of biotite-muscovite granite that were emplaced during multiple magmatic pulses and possible remelting events. The plutons are tourmaline- and garnet-bearing and crop out over an area of approximately 10 km². The Rose Blanche pluton (~45 km W of the main study area) is also compared to these plutons due to reported similarities. New LA-ICP-MS and CA-ID-TIMS U–Pb dating of three samples from the Peter Snout pluton yielded four ages between 419 $\pm$ 10 and 392 $\pm$ 10 Ma. A sample of the Rose Blanche pluton yielded an age of 397.49 $\pm$ 0.17 Ma. Geochemical data show that all three plutons are strongly peraluminous and show a negative REE slope with a negative Eu anomaly, with the Rose Blanche pluton showing a steeper negative REE slope than the Couteau Brook and Peter Snout plutons. Trace element patterns for the Couteau Brook and Peter Snout plutons show a slightly negative trend and differ from the Rose Blanche pluton due to their elevated concentrations of elements such as Cs, Rb, and Ta, and relative depletion in Ba. Tourmaline and mica compositions show that the Peter Snout pluton is more geochemically evolved than the Rose Blanche pluton which is more geochemically evolved than the Couteau Brook pluton. Tectonic classification diagrams show that the Couteau Brook and Peter Snout plutons are syn-collisional (Acadian orogeny) whereas the Rose Blanche pluton is post-collisional (Salinic orogeny). The Nd–Sr isotopic data from all three plutons reflect a derivation from a continental crust source. Taken together, these plutons provide better age and tectonic constraints for this region of Ganderia in the Devonian.

Alkaline mafic-ultramafic intrusions northwest of La Tuque, Grenville Province: New mineral data and geochemical constraints

Brahim Mali¹, Azam Soltanmohammadi², Pierre-Simon Ross¹, Abdelali Moukhsil³, Mhamed El Bourki³

¹Institut National de la Recherche Scientifique, ²Natural Resources Canada, Geological Survey of Canada, ³Ministère des Ressources naturelles et des Forêts.

E-mail: azam.soltanmohammadi@nrcan-nrcan.gc.ca

Alkaline rocks, although volumetrically minor within the global igneous rock record, are of considerable importance from both scientific and economic perspectives. They record key mantle processes and commonly host critical-element mineralization. Their mineralogical and geochemical signatures, characteristic of a major reservoir for critical metal mineralization provide insights into the processes responsible for enrichment in alkali metals, rare earth elements, Nb, Ta, Zr, and other high-field-strength elements. Glimmerites represent an end-member of alkaline ultramafic magmatism, characterized by a phlogopite-dominated mineralogy and remarkable enrichment in alkali metals. In this study, we combine field observations and geochemical analyses to characterize alkaline ultramafic intrusions identified northwest of La Tuque (Quebec), within the central Grenville Province. Field observations show that glimmerite occurs as discrete bodies, spatially and structurally associated with alkaline mafic intrusions. The mineralogical assemblages, dominated by high-Mg phlogopite associated with clinopyroxene and alkali feldspar, are consistent with crystallization from alkaline magmas rather than with metasomatic overprinting, and the cumulate textures of pyroxene, observed in petrography, further confirm an igneous origin. The geochemical composition of these rocks is characterized by high alkali contents and coherent variations in major and trace elements, positioning these intrusions among the most extreme manifestations of the alkaline spectrum in the province. These rocks are associated with magmatism related to later intraplate rifting, passive margins, and collisional orogens. The study enhances the documented diversity of alkaline ultramafic rocks and refines our understanding of the tectonomagmatic conditions that controlled their genesis and mineralization in the Grenville Province.

Deciphering the post-Grenvillian geological history in the Long Range Inlier, West Newfoundland: Implications for gold mineralization

Keaton Markham¹, Shawna White¹, Mo Snyder², Sebastian Kommesch³

¹Saint Mary's University, ²Acadia University, ³Memorial University of Newfoundland.

E-mail: keaton.markham@gmail.com

Appalachian mountain building processes, involving episodic accretion of microcontinents and exotic terranes to Laurentia, are the primary reasons for gold occurrences in Newfoundland. Although most gold occurrences are within central Newfoundland Gondwanan terranes, recent exploration has uncovered gold occurrences within the Mesoproterozoic (ca. 1.0 Ga) Laurentian Long Range Inlier (LRI) of western Newfoundland. High-grade gold occurrences are spatially associated with regional, northwest-trending lineaments defined by light detection and ranging (LiDAR), which extend along strike to inherited basement structures farther west. Although these observations point to potential structural control, locating a significant deposit is

hindered by a lack of detailed mapping and geoscientific research in the LRI. This study combines geological mapping and geochronology in the vicinity of gold showings to better constrain the inlier's geological history. Results show a metasedimentary sequence, previously grouped with Mesoproterozoic rocks, that nonconformably overlies crystalline basement and has a maximum depositional age of ca. 705 Ma. Mafic rocks, originally correlated with Mesoproterozoic amphibolite, are reclassified as dioritic-gabbroic intrusions. Observed textural variability, map relationships, and U–Pb zircon dates of ca. 425 Ma suggest correlation of these plutonic rocks with the ca. 430 Ma Taylors Brook Gabbro further south. LiDAR lineaments correlate with a major SE-striking sinistral fault system which displays pervasive gouge, breccia, mineralized veins, and altered host rock. All significant gold showings reside in releasing bends or at branch points within the deformation zone. Orientations and kinematics are consistent with generation (or reactivation) during documented Carboniferous dextral motion along regional NE-striking Appalachian trend faults. Ongoing K–Ar dating of illite in fault gouge will constrain the timing of fault motion. Recognition that significant Silurian magmatism and gold mineralization are spatially related to major basement faults point to structural inheritance playing a key role in focusing magma and fluids in western Newfoundland. These results are currently being used to move gold exploration in western Newfoundland forward.

Cosmopolitan record of reticular small carbonaceous fossils from the Ediacaran-Cambrian boundary interval

Blanca Martínez-Benítez^{1,2}, Teodoro Palacios³, Javier Álvaro¹

¹Instituto de Geociencias (Spanish Research Council), ²Universidad Complutense de Madrid, ³Universidad de Extremadura.

E-mail: blanca.m@igeo.ucm-csic.es

The Ediacaran-Cambrian boundary interval was marked by major changes in the biosphere and evolutionary innovations, such as the global appearance of the first complex trace fossils and mineralized skeletons. In this context, small carbonaceous fossils (SCFs) provide another important window for better understanding of rapidly shifting ecosystems. A distinct SCF has been found in the uppermost Ediacaran-Terreneuvian interval from Fortune Head Global boundary stratotype section and point (GSSP) in Newfoundland and Cape Breton Island in Nova Scotia, (both in Canada) and also in South China. Microfossils were extracted from shales and kerogenous limestones following traditional palynological techniques, and studied using Raman spectrometry, light microscopy and electron microscopy. The SCF is characterized by a morphology comprising a thicker reticular “frame” forming polygonal (mainly hexagonal) patterns, encrusted by a thin biofilm. Its occurrence in Member 1 of the Chapel Island Formation from Fortune Head may be used as supporting evidence for the informal ‘leiosphaerid zone’ that includes the Ediacaran-Cambrian GSSP boundary. The biozone is rich in leiosphaerids, vendotaenid fragments and filamentous sheaths, and topped by the first appearance of *Granomarginata squamacea*, a horizon close to the base of the *Rusophycus avalonensis* Zone. Reticulated fragments had been so far informally assigned to *?Dictyotidium* sp. and aff. *Sagatum priscum*.

Pegmatite petrogenesis: A retrospect and looking into future research avenues

Tania Martins

Manitoba Geological Survey.

E-mail: tania.martins@gov.mb.ca

The demand for raw materials and metals considered essential for green energy technologies to achieve Canada's goal of net-zero emissions by 2050 has put a spotlight on pegmatite research. This is in part because these rocks are the main sources of some of the critically important minerals and metals. Pegmatites are fascinating intrusive igneous rocks with very large crystals. The most common type of pegmatite is of granitic composition: mostly quartz, feldspar and micas. Even if pegmatite is a textural term there is sometimes a tendency to associate it with rare-element mineralization (e.g. Li, Cs, Be, Nb, Ta, Sn, F, Y, REEs). Pegmatites can have some of the most intriguing and diverse features including complex mineral textures, wide variation of grain size, internal and regional zonation, exotic mineral associations, and can also be hosts of extreme rare-element enrichments. The presence of fluxes and volatiles in granitic pegmatite melts is seen as essential to explain these features and is thought to play a role in lowering the crystallization temperature, decreasing nucleation rates, melt viscosity and polymerization, and increasing diffusion rates and solubility. However, the mechanisms involved in the formation of granitic pegmatite melts and their crystallization history remain controversial. Authors have invoked different mechanisms and processes to explain these features and rare-element enrichments, such as fractional crystallization, multistage melting, liquid immiscibility, boundary layer effects, rapid cooling rates, disequilibrium crystallization, and gas-driven filter pressing to refer to some examples. Recent research developments in analytical techniques, pegmatite classification, thermodynamic modelling, experimental petrology, geochronology, and the role of anatexis as a major process in pegmatite genesis and rare-element enrichments continuously contribute to our better understanding of pegmatite petrogenesis.

Magmatic evolution from the Paleoproterozoic fluorite-bearing Thorsteinson A-type granite, northern Manitoba: Insights into petrogenesis

Tania Martins¹, Chris McFarlane², David Lentz²

¹Manitoba Geological Survey, ²University of New Brunswick.

E-mail: tania.martins@gov.mb.ca

The Thorsteinson fluorite-bearing granite is part of Manitoba's Southern Indian domain of the Trans-Hudson Orogen located between the Chipewyan and Baldock batholiths. This fluorite-bearing granite is leucocratic with less than 5 vol.% ferromagnesian minerals. Major mineral components are quartz (~36 vol.%), K-feldspar (~35 vol.%), plagioclase (~24 vol.%), biotite (~2 vol.%), ~1 vol.% each of hornblende, fluorite, and apatite and < 1% of titanite, ilmenite, magnetite, zircon, and allanite. Petrographic observations indicate that fluorite is a primary phase occurring both as isolated subhedral grains and in association with ilmenite, magnetite, biotite, and hornblende. Micro-XRF-EDS elemental mapping of polished thin sections reveal that fluorite has an inhomogeneous composition with rims enriched in Ca and REE + Y concentrations > 3000 ppm. Titanite has associations

similar to those of fluorite and is locally found replacing ilmenite. Primary titanite and ilmenite are locally associated with biotite and hornblende but also form during partial replacement. Zircon occurs in association with biotite and hornblende and is locally metamict. Whole-rock geochemistry indicates that the Thorsteinson pluton is peraluminous and trace-element geochemical data indicate a crustal A-type (A2) signature ($Ga/Al > 2.8$, $Zr+Y+Ce+Nb > 353$ ppm with $Nb/Y < 1$), with HFSE depletion and LREE enrichment. Discrimination diagrams indicate an affinity to relatively hydrous, and high Fe/Mg (reduced, with local magnetite) source regions consistent with an arc-like granulitic lower crust, compatible with an interpretation that the granitoid rocks formed in a tectonic regime originally related to subduction, followed by collision during Trans-Hudson orogenesis. Previous workers interpreted the fluorite-bearing Thorsteinson Granite as an anorogenic-type granite thought to represent a late-stage consolidation of the Proterozoic craton at ca. 1713 ± 19 Ma (Rb–Sr age determination). However, recent U–Pb geochronology of 30 zircon grains yielded a linear regression of the concordant or moderately discordant analyses with an upper-intercept crystallization age of 1829 ± 5.5 Ma.

A Paleozoic microbial sea in the basal Windsor Group of Cape Breton

Edward (Ted) J. Matheson¹, Zailynne Durant^{1,2}, Kayla Youngchief^{1,2}, Graydon MacIsaac¹, George Bradley^{1,3}

¹Cape Breton University, ²Acadia University, ³Queen's University.

E-mail: ted_matheson@cbu.ca

Carbonates, evaporites, and siltstones in the Windsor and Codroy groups of Atlantic Canada accumulated following a pronounced oceanographic and geomorphologic transition. Semi-arid siliciclastic valley fills were overlain by marine sediments associated with the Viséan inundation of the Maritimes Basin. In the onshore Sydney Basin, this interval is recorded by the basal Windsor Group Gays River and MacBeth Brook formations. Outcrop, quarry, and core data are combined with petrography, mesoscale assessment of fabrics, and quarry-scale assessment of stratigraphic architecture to better constrain eustatic and paleoenvironment controls during this transition. Data reveal rapid inundation followed by the prolonged persistence of microbial communities across a range of water depths. Low-energy shoreline deposits consist of sabkha facies with flat-lying microbial bindstone, displacive evaporite nodules, and gastropod-ostracod-rich fossiliferous muddy facies. Subtidal facies reveal an atypical dominance of microbial communities over biocalcifying metazoans. This is most pronounced in a large microbial reef complex built from a wave-resistant microbial framework elevated above the seafloor, evidenced by internal cementation, primary cavities, and margins steeper than the angle of repose. Petrography and sub-cm-scale serial slabbing of reefal specimens reveal elements of thrombolitic, dendritic, and stromatolitic textures with opportunistic microbial growth supplemented by early cementation as opposed to the self-sustaining ecological feedbacks characteristic of metazoan reefs. Between the reef and coastline, lensoidal microbial mounds (patch reefs, bioherms) as well as microbial towers (rigid columnar accumulations) dotted the lagoon. Benthic communities were a low-diversity assemblage of molluscs and poorly preserved enigmatic and problematical forms with abundant microscopic microbial fabrics, including laminated, oncolitic, cryptic, and irregular textures not recognizable at outcrop scale. Skeletal grains were coated by microstromatolites during life or coated post-death, revealing the pervasive microbial dominance. Recognition of this previously unknown microbial sea provides new insights into flooding of the Maritimes Basin and the paleoenvironment conditions that supported microbial communities.

Are they seismites? Evaluating soft-sediment deformation in the Mabou Group

Edward (Ted) J. Matheson¹, Jessica MacIsaac¹, Mo E. Snyder², Jason Loxton¹

¹Cape Breton University, ²Acadia University.

E-mail: ted_matheson@cbu.ca

Soft-sediment deformation structures (SSDS) result from the deformation of unconsolidated or partially consolidated sediment not long after deposition. SSDS provide valuable insights into the processes operating shortly after accumulation, including gravity-driven instability, earthquake activity, and their interplay with sediment rheology. The late Mississippian Mabou Group of Nova Scotia contains abundant sub-centimetre to multi-metre-scale SSDS. The Mabou Group is interbedded sandstones, siltstones, and mudstones that accumulated in a broad lake system and surrounding terrestrial and fluvial environments. Although Mabou Group SSDS have been previously recognized and linked to autogenic processes (e.g. loading due to channel incision), our recent re-investigation has broadened the known examples and distribution of these features. At twelve Mabou Group sections across Cape Breton and the Nova Scotian mainland, detailed description and photography in the context of pre-existing stratigraphic logs were coupled with sampling, petrography, and drone-based structure-from-motion photogrammetry to document SSDS spatial distribution, facies associations, and stratal architecture. Three types of SSDS with pervasive deformation of entire 20 cm to 2 m thick beds were identified. They are dish structures, convolute shale with extensive folding and, most prominently, bulbous sandstone masses (pseudonodules) found in convolute shale matrix. In one section, 12 SSDS beds were found within both fine- and coarse-grained rock types in a 130 m succession. Sedimentologic and stratigraphic observations of many beds do not support surface-linked deformation; i.e. there is no clear direct or autogenic trigger in some instances. Given this observation, combined with their stratigraphic recurrence, lateral persistence, and facies independence, we consider the possibility that earthquake-induced liquefaction and fluidization were the causes (i.e. these rocks are seismites). Seismic events likely occurred along unknown basin-bounding faults some distance from the studied localities. As such, the Mabou Group offers an opportunity to evaluate the sedimentological response of lacustrine, marginal-lacustrine, and fluvial-pedogenic siliciclastic sediments to syndepositional, but non-local, faulting in a late Paleozoic continental basin.

Reassessing crustal nature beneath the Vøring Plateau and Vøring Spur using seismic refraction tomography

Anika Nawar Mayeesha¹, Asif Ashraf², Irina Filina¹

¹University of Nebraska-Lincoln, ²University of Oregon.

E-mail: amayeesha2@huskers.unl.edu

The Vøring Plateau and Vøring Spur are key elements of the Norwegian rifted margin, yet their crustal nature remains debated. Seismic refraction data across these features indicate crustal thicknesses of up to ~20 km beneath the Vøring Plateau and ~18 km beneath the Vøring Spur. Previous work has interpreted these domains as anomalously thick oceanic crust based on crustal thickness and magnetic signatures, whereas structurally similar crust on the conjugate Greenland margin has been classified as extended and intruded continental crust. This discrepancy complicates models of continental breakup and the tectonic reconstruction of the North Atlantic. In this study, we re-evaluate the crustal structure beneath the Vøring Plateau and Vøring Spur using seismic refraction data provided by the University of Oslo along profile 11-03 from the 2003 EUROMARGINS experiment. First-arrival travel times are picked using tIPicker, a Matlab-based tool for refraction data, and inverted with seismic tomography to obtain a detailed P-wave velocity model of the crust. To test the robustness of the inferred structure, we explore a suite of tomographic results generated with alternative initial models. We then compare our inverted results with previously published crustal models from Norwegian scientists. Our inversion suggests that the crust is significantly thicker than the “normal” oceanic one beneath both the Vøring Plateau and Vøring Spur, broadly consistent with earlier interpretations but with improved structural resolution. These new models provide updated constraints on the crustal affinity of the Vøring margin and help distinguish between interpretations of thickened oceanic crust vs stretched, intruded continental crust.

The regional significance of the Porcupine fault system, Yukon and Alaska

William C. McClelland^{1,2}, Justin V. Strauss¹, Karol Faehnrich^{1,3}, Margo L. Odlum⁴, Erin E. Donaghy⁵, E. Troy Rasbury⁶, Maurice Colpron⁷

¹Dartmouth College, ²University of Iowa, ³University of Adelaide, ⁴Scripps Institute of Oceanography, ⁵University of Nevada at Las Vegas, ⁶Stony Brook University, ⁷Yukon Geological Survey.

E-mail: bill-mcclelland@uiowa.edu

The northeast-trending topographic low extending from the Porcupine River and Yukon Flats Basin, Alaska to the Old Crow Basin and Rapid depression, Yukon coincides with a significant break in the continuity of the Cordilleran orogen. This discontinuity separates the Arctic Alaska terrane and Brooks Range orogen from the northwestern Laurentian margin and northern Cordilleran orogen. Current Paleozoic, Mesozoic and Cenozoic tectonic models for the northern Cordillera typically either stop at the discontinuity or assume structural and stratigraphic continuity across it. Our field-based multidisciplinary studies conducted along the Porcupine River corridor have generated a robust body of structural, stratigraphic, paleontological, geochemical, isotopic, geochronologic and thermochronologic data that document a complex displacement history on the Porcupine fault system. Fault displacement includes (1) Paleozoic sinistral translation of the Arctic Alaska terrane and other parautochthonous crustal fragments along the northern Laurentian margin, (2) sinistral displacement of Arctic Alaska during the Mesozoic opening of the Canada Basin, and (3) Late Cretaceous–Paleogene dextral displacement of Arctic Alaska. The Porcupine fault system is interpreted as the western continuation of a fault system developed on the Arctic Laurentian margin that accommodated Paleozoic and younger translation of circum-Arctic terranes to the paleo-Pacific realm. Mesozoic displacement is consistent with non-rotation and hybrid-rotation models for opening of the Canada Basin. Late Cretaceous–Paleogene activity on the Porcupine fault system is interpreted to be synchronous with and kinematically linked to dextral strike-slip faults in southern Alaska (e.g. Tintina, Kaltag, Denali) that are responsible for northward translation of Cordilleran terranes and commonly associated with development of the southern Alaska orocline. Incorporating the Porcupine fault system into Late Cretaceous–Paleogene tectonic models linking northern and southern Alaska will improve understanding of Yukon Flats Basin evolution, terrane re-organization in central Alaska (e.g. Ruby terrane) and likely reduce the need for several inferred oroclines and terrane wrecks.

A multi-chronometer geochronological framework for metamorphism and magmatism in the Bird River Greenstone Belt, Manitoba

Chris McFarlane¹, Claude Nambaje¹, Tania Martins²

¹University of New Brunswick, ²Manitoba Geological Survey.

E-mail: crmm@unb.ca

This talk will explore the absolute timing of events that shaped the Neoproterozoic Bird River Greenstone Belt (BRGB), SE Manitoba, using a variety of geochronometers sensitive to different crustal regimes and processes. Understanding the P-T-t-D evolution of the BRGB is of particular interest because of its lithium-cesium-tantalum (LCT) pegmatite endowment. Temporal relationships between the BRGB and adjacent English River Subprovince (ERS) may also help to shed light on the broader geodynamic setting for pegmatite emplacement. Metamorphosed VMS-altered sedimentary rocks within the Bernic Lake and Petersen Creek formation contain assemblages of cordierite ± andalusite + biotite + muscovite ± tourmaline, with large cordierite porphyroblasts recording growth from pre- to syn-kinematic with respect to the main fabric. Monazite occurs in two key textural settings as revealed by micro-XRF and detailed back-scattered electron (BSE) imaging. LA-ICP-MS monazite U–Pb ages constrain static metamorphism to ca. 2680 to 2660 Ma and fabric development ca. 2660 to 2640 Ma. Monazite in layered metatexite migmatites that crop out in the ERS just across the Manitoba-Ontario border crystallized at 2664 ± 4 Ma, similar to 2672 ± 5 Ma monazite ages from amphibolite-facies gneisses in the ERS north of the Cat Lake Euclid Lake Shear Zone (CLELSZ). Well-recognized LCT pegmatite groups from across the BRGB were dated using a combination of apatite and columbite-tantalite (coltan) U–Pb geochronology and yielded a single cluster of dates at 2650 ± 5 Ma. The final stage of belt evolution is recorded by subvertical tectonites within the transpressional CLELSZ which, at its northern and eastern extensions, record low-

dispersion in-situ Rb–Sr biotite isochron ages of ca. 2580 Ma. More work will be needed on the metamorphic infrastructure of the region to better understand the geodynamic setting for the generation and ultimate emplacement of rare-metal pegmatites in the belt.

Facies analysis of the Rocky Ridge sub-basin within the Silurian La Poile Group, southern Newfoundland

Rachel McKeough¹, D.G. Lowe¹, Celeste Cunningham², Donnelly B. Archibald², James Conliffe³

¹Memorial University of Newfoundland, ²St. Francis Xavier University, ³Geological Survey of Newfoundland and Labrador.

E-mail: rhmckeough@mun.ca

The La Poile Group in southern Newfoundland consists of a ca. 7 km thick succession of Silurian volcanic and siliciclastic rocks that were deposited in a tectonically and volcanically active basin. Growing interest in lithium pegmatite mineralization in southern Newfoundland highlights the need to better constrain the tectonostratigraphic framework of the La Poile Group, as improved stratigraphic resolution is essential for regional correlations and developing tectonic models for pegmatite emplacement. The La Poile Group is split into a western volcanic and an eastern succession, with the latter exposed in the Rocky Ridge sub-basin. The paleoenvironmental significance and stratal evolution of these siliciclastic strata remain poorly studied. This study aims to provide a stratigraphic and sedimentological framework for the sub-basin through detailed facies analysis, stratigraphic logging, and interpretation of depositional environments. The Rocky Ridge sub-basin succession is dominated by coarse sandstone with trough cross-stratification, pebble conglomerate, and volcanoclastic strata, along with minor planar-stratified facies. Preliminary facies analysis suggests that sedimentation was mainly within a high-energy braided fluvial system, with occasional minor volcanoclastic input, and intermittent shifts in depositional conditions including possible lacustrine-deltaic development near the base of the section and rare aeolian intervals in the middle of the succession. Episodic volcanoclastic input reworked within fluvial deposits highlights the continued influence of volcanism on sediment supply during basin development. Detrital zircon U–Pb geochronology tracks maximum depositional ages from ca. 430 Ma near the base to ca. 420 Ma near the top of the Rocky Ridge sub-basin succession, and age populations indicate primary derivation from early Paleozoic sources along with Ediacaran and Proterozoic basement sources; the latter become less significant upwards, indicating a change toward more local sources through time. Further facies and provenance analysis will refine interpretations of basin architecture, contributing to our understanding of the broader geological evolution of southern Newfoundland during the Silurian.

The electrochemical flocculation of colloidal gold by semiconductive p-type pyrite: A novel ore forming mechanism for bonanza-type hydrothermal gold deposits

Duncan F. McLeish, Anthony E. Williams-Jones, James R. Clark

McGill University.

E-mail: duncan.mcleish@mail.mcgill.ca

A growing body of evidence suggests that bonanza-grade hydrothermal gold deposits are formed by the physical transport of gold as a colloid (i.e. a suspension of ≤ 10 nm, negatively charged nanoparticles in an electrolyte solution) rather than direct deposition from dissolved, aqueous Au-complexes. While there is general consensus that colloidal suspensions can explain how gold may be mobilized within hydrothermal systems at concentrations many orders of magnitude greater than those predicted by solubility models, there is little consensus over the processes by which colloidal gold suspensions aggregate (i.e. flocculate) to produce ultra-high-grade gold occurrences in hydrothermal veins. Detailed paragenetic observations at the high-grade Brucejack Au–Ag deposit, northwestern British Columbia, Canada, show that ore-stage epithermal carbonate-quartz-electrum veins commonly host bonanza gold where these veins cross-cut earlier mesothermal pyrite veins. This observation, coupled with the discovery of abundant arsenic-rich growth zones in pyrite during LA-ICP-MS and electron microprobe trace element analyses, offers insight into how such flocculation might occur. We propose that positively charged surfaces on arsenian pyrite, which behave as a p-type semiconductor (due to As substitution in the sulphide structure), promote cationic bridging and electrochemically destabilize colloidal gold suspensions circulating in epithermal carbonate-quartz veins. This destabilization triggers flocculation (deposition) of the colloidal gold particles and explains why, at Brucejack, many spectacular gold occurrences appear to have been triggered by the intersection of ore-stage epithermal veins with earlier pyrite veins. This genetic model offers a novel explanation for how bonanza gold may form paragenetically late in hydrothermal ore deposits, i.e. after most sulphide mineral deposition has occurred, without the need for phase separation (boiling) or the presence of steep physicochemical gradients.

Comparison of earthquake swarms in volcanic and tectonic areas of the crust around the western North Atlantic margin

Stephen R. McNutt¹, John E. Ebel²

¹University of South Florida, ²Boston College.

E-mail: smcnutt@usf.edu

Earthquakes manifest ongoing volcanic and tectonic activity in the brittle part of the crust and can cast light on both structures and processes of current societal importance. In order to distinguish magma-related crustal activity from tectonic-related activity we compare earthquake swarms – clustered earthquakes with no mainshock – in volcanic and tectonic areas. At volcanoes, different types of events occur; a common sequence is high-frequency (HF) events, followed by low-frequency (LF) events, volcanic tremors, and explosion quakes. The different events likely represent different physical processes; shear fracture for HF events and fluid processes for LF events and tremors. Swarms last hours to weeks, and rates are well above background, often hundreds of events per day. The magnitude range generally increases with the size of impending eruptions. Depths are 3 to 7 km, although deeper events often occur. The b-values are systematically high (> 1). In stable cratonic areas in the USA northeast, fifteen swarms were studied. The numbers of events per swarm are smaller, from 4 to 177 (mean 50). Maximum magnitudes range from 1.7 to 4.2, with only 5 cases (1/3) where magnitudes exceed 3. Depths are < 4 km, except for Berne, NY, (6 to 24 km). The swarms are shear fractures concentrated in zones ≤ 3.5 km across. The b-values are ≤ 0.8 for a subset of swarms, suggesting locally higher stresses based on laboratory studies. The swarms of cratonic North

America suggest that the entire region has a high horizontal maximum compressive stress consistent with modern plate stresses. Volcanic swarms occur near volcanoes, adjacent to magma bodies at depth. Tectonic swarms are instead spread around relic structures, but evidence suggests they occur adjacent to crust with different mechanical properties. Volcanic swarms represent active processes of magma movements and high strain rates. In contrast, tectonic swarms represent readjustments and low strain rates. Study of both reveals clues about the evolution of the crust in the western North Atlantic region.

Paleomagnetism and a baked contact test of the Kingston dyke swarm remanence age

Natasha E. Melymuka¹, Phil J.A. McCausland¹, Mike A. Hamilton², Sandra L. Kamo², Henry C. Halls²

¹Western University, ²University of Toronto.

E-mail: nmelymuk@uwo.ca

The Kingston olivine diabase dyke swarm in the Frontenac Arch of southeastern Ontario has a preliminary age date of 1157 Ma (U–Pb baddeleyite). Previous reconnaissance paleomagnetic studies over 50 years ago identified groupings of dykes with northwest and north trends: each having a distinct paleomagnetic direction but with primary or secondary identity untested. Two north-trending dykes north of highway 15 gave northwest and shallow up paleomagnetic directions. Six northwest-trending dykes, sampled primarily near Gananoque and at the highway 401/15 interchange gave east and down paleomagnetic directions. In this study, samples were collected from the 17 m wide dyke at the Highway 401/15 interchange, including a baked contact test extending up to 25 m into gneiss host rock. Five additional Kingston dykes were sampled further north, near highway 15. Samples underwent stepwise demagnetization using alternating field (AF) and thermal methods to remove the viscous remanent magnetization (VRM), isolating characteristic remanent magnetizations (ChRMs). Preliminary results show the VRM component is removed by 10–20 mT, giving a mean direction of 345, 48°, consistent with the present Earth field direction at these localities. After VRM is removed, results show two characteristic directional groupings, with an inconclusive baked contact test. One directional grouping is northwest and shallow up, carried in all the new Kingston dykes as well as host rocks. The other directional group, observed in at least three dykes, is east and down in agreement with the original study. Neither ChRM directional grouping has yet been shown to be primary, however in two of the dykes both ChRM directions are seen in the same pilot specimens, with the east, down component being removed by 560°C, and the northwest, up component unblocking between 560–580°C. At least one or possibly both of the ChRM directions may have a secondary origin.

The Late Variscan geological history of northern Germany – results of modern zircon analyses on drill core samples from the Loissin 1/70 borehole

Katja Mende¹, Karsten Obst², Johannes Zieger¹, Philipp Richter¹, Sebastian Krause¹, Rita Krause¹, Mandy Zieger-Hofmann¹, Ilf Linnemann¹

¹Senckenberg Natural History Collections Dresden, ²Geological Survey of Mecklenburg-Western Pomerania.

E-mail: Katja.Mende@senckenberg.de

Research into the geological development of northern Germany during and after the Variscan orogeny is greatly complicated by the thick Tertiary and Quaternary strata in this area. In collaboration with the state office for environment, nature conservation and geology of Mecklenburg–Western Pomerania in Germany, various rock samples from the drill cores of the Loissin 1/70 borehole within the northeast German Trough (Mecklenburg–Western Pomerania, Germany) were therefore examined. Using the LA-ICP-MS method at the GeoPlasmaLab of the Senckenberg Natural History Collections in Dresden, zircon grains from two sandstones, an ignimbrite and a syenogranite were analyzed for their U–Pb ratios. According to the stratigraphic index of the Geological Survey of Mecklenburg–Western Pomerania (2021), these rocks were Late Carboniferous in age. The age distributions of the detrital zircons from the sandstones provide insights into the source regions and the genesis of the parent rocks. At the same time, the magmatic zircons enable the chronological dating of volcanic and plutonic events. The new results contribute significantly to our understanding of regional geological development in the Late Carboniferous of northern Germany and enable a more detailed tectonic reconstruction.

Interplay between metamorphic reaction and fluid-assisted deformation in controlling subduction dynamics: The Newfoundland basal ophiolite

Louise Mérit¹, Philippe Agard^{1,2}, Loïc Labrousse¹, Benoît Dubacq¹, Cécile Prigent³, Carl Guilmette⁴, Jean H. Bédard⁵

¹Sorbonne Université, ²Institut Universitaire de France, ³Université de Paris Cité, ⁴Université Laval, ⁵Natural Resources Canada, Geological Survey of Canada.

E-mail: louisemerit1999@gmail.com

Ophiolite sole systems preserve slices of oceanic crust metamorphosed under amphibolite- to granulite-facies conditions beneath mantle peridotites, providing archives of petrological and micro-structural processes operating at nascent subduction interfaces. We present an investigation of the high-temperature metamorphic sole and the basal peridotites of the Bay of Islands ophiolitic complex, Newfoundland, based on field observations combined with petrological, geochemical, and microstructural analyses. Our results reveal progressive metasomatism of the basal peridotites, recorded by amphibole crystallization and compositional changes from primary clinopyroxene, orthopyroxene, olivine and spinel to secondary clinopyroxene, orthopyroxene, olivine and spinel. These changes extend up to 2 km above the metamorphic sole but are pervasive in the first 200 m only. This metasomatism is associated with progressive deformation, from porphyroclastic tectonite textures to ultramylonitic fabrics, with thermometric estimates indicating syn-kinematic cooling from ~1150°C to ~800°C. The metasomatic agent is aqueous in nature and results from the dehydration of the protolith of the metamorphic sole, of oceanic crustal affinity. At the contact with the sole, primary mantle minerals are entirely replaced by a re-equilibrated metamorphic paragenesis forming hybrid rocks, which locally show evidence of melt infiltration. In the basal peridotites, the resulting mineral transformations and chemical re-equilibrations are accompanied by a transition in deformation mechanisms from dislocation creep to

dissolution-precipitation creep, reflecting weakening of the mantle. Microstructural observations in the metamorphic sole show upward strengthening, with a transition from fluid-assisted deformation in amphibolites at the base of the sole to dislocation-creep dominated deformation in granulites towards the mantle contact. This rheological contrast across the nascent plate interface provides an explanation for the onset of mechanical coupling along the interface near 850°C, shedding light on the control of coupling over the initiation and evolution of subduction systems and over the localization of deformation along plate boundaries.

Percé UNESCO Global Geopark, 500 million years of Earth history to discover

Marie France Methot

Percé UNESCO Global Geopark.

E-mail: geoscientifique@geoparcdeperce.com

The Percé UNESCO Global Geopark is located at the very tip of the Gaspé Peninsula in eastern Québec. Spectacular, earth-toned, sedimentary rocks, ranging in age from the Cambrian to the Carboniferous will amaze visitors of all ages. This Geopark is situated within the Appalachian Mountains, where forest meets the sea. Understanding Percé's geological history, visitors learn more about Earth science and the local people and their culture that they connect with during their visit. At Percé UNESCO Global Geopark, not only will you find hiking trails and beautiful lookouts, but you will also find a unique local culture, coloured by its history and its residents' love for the seaside. A visit to the Geopark's resource centre and a talk with one of the guides will help you learn more about the local geology. The guides also participate in collaborative activities with local schools and colleges to pique youth curiosity and possibly steer them towards careers in science, technology, engineering and mathematics (STEM) fields. The Geopark's efforts towards science communication aim to help young Canadian and international visitors understand that science is a world of discoveries that all can appreciate, whether it is in small amounts or through a career opportunity. The mission of a UNESCO Global Geopark is to connect education, science and culture under the great topic of geology, with the help of the local communities, but also through geotourism. Every year the Percé UNESCO Global Geopark greets thousands of visitors and has been doing so since its introduction to the UNESCO Global Geopark Network family in 2018. This local initiative is growing and reaching more people each year. The Percé UNESCO Global Geopark is proud to exist, leaving a positive mark on a geological scale, whether it is by spreading awareness of Earth's changing climate, participating in the United Nations sustainable development goals or by getting youth interested in science.

Peraluminous melts signal crustal anatexis in the North Atlantic Realm

Romain Meyer

Government of Greenland.

E-mail: RNMR@nanoq.gl

Many petrologists support the hypothesis that felsic magmas originate predominantly from mantle-derived melts that have undergone extensive fractional crystallization and associated progressive chemical differentiation. However, the formation of S-type granites is consistently explained by crustal anatexis. One of the earliest experimental validations of crustal melt generation was provided by Tuttle and Bowen in 1958. Their pioneering results demonstrated that granitic melts can form under conditions of high hydrostatic pressure and low temperatures (< 700°C). These findings suggest that at least S-type granitic magmas may be generated directly through partial melting processes at continental crustal levels. Al_2O_3 is the second most abundant component in silicic melts and provides an alternative base for petrogenetic classification. The alumina-saturation index (ASI) is defined as the molecular ratio $\text{Al}_2\text{O}_3/(\text{K}_2\text{O}+\text{Na}_2\text{O}+\text{CaO})$, [equals 1 in feldspars or feldspathoids]. Alumina-oversaturated melts ($\text{ASI} > 1$) have excess Al and will form Al-rich accessory minerals such as muscovite, cordierite, sillimanite, corundum or andalusite. These rocks are defined in petrology as peraluminous. The geochemical distinctiveness of such felsic melts has been used not only to interpret the petrogenetic source of these magmas but also has been used as characteristic chemistry for assessing tectonic settings. Aluminous schists and metasedimentary gneisses are considered to be the melting source rocks for peraluminous magmas. To generate potassic peraluminous felsic melts solely through crystal fractionation, without involving a continental crustal component, is highly implausible. Peraluminous melts have been identified during the emplacement of the North Atlantic Igneous Province, notably in the volcanic rifted margins of Norway, Greenland, the Rockall Trough, the Faroe-Shetland Basin, Iceland and the oceanic Jan Mayen fracture zone. This raises the question of whether these felsic peraluminous melts might be an ideal fingerprint to report continental crustal anatexis in the North Atlantic Realm.

Resolving polymetamorphism in the Nain Province using in situ Lu–Hf garnet geochronology

Ethan Milkowski¹, Brendan V. Dyck¹, Sally Pehrsson², Kyle P. Larson¹, Alana M. Hinchey³

¹University of British Columbia Okanagan, ²Natural Resources Canada, Geological Survey of Canada, ³Geological Survey of Newfoundland and Labrador.

E-mail: ethan.milkowski@UBC.ca

The Nain Province is a ~500 km long Archean terrane forming the western edge of the North Atlantic Craton as exposed in northeastern Labrador. It is subdivided into two crustal blocks: the Saglék Block to the north and the Hopedale Block to the south. These blocks are juxtaposed along an inferred northeast-southwest-trending suture zone and record a complex polymetamorphic history. Most previous geochronological work in the region has focused on identifying the oldest crust-forming events and establishing the antiquity of the terrane. More recently, detrital zircon U–Pb geochronology of regional supracrustal strata indicates that sedimentary protoliths were deposited throughout the Eoarchean to late Mesoproterozoic. These supracrustal strata, along with the crystalline basement units, were subsequently metamorphosed to upper amphibolite- and granulite-facies

conditions at ca. 2.7 Ga and again at ca. 2.5 Ga, producing orthogneisses and infolded garnet-bearing paragneisses that exhibit variable degrees of ductile deformation. The record of these Archean events was later overprinted by Paleoproterozoic metamorphism and deformation associated with the Torngat Orogen (ca. 1.9–1.8 Ga) and by emplacement of the Nain Plutonic Suite at ca. 1.3 Ga. This study focuses on quantifying the conditions and extent of metamorphism associated with reactivation of the boundary between the Saglék and Hopedale blocks at ca. 2.5 Ga. We are employing campaign-style in-situ Lu–Hf geochronology and trace element mapping of garnet to identify samples that preserve ca. 2.5 Ga garnet growth and/or polymetamorphic (re)crystallization. Samples yielding robust ca. 2.5 Ga ages will be analyzed by electron microprobe methods with the aim of determining the pressure-temperature conditions of the ca. 2.5 Ga metamorphic event.

The Isthmus of Avalon revisited: Insights into the age, petrogenesis and structural evolution of the bimodal Ediacaran Bull Arm Group, Musgravetown Supergroup, Avalon Zone, Newfoundland

Andrea Mills, Zachary Adam

Geological Survey of Newfoundland and Labrador.

E-mail: andreamills@gov.nl.ca

The Isthmus of Avalon is the narrow landmass that connects the Avalon Peninsula to the main part of the island of Newfoundland. The region is underlain mainly by Ediacaran volcanic and sedimentary rocks of the Musgravetown Supergroup (MSG), with an age constraint of ca. 605 Ma on the Doe Hills rhyolite, lower Bull Arm Group (basal MSG). The Bull Arm Group is overlain to the south and east by green siltstone and sandstone of the Big Head Formation, which contains a distinctive diamictite unit that may be correlative with glacially derived deposits of the ca. 580 Ma Gaskiers glaciation. Rock types of the ca. 605–580 Ma Bull Arm Group include mafic and felsic flows, voluminous pyroclastic and lesser clastic rocks. Bimodal conglomerate and convoluted sandstone to mudstone containing subrounded volcanic boulders are common and reflect a (trans)tensional depositional setting; geochemically, the volcanic rocks are transitional between calc-alkaline and tholeiitic, indicating an extensional arc tectonic setting. Lineament analysis, complemented by field observations superimposed on high-resolution drone imagery, reveals a complex deformation history. Southeast-directed thrust imbrication characterizes the earliest deformation, thought to result from Ediacaran (Avalonian) D1 deformation. Sinistral strike-slip deformation across a N-trending principal shear zone is evident from lineament analysis and may reflect mid-Paleozoic Acadian (D2) accretion of Avalonia to composite Laurentia. A penetrative NNE-trending cleavage axial planar to NNE- and SSW-plunging folds reflects subsequent (D3) E-W compression, possibly related to late Paleozoic amalgamation of Pangea. Conjugate subvertical faults crosscut all other structural elements and reflect a stress regime compatible with a NW-SE oriented tensional setting (D4), possibly linked to Mesozoic Pangea breakup. The new data indicate that the Bull Arm Group originated as an Ediacaran extensional volcanic field, possibly during Rodinia breakup, and records complex polydeformation that can be linked to global events through Neoproterozoic to Mesozoic times.

A tale of three basins: Summary of the geological evolution of the Bonavista Peninsula, Avalon Zone, Newfoundland

Andrea Mills¹, Nicolás Gómez², Chidera Ikechukwu², David Lowe²

¹Geological Survey of Newfoundland and Labrador, ²Memorial University of Newfoundland.

E-mail: andreamills@gov.nl.ca

The Bonavista Peninsula, northeastern Newfoundland, is underlain by strata of three distinct, largely fault-bounded Ediacaran depositional basins, namely the West Bonavista, Bonavista and St. John's basins. West of the Indian Arm Fault, the West Bonavista basin succession comprises deep marine, turbiditic strata (Connecting Point Group, CPG) deposited in an arc-adjacent depocenter during ca. 620–600 Ma arc extension. Initially narrow and steep-sided, the basin widened following catastrophic seismicity linked to magmatic intrusion and coeval deposition of a regional olistostrome at ca. 610 Ma. The basin continued to mature, becoming more gently sloped, as deposition resumed with an upward-coarsening and upward-thickening trend. An angular unconformity indicates basin uplift between ca. 605 and 600 Ma, marking an abrupt flysch-to-molasse transition coincident with basin shortening. Calc-alkaline basalt flows and coarse volcanogenic rocks at the base of the Musgravetown Supergroup – the dominant unit of the Bonavista basin – overlie the CPG to the east. Voluminous bimodal (tholeiitic mafic and alkaline felsic) magmatism signals extension at ca. 592 Ma. The volcanic edifices likely formed island chains, flanked by shallow marine to terrestrial deposits derived from the eroding newly formed topography. Glacial conditions ensued and largely controlled deposition during the ca. 589–580 Ma Gaskiers glaciation. Local alkaline basaltic centres within the Bonavista basin indicate further episodic pre- and post-glacial extensional pulses. The easternmost St. John's basin, separated from the Bonavista basin by the Spillars Cove Fault, comprises strata that correlate with units on the eastern Avalon Peninsula deposited between ca. 580–556 Ma. These strata record a depositional history that is distinct in age and depositional setting from both West Bonavista and Bonavista basin strata, respectively. In summary, the Ediacaran evolution of the area involves early Ediacaran extension followed by cycles of episodic extension and shortening as the island chains and their small, marginal basins shifted.

New insights into the geology of the Burin Peninsula, Newfoundland, and implications for correlation with Avalonian terrane assemblages in the Canadian Maritimes

Andrea Mills¹, Greg Sparkes¹, Michael Hamilton²

¹Geological Survey of Newfoundland and Labrador, ²University of Toronto.

E-mail: andreamills@gov.nl.ca

The bedrock underlying the Burin Peninsula, southeastern Newfoundland, contrasts with that of the Avalon and Bonavista peninsulas, particularly in the wide range of magmatic ages recorded in the former. Whereas the Avalon and Bonavista peninsulas comprise mainly Ediacaran strata and an

unconformably overlying Cambro–Ordovician overstep sequence, rocks of the Burin Peninsula range from Tonian to Carboniferous in age. The oldest units include basalts (locally pillowed), mafic dykes and sills, and minor mafic tuffs as well as clastic and carbonate rocks of the ca. 760 Ma Burin Group. This group is interpreted as a remnant oceanic arc based on chemical and isotopic compositions; Tonian back-arc assemblages in the Cobequid Highlands of mainland Nova Scotia (NS) may represent tectonomagmatic equivalents. The most areally extensive unit on the Burin Peninsula, the ca. 589–572 Ma Marystown Group, comprises bimodal volcanic and pyroclastic rocks that exhibit calc-alkaline to transitional geochemical signatures; chemically calc-alkaline pyroclastic rocks of the Fourchu Group in the Mira terrane of Cape Breton Island (CBI, NS) may be correlative. Preliminary U–Pb (zircon) ages from a flow-banded rhyolite from southwestern Burin and a welded tuff from 3 km northeast of Garnish, both previously included in the Marystown Group, give ages of ca. 680 Ma. These ages preclude inclusion within the Marystown Group and instead indicate the presence of previously unrecognized Cryogenian felsic volcanic magmatism on the Burin Peninsula. Previous and new U–Pb (zircon) ages indicate a hiatus in volcanic activity between ca. 680 and ca. 589 Ma, with the ca. 635 Ma Peter Brook granite representing the only known intervening magmatism. The Neoproterozoic tectonomagmatic evolution of the Burin Group and southwestern Burin Peninsula more closely resembles that of the Cobequid Highlands and Mira terrane (CBI), respectively, than that of northeastern and eastern segments of the Avalon Zone in Newfoundland.

Biosignatures from microbes and trees reveal lithium dynamics in natural watersheds

Aleksandra Młoszewski¹, Alexandre Voinot¹, Steven Rossiter², Lyndsay Moore¹, Sabrina Chan¹, Stephen Day¹, Margaret Lintell¹

¹Natural Resources Canada, Geological Survey of Canada, ²New Brunswick Department of Natural Resources.

E-mail: aleksandra.mloszewski@nrcan-nrcan.gc.ca

Rising use of lithium (Li) in energy storage has increased the need to understand Li sources, mobility, and ecological exposure in natural watersheds. It has also motivated the development of new, low-impact approaches for detecting buried Li enrichment. Along the Magaguadavic River (southwestern New Brunswick, Canada), we evaluated whether biological archives – microbial communities and vegetation – capture watershed-scale signals tied to positive Li anomalies. We further assessed whether these signals complement conventional geochemistry. We profiled microbial communities from environmental DNA (eDNA) in river water and stream sediments using 16S rRNA metabarcoding and analyzed white spruce (*Picea glauca*) bark collected along the same corridor, integrating all biological data with multi-media geochemistry from water, sediments, and regional glacial till. Microbial community composition varied along the watercourse, with the strongest shifts aligning with increased Li concentrations in surrounding till rather than dissolved or bulk-sediment Li. This is consistent with till weathering as a persistent Li source and with short term partitioning between dissolved and particulate phases. Sediment microbial communities exhibited larger compositional changes than water, reflecting greater physicochemical heterogeneity and sediment-water exchange that modulate Li bioavailability. Complementing these microbial patterns, white spruce bark delineated upstream low-Li and downstream high-Li geochemical groupings coincident with Li-enriched granitic influences. Sequential leaching indicates that Li (along with Mo, As and Se) likely lies in complex molecules (e.g. tannins, lignin) within the bark, whereas Cu, Zn, and Pb are more readily desorbed, illustrating that bark integrates longer term bioavailable Li. Conversely, Li may be muted in water and sediment by secondary processes such as clay formation and sorption. Together, eDNA-based microbial fingerprints and tree-bark biogeochemistry reveal complementary expressions of Li source-to-sink dynamics in the Magaguadavic River watershed, strengthening our ability to evaluate environmental Li behaviour and to identify concealed Li enrichment from surface materials.

From plant signals to subsurface mineralization: High-resolution biogeochemical and isotopic approaches for deep mineral exploration

Sara Momenipour¹, Matthew Leybourne¹, Maarit Middleton², Solveig Pospiech³, Andreas Knobloch⁴, Vojtěch Wertich⁵, Tuomo Törmänen², Sari Romppanen²

¹Queen's University, ²Geological Survey of Finland, ³Helmholtz-Zentrum Dresden-Rossendorf, ⁴Beak Consultants GmbH, ⁵Czech Geological Survey.

E-mail: sara.momenipour@queensu.ca

Detecting deeply buried mineral deposits using surface-based methods is challenging because geochemical signals may weaken with depth and be further masked by complex overlying cover materials. The DeepBEAT (Deep exploration BoostEd by advanced exploration technologies) project is designed to overcome these limitations by advancing innovative, low-impact geochemical exploration methods integrated with geophysics, mineral systems science, and social engagement. The project aims to develop a universal and sustainable exploration workflow capable of identifying distal geochemical footprints of deep-seated ore systems while aligning with responsible resource management and public acceptance. Queen's University (Canada) contributes to DeepBEAT by leading the development of advanced biogeochemical and isotopic analytical methods designed to enhance the sensitivity, precision, and interpretive capacity of surface geochemical datasets. This research focuses on ultra-trace and isotopic analysis of vegetation, soil/till, existing drill core and biological materials using Triple Quadrupole ICP-MS (TQ-ICP-MS). This method enables highly sensitive ultra-trace elemental and isotopic analysis by efficiently removing spectral interferences in complex samples. Analytical protocols will be developed at Queen's Facility for Isotope Research to target key elements and isotopic systems (e.g. Sr, Pb), to reduce matrix interferences and enhance detection of subtle anomalies linked to concealed mineralization. These methods are tested across three different mineral systems: a volcanogenic massive sulfide (VMS) deposit at Saramäki, Finland; fertile Li-Sn-W granite in the Erzgebirge-Krušné hory region, Germany/Czech Republic; and an alkaline metasomatic REE-Zr-Mo system at Hůrky, Czech Republic. By developing advanced methods for targeted isotope systems and generating high-resolution geochemical and isotopic datasets we integrate these data into AI-assisted 3D mineral prospectivity models to bridge laboratory-scale analyses with field-based exploration workflows. This contribution supports the DeepBEAT objective to push the limits of surface geochemistry, reduce exploration risk and environmental impact, and support sustainable discovery of critical raw materials in covered terrains.

Volcanic stratigraphy and pyrite chemistry of the Horne and Quémont volcanogenic massive sulphide system, Abitibi greenstone belt, Québec, Canada

Lyndsay Moore¹, Claude Pilote², Janina Czas¹, Duane Petts¹, Alex Krushnisky¹, Patrick Mercier-Langevin³, John Stix⁴

¹Natural Resources Canada, Geological Survey of Canada, ²Barrick Mining Corp., ³Agnico Eagle Mines Ltd., ⁴McGill University.

E-mail: lyndsay.moore@nrcan-mrcan.gc.ca

Pyrite is an abundant sulphide phase in various mineralized systems and in the Earth's crust. In volcanogenic massive sulphide (VMS) deposits, pyrite is typically found in massive, semi-massive, stockwork, and disseminated zones hosted in various volcanic facies and structures. Over the past several decades, studies of trace element concentrations in pyrite have been used to investigate its use as an effective indicator mineral for VMS deposits and as a marker of system fertility. However, this process is complicated by deformation, recrystallization, alteration, weathering, and conducting representative sampling at the deposit or camp scale. Ongoing study of the Horne and Quémont volcanogenic massive sulphide system is examining the relationship between the two deposits, host volcanic lithofacies, and trace element pyrite chemistry to establish: 1) whether there is a petrogenetic relationship between these two Au-rich deposits, their host volcanic facies, and neighbouring felsic volcanic centres; and 2) if there is a key geochemical or textural signature in pyrite phases from different levels or areas within the two deposits that could help identify similar systems. The latter point is particularly significant in relation to exploration for similar deposits as the volume of mineralization at the Horne and Quémont system is an order of magnitude greater than deposits found within the neighbouring Noranda VMS camp. Results to date show there is a compositional transition within the complex from intermediate to felsic effusive submarine lavas and that volcanic rocks are later cross-cut by a series of mafic to intermediate composition intrusive rocks. Trace element concentrations in pyrite are distinct between the deposits but also show influence from a larger, mafic-dominated submarine volcanic complex.

Cambrian correlation: The use of quantitative biostratigraphy as a test of trilobite biostratigraphic frameworks

Chad A. Morgan^{1,2}, Charles M. Henderson²

¹Yukon University, ²University of Calgary.

E-mail: cmorgan@yukonu.ca

A quantitative biostratigraphic framework using unitary association analysis tests current regional biozones from the southwestern USA and western Canada to assist development of a unified faunal succession of Miaolingian trilobite occurrences (582 taxa, 1035 samples, 121 sections, and 48 formations). Seventy-three unitary association zones (UAZ) were delineated and inform redefinition of standard trilobite genus assemblage biozones into new regional superzones comprising high-resolution species-defined interval biozones. Nineteen UAZ encompass the top of the upper *Bonnia-Olenellus* Superzone, 11 in the *Plagiura-Poliella* Superzone, 18 in the *Albertella* Superzone, 10 within the *Glossopleura* Superzone, 7 within the *Ehmaniella* Superzone, and 8 in the *Bolaspidea* and *Cedaria* superzones, from the upper *Bonnia-Olenellus* to *Cedaria* interval. Thirty-three of these UAZs coincide with previously defined biozones along with six new interval biozones in the Wulian succession (*Fielaspis superba*, *Paralbertella bosworthi*, *Glossopleura boccar*, *Proehmaniella basilica*, *Spencella montanensis*, and *Bathyriscus adaeus* biozones) defined and characterized from this analysis. This is the first recognition of temporal equivalence of regional mid Cambrian biozones using unitary association quantitative biostratigraphic analytical methods. The derived faunal succession tests biostratigraphic correlation potential and points to intervals of the mid-Cambrian that may yet yield additional high-resolution biozones in the future.

Trilobite biostratigraphy of the subsurface Mount Cap Formation (Cambrian Series 2 - Miaolingian), Sahtu Basin, Northwest Territories, Canada

Chad A. Morgan^{1,2}, Robert B. MacNaughton³, Matthew J. Sommers⁴

¹Yukon University, ²University of Calgary, ³Natural Resources Canada, Geological Survey of Canada, ⁴Calgary, Alberta.

E-mail: cmorgan@yukonu.ca

Trilobite collections from five industry cores inform high-resolution biostratigraphy of the Cambrian Series 2 - Miaolingian (lower-middle Cambrian) Mount Cap Formation in the Sahtu Basin, Northwest Territories. The formation is shale dominated with lesser silty carbonate and sandstone facies deposited within an intracratonic basin during the Cambrian. Biostratigraphic age constraints for this formation previously relied almost exclusively on trilobite collections from outcrops in the eastern Mackenzie Mountains. Subsurface core collections augment previous data, with the addition of 31 trilobite species, including olenelloid, corynexochid, and ptychopariid taxa. One new species, *Bathyriscus* sp. nov. is also reported. Trilobite collections range from the middle *Bonnia-Olenellus* Biozone to the *Glossopleura* Biozone. The lower member of the Mount Cap Formation ranges through the middle *Bonnia - Olenellus* Biozone to *Albertella?* Biozone. *Plagiura-Poliella* Biozone trilobites of the *Eokochaspis nodosa* and *Alokistocare arrosensis* interval biozones are documented in the lower Mount Cap Formation, constraining timing of a regionally extensive maximum flooding surface. The upper member of the Mount Cap Formation was deposited during earliest *Glossopleura walcotti* to *Glossopleura boccar* interval biozones. Another regional maximum flooding surface is contained within the *Glossopleura boccar* Biozone. These biostratigraphic results constrain the timing of subsidence events within the Sahtu Basin which were documented in a previous reflection-seismic study. Initial subsidence recorded by the underlying, sandstone-dominated Mount Clark Formation occurred before the middle *Bonnia - Olenellus* Biozone but after onset of the Cambrian. An episode of increased subsidence, corresponding to deposition of the Mount Cap Formation, began during the middle *Bonnia - Olenellus* Biozone and continued to the latter part of the *Glossopleura* Biozone, possibly ending during the earliest *Ehmaniella* Biozone. The Mount Cap Formation beneath the Northern Interior Plains correlates with formations within the Canadian Rocky Mountains and southwestern Great Basin, representing a newly refined tie point for Cambrian continental correlation.

Polymetamorphism of the Hyland River area, northern Canadian Cordillera and constraints on the timescales of low-pressure metamorphism

¹David P. Moynihan and ²James L. Crowley

¹Yukon Geological Survey ²Boise State University.

E-mail: jimcrowley@boise.edu

The Hyland River schist-gneiss belt is an elongate, partly fault-bounded regional metamorphic high in the Laurentian part of the northern Canadian Cordillera. It includes a migmatitic core flanked by schist and phyllite and hosts numerous mid-Cretaceous intrusions. Regional metamorphic grade increases progressively from the chlorite zone on the flanks to the cordierite+K-feldspar zone over a structural thickness of approximately 4 km. An early stage of regional metamorphism (M₂) produced garnet-staurolite±sillimanite schists. This was followed by low-pressure, high-temperature (LP-HT) regional metamorphism (M₃), which resulted in partial melting of deep structural levels. Regional (M₂₋₃) isograds were folded prior to the emplacement of late- to post-tectonic batholiths. These upright folds produced km-scale structural relief, with the result that contact aureoles were developed across steep regional metamorphic gradients. We document the timescales involved in the transition from regional LP-HT to contact metamorphism by integrating mineralogical and microstructural observations with high resolution U–Pb TIMS geochronological data from variably deformed intrusions. The difference in the interpreted age of peak regional LP-HT metamorphism and the emplacement of batholiths that produced contact aureoles is approximately 0.7 Myr.

Shedding new light on the Ordovician Cat Head Lagerstätte (Manitoba) through Indigenous community-led field work

Joseph Moysiuk^{1,2,3}, Tabitha Harper^{1,4}, Ricardo L. Silva⁵, Colin Sproat³, David Wright¹, Urgan J.T. Snider^{1,5}

¹Manitoba Museum, ²Royal Ontario Museum, ³University of Saskatchewan, ⁴Red River College Polytechnic, ⁵University of Manitoba.

E-mail: jmoysiuk@manitobamuseum.ca

The Upper Ordovician Cat Head Lagerstätte is located along the western shore of Lake Winnipeg, Manitoba. It is unusual for preserving soft-bodied organisms like macroalgae and sponges alongside a typical diverse shelly marine fauna. Although first described in the literature nearly 200 years ago, the paleoenvironment at this site remains poorly constrained. To advance our knowledge, we undertook fieldwork in collaboration with Kinonjeoshtegon First Nation (KFN), a community located ~25 km southwest of the site. Initial relationship-building included sessions with KFN Elders and leadership, leaders of KFN Jordan's Principle, and the broader community to explore opportunities for reciprocal learning and engagement. Following strong community interest and support, we were able to visit Cat Head in July 2025. In addition to collecting fossil and rock specimens and recording stratigraphic data, our team also led a day trip for members of KFN Jordan's Principle Youth Camp to the field site, where we had the opportunity to view fossils in situ and discuss intersections of science and traditional knowledge. During this first field trip, our team discovered a large fossiliferous surface near the top of the section that was preserved at lake level after a recent rockfall containing numerous articulated crinoids and other benthic invertebrates. With support from KFN, Fisher River Cree Nation, and McBeth Fisheries, we returned in October 2025 to collect part of this surface. The block, which weighs approximately 320 kg, was jacketed and lifted from the shore by helicopter to KFN, then transported to the Manitoba Museum, where it will be studied and eventually displayed. Fieldwork resulted in the collection of 99 new fossil specimens, housed at the Manitoba Museum, as well as more than 50 rock samples used to produce thin sections and for microfossil analysis. We share these initial results as a case study for developing Indigenous community-led field work projects.

Neoproterozoic evolution of Avalonia and related terranes: A geodynamic approach

J. Brendan Murphy¹, R. Damian Nance^{2,3}, Jiri Zak⁴

¹St. Francis Xavier University, ²Ohio University, ³Yale University, ⁴Charles University.

E-mail: bmurphy@stfx.ca

The Avalon composite terrane, now widely dispersed in the Appalachian-Caledonian-Variscan orogen, is defined by a lithostratigraphically correlative Ediacaran–Early Paleozoic sequence that overlies basements of different compositions. West Avalonia basement is juvenile with Sm–Nd isotopic signatures consistent with an origin in the peri-Rodinian Mirovoi Ocean. The Sm–Nd data from East Avalonia basement have both juvenile and cratonic basement affinities, similar in composition to West Avalonia and Cadomia/West Africa, respectively, implying that it contains a cryptic suture beneath the Avalon overstep sequence. Recent interpretations of paleomagnetic and isotopic data imply that West Avalonia had early affinities with Baltica, whereas a wealth of data indicate that it departed from the Amazonia–West African margin of Gondwana in the early Ordovician with the opening of the Rheic Ocean. These bookend affinities require that West Avalonia migrated from Baltica to the Amazonian–West African margin. A limiting factor to the reconstructions is that West Avalonia must have migrated into the peri-Gondwanan realm before the East Iapetus–Torquatus rift system severed the contiguity between Amazonia and Baltica. Several published models emphasize transfer along the Baltica–Amazonian margin by strike-slip tectonics. Here, we explore a rival model, in which proto-Avalonia forms from crust severed from Baltica by subduction zone roll-back into the Mirovoi Ocean, in a manner analogous to the Mesozoic–Cenozoic evolution of juvenile arcs in the SW Pacific, which were constructed upon slivers of detached Australian basement. Roll-back stabilized when the subduction zone encountered the subduction girdle (geoid low) that encircled Rodinia following breakup. In this model, the 700–650 Ma opening of the Puncoviscana Ocean between Laurentia and Amazonia drove western Gondwana southward, with proto-Cadomia along its leading edge, until it collided with juvenile proto-Avalonian arcs along the subduction girdle. Following juvenile arc accretion, subduction stabilized beneath the Amazonian–West African margin of Gondwana, recycling juvenile crust (West Avalonia) and ancient cratonic basement (Cadomia).

Lu–Hf garnet geochronometry at extreme conditions: Insights from the cratonic mantle

Kira A. Musiyachenko¹, Matthijs A. Smit^{1,2}

¹University of British Columbia, ²Swedish Museum of Natural History.

E-mail: kmusiyachenko@eoas.ubc.ca

Garnet Lu–Hf geochronology has emerged as a powerful tool for dating metamorphic processes. Empirical observations indicate that Lu–Hf age records may be preserved in garnet that was metamorphosed at high-temperature conditions within the crust. The application of the Lu–Hf system in garnet at extreme conditions in the crust and mantle nevertheless still relies on assumptions about isotopic closure, element mobility, and open-system behaviour during melt-rock interaction, which are not yet fully tested. These uncertainties become particularly important for rocks that were exposed to ultrahigh temperatures and/or resided in extreme metamorphic conditions for a very long time. Testing these assumptions would greatly improve our ability to reliably constrain the age record of ultrahigh temperatures in the lower crust and the mantle. To do so, we focus on cratonic mantle garnet, which provides an extreme end-member for evaluating Lu–Hf systematics; garnet in the mantle forms and re-equilibrates under pressure-temperature conditions that exceed those typical of crustal metamorphism and may reside at such conditions for billions of years. Recent analytical advances now allow high-precision Lu–Hf analyses on very small garnet aliquots, enabling the construction of internal isochrons even for highly depleted rock types. Here, we analyzed garnet in a broad textural and compositional variety of mantle xenoliths to investigate the behaviour of the Lu–Hf system and its response to protracted residence at mantle temperatures, mineral reactions, melt percolation, and deformation. Special focus is placed on the role of texture, matrix composition, and open-system processes in governing age preservation and resetting. The results underscore that Lu–Hf ages in garnet record episodes of garnet growth or isotope re-equilibration during deformation and melt-rock interaction, rather than an arbitrary stage of cooling. These insights open new research possibilities in dating mantle processes and provide a framework for more robust application of Lu–Hf garnet geochronology to high-temperature systems in general.

Alkaline-silicate and carbonatite complexes in the Canadian Cordillera: Investigating temporal and spatial gaps and metallogenic potential in the Yukon

Tiera Naber

Yukon Geological Survey.

E-mail: tiera.naber@yukon.ca

Alkaline-silicate and carbonatite complexes account for over half the global production of rare earth elements (e.g. La and Ce) and high-field-strength elements (HFSE; e.g. Nb and Ta) and are deemed critical for low carbon technologies and economic security for Canada. These elements are mobilized by hot late-stage metasomatic fluids and can alter and mineralize the source intrusion and surrounding country rock, producing ‘fenite’ (a term used mostly in the context of carbonatites). Alkaline-silicate and associated carbonatite magmatism is present across the western North American Cordillera. Twenty alkaline-silicate complexes occur within the western Laurentian margin strata that are exposed in the Canadian Cordillera. These complexes are attributed to rift-related processes associated with the breakup of the supercontinent Rodinia. Notably, there are multiple spatial and temporal gaps between these complexes in the Canadian Cordillera, and the tectonic controls of these gaps are poorly understood. In southeastern Yukon (NTS 095C and NTS 095D) there are three alkaline-silicate complexes that are temporally and mineralogically distinct. Two of these have documented REE and HFSE mineralization and, in one area, are spatially overlapping. The ca. 650 Ma Pool Creek nepheline syenite is cut by the ca. 52.0 Ma Eocene biotite syenite, a member of the Ting suite. Detailed work in a small (2 x 2 km) area reveals that the Pool Creek syenite is a multi-phase complex with a fenite aureole that is enriched in F, Na, K, Fe, Ti, Y, La, Ce, Nb, Ta, Zr, Th, and U with respect to the country rock. Mineralization is controlled by the composition of the host rocks. The U–Pb in situ zircon geochronology confirms that the fenitic alteration is Neoproterozoic, occurring between 680 and 590 Ma. This study highlights the need for detailed mapping and sampling across the alkaline-silicate complexes in southern Yukon to further the understanding of the tectonic history and metallogeny of southeastern Yukon.

Nature and timing of Siluro–Devonian magmatism and copper mineralization in the Gaspé Peninsula (Québec Appalachians)

Rémi Naulot¹, Bertrand Rottier¹, Hélène Legros², Larson Kyle³

¹Université Laval, ²Ministère des Ressources naturelles et des Forêts, ³University of British Columbia Okanagan.

E-mail: remi.naulot.1@ulaval.ca

A study integrating litho-geochemistry, U–Pb dating of zircon and garnet, and zircon trace-element geochemistry has been carried out to constrain magmatic evolution and ore deposit formation in the Gaspé Peninsula in the eastern Québec Appalachians. It reveals two distinct periods of magmatic activity. The first (Type I), formed between 415 and 390 Ma, consists of calc-alkaline to alkaline intrusive and volcanic rocks with a slightly fractionated REE pattern ($La/Yb < 15$) and an enrichment in incompatible elements (Zr, Y, Nb, Ta). The second (Type II), formed between 395 and 377 Ma, comprises calc-alkaline intrusions with a strongly fractionated REE pattern ($La/Yb > 20$) and an adakitic-like signature. Trace element data from zircon indicate that rocks from both types are oxidized ($\Delta NNO > 1$). However, Type II rocks are more hydrated and display lower zircon crystallization temperatures than Type I, generally $< 750^\circ\text{C}$. Skarn garnets from various mineralized showings of the Gaspé Peninsula were dated using U–Pb methods. Garnets associated with Type I intrusions give ages of 404.9 ± 4.8 and 401.2 ± 2.1 Ma for deep skarns at Lemieux Dome, 396.6 ± 1.6 Ma for Sullipek P-82 and 390.6 ± 2.6 Ma for Mine Madeleine. Skarns from Gaspé Copper are dated at ca. 380 Ma. These dates reveal that both periods were fertile for magmatic-hydrothermal mineralization. However, Type I mineralization, such as the epithermal deposits of the Lemieux Dome and the Sullipek P-82 skarn, are smaller than the deposits associated with Type II intrusions like the Gaspé Copper porphyry-skarn Cu–Mo and the Sullipek-

East polymetallic skarn. The differences in metal endowment of those mineralizations are likely linked to the lower water content and higher crystallization temperature of Type I intrusions. These two magmatic and metallogenic periods also reflect the evolution of the Appalachians, as Type I intrusions were emplaced during Salinic back-arc extension, whereas Type II intrusions are associated with Acadian collision.

Building momentum for IGC2028 Canada: National and International initiatives showcasing geoscience research, education, and community collaboration

Lilian Navarro¹, Katherine Boggs², Glenn Dolphin³, Amrine Dubois Gafar², David Eaton³, Laurance Donnelly⁴, Daniel Lebel⁵, Grant Wach⁶

¹Cape Breton University, ²Mount Royal University, ³University of Calgary, ⁴IUGS Initiative on Forensic Geology, ⁵IGC 2028 Foundation Board, ⁶Dalhousie University.

E-mail: lilian_navarro@cbu.ca

The International Geological Congress (IGC) is coming to Calgary, Canada, (August 2028) for the first time since 1972 (Montreal). IGC 2028 will advance geoscience research and education, while fostering international collaboration, which is particularly powerful for early career researchers. Anchored by the congress tagline “Geosciences for Humanity”, IGC 2028 will integrate interdisciplinary geosciences and will be leveraged to promote the geosciences. Two years of national geoscience outreach activities, in collaboration with the Geological Society of America (2027 in Montreal, 2028 in Portland), and Explore 2027 (Toronto), will increase the visibility and public awareness of IGC 2028. Outreach initiatives include the GeoPromotion competition for K-12 students, geoscience sport camps led by local universities, and public-facing ‘forensic geology’ workshops that employ simulated crime scenes to demonstrate applied geoscience methods in law enforcement cases, including geological trace evidence and searches for graves and other burials. Geoscience signage will be increased in Canadian municipalities, provincial-territorial-national parks, and the 14 Canadian IUGS Geological Heritage sites. Session submission will start with the distribution of the first circular (March 2026 to March 2027). Over 200 international geoscientists have collaborated to design the theme groups and theme structure for session submissions. Keynote daily themes include “Critical Minerals and Sustainable Energy Transition”, “Water Resources”, “Space and Planetary Geosciences”, “Future of Geosciences”, and “Sustainability, Climate Change and Natural Hazards”. Panel discussions and plenary talks will be recorded and distributed to junior and high school classes in Canada and internationally. The IGC International Advisory Council, with members from over 70 countries, provides strategic guidance for ensuring international representation across the scientific program. Additionally, an Indigenous advisory board is being developed to guide all Indigenous aspects for IGC 2028. IGC2028 will be a transformative event that unites geoscientists, policymakers, educators, and the public to advance the role of geoscience in addressing societal challenges.

Facies analysis and isotope stratigraphy of the upper Cambrian Lynx Group, Western Canada Sedimentary Basin

Muhammad Nawaz¹, Murray K. Gingras¹, Hilary Corlett²

¹University of Alberta, ²Memorial University of Newfoundland.

E-mail: mnawaz@ualberta.ca

The latter half of the Cambrian experienced major environmental changes, including global carbon-cycle perturbations, redox oceanic conditions, and trilobite turnover. The Steptoean Positive Carbon Isotope Excursion (SPICE) records these changes globally, and its expression in regional depositional systems is key to reconstructing environmental change along the western margin of Laurentia. The upper Cambrian Lynx Group of the Western Canada Sedimentary Basin consists of cyclic carbonate and siliciclastic strata deposited along the western Laurentian margin. Early research on the Lynx Group was focused on outcrop exposures but the subsurface depositional framework and stable isotope geochemistry remain poorly constrained. This study presents the first multiproxy, core-based analysis of the Lynx Group, incorporating sedimentological, ichnological, petrographic, and stable isotope ($\delta^{13}\text{C}_{\text{PDB}}$, $\delta^{18}\text{O}_{\text{PDB}}$) data from six cores across five wells in Alberta. Seven lithofacies are characterized based on sedimentological and petrographic observations from drill core logging, including organic-rich shale, silty dolostone, flat-pebble conglomerate, dolomitic mudstone, stromatolitic bindstone and microbial boundstones. Facies associations indicate deposition in a marginal-marine setting, transitioning upward from peritidal-lagoonal environments to a storm-dominated carbonate ramp marked by erosional surfaces and oriented intraclasts. Ichnological data show impoverished assemblages (commonly dominated by *Teichichnus*, *Skolithos*, and *Cylindrichnus*) or the absence of bioturbation in peritidal and lagoonal facies, reflecting stressed, variably oxygenated conditions, whereas offshore-transition to ramp facies display mixed *Cruziana-Skolithos* ichnofacies indicative of more stable marine environments. Stable isotope values range from -1.8‰ to +3.3‰ for $\delta^{13}\text{C}_{\text{PDB}}$, with moderate $\delta^{13}\text{C} - \delta^{18}\text{O}$ covariance suggesting variable diagenetic influence. A positive $\delta^{13}\text{C}$ excursion within stromatolitic bindstone facies is correlated with the global SPICE, representing its first recognition in the subsurface Lynx Group. By integrating facies analysis with chemostratigraphy, this study refines the depositional and stratigraphic framework of the Lynx Group, improves regional correlations within the WCSB, and provides new insight into late Cambrian environmental change along the western Laurentian margin.

Gamma-ray spectrometry and its application to pegmatite prospecting: Case study of the Yellowknife and Aylmer Lake pegmatite fields, Slave Craton, Northwest Territories, Canada

Gilles Ngoran¹, Gideon Lambiv Dzemua², David Lentz¹

¹University of New Brunswick Fredericton, ²Northwest Territories Geological Survey.

E-mail: gilles.ngoran@unb.ca

Handheld gamma-ray spectrometry (GRS) offers a cheap, reliable, and rapid tool for assessing pegmatite fertility. By measuring the concentrations of potassium, uranium, and thorium, we can identify the most evolved pegmatites, which are the most likely to host lithium and rare-metal mineralization. Late Archean lithium-cesium-tantalum (LCT) pegmatites in the Yellowknife and Aylmer Lake pegmatite fields are hosted by metasedimentary rocks and in places by granitoid rocks. The pegmatites occur as dykes, commonly obscured by vegetation and drift, which hinders regional assessment. These pegmatites are characterized by feldspars, quartz, muscovite, and accessory apatite, garnet, tourmaline, tantalite, biotite, and cassiterite, and contain trace to anomalous concentrations of U and Th. The objective of this study was to evaluate the usefulness of handheld GRS in pegmatite prospecting in the Yellowknife and Aylmer Lake pegmatite fields, located in the Archean Slave Craton, Northwest Territories, Canada, based on estimated Th–U values (eTh, eU) from field measurements. Our findings revealed that fractionation of granitic magmas is associated with a larger increase in eU compared to eTh. Concentrations of eTh and eU can be used to effectively discriminate pegmatites from host metasedimentary rocks and migmatite. This was not the case in pegmatites that were hosted in granites, as both pegmatites and granites demonstrate similar signatures. Outcrop radiometric measurements of 390 spots were completed for eK, eU, and eTh on aplite, granite, migmatite, and pegmatite using a handheld Super-Spec RS-125 gamma-ray spectrometer. Most of the pegmatites have low to very low eTh/eU, suggesting moderate to strong fractionation. Plots of eTh/eU versus eU show two distinct fractionation trends, which could have profound implications for the genesis and evolution of the pegmatites. Spodumene-mineralized pegmatites returned lower potassium (eK) concentrations, especially along their edges. This is probably due to strong albitization. This study highlights the usefulness of GRS in the early evaluation and fertility assessment of pegmatites in the Slave Craton, thereby reducing exploration cost.

An automatic workflow to develop first-order paleo-DEMs for any advanced Precambrian reconstruction model

Hoang Anh Tu (Lavie) Nguyen-Ridgway, Bruce Eglington, Dène Tarkyth, Drew Heasman

University of Saskatchewan.

E-mail: hoanganhtu.nguyen@usask.ca

A paleo-digital elevation model (paleo-DEM) represents past topographic variation across a region at a specific point in geological time. Paleo-DEMs are used to track changes in eustatic and relative sea level, explore global paleoclimate conditions through time, and identify regional uplift and subsidence relevant to energy and mineral resources. Earlier paleo-DEM workflows relied on manually repositioning present-day geological features to past locations based on a chosen paleo-reconstruction or plate tectonic model. Other approaches extracted features from published paleogeographic maps and reconfigured them using two different reconstruction models. These manual methods are difficult to integrate with modern global reconstruction models that extend into the Precambrian and include hundreds of geodynamic units representing preserved lithospheric fragments. Additionally, lithofacies data and marine fossils, which were heavily utilized to constrain paleoenvironments, became increasingly scarce in Precambrian time. Leveraging modern computational power and open-source scientific tools in Python (e.g. pyGPlates, GeoPandas, NumPy and Shapely), we present an automated workflow that combines an advanced Precambrian reconstruction model (e.g. PaeoPlates) with a global geochronological dataset (e.g. DateView) to generate first-order paleo-DEMs for the full duration of the reconstruction model. Present-day analogues of geodynamic settings and their characteristic elevations are used to infer paleo-elevations. Continental collision zones are assigned to the highest elevations, followed by continental volcanic arcs on older crust. Zero elevation is placed at the continent-ocean boundary, which is an overestimate of true coastlines but a reasonable first-order approximation for poorly constrained Precambrian geology.

Implications of rift domain variability and crustal necking along the Newfoundland rifted margin, eastern Canada

Wubamlak Nigussie, J. Kim Welford

Memorial University of Newfoundland.

E-mail: wualehegn@mun.ca

The Newfoundland rifted margin (NLRM) exhibits complex lithospheric features, including failed rifts, continental ribbons, transfer zones, and along-strike segmentation. Although the spatial variability of these tectonic features is central to understanding the region's tectonic evolution, their interactions and broader implications remain debated. In this study, drawing on an unprecedented deep multichannel seismic dataset, we interpret a grid of margin-scale seismic reflection profiles to examine the variability of crustal necking and rift domain architectures along the NLRM and the associated Orphan Basin – Flemish Pass failed rift. Our interpretation reveals asymmetrical crustal necking on the conjugate sides of the failed rift, consistent with published numerical modelling studies that suggest asymmetric rifting is an early-stage process, potentially occurring before the necking phase. We observe more gradual crustal necking in regions of thinned and inferred weaker crust. In contrast, more abrupt crustal necking is associated with areas of thicker, inferred stronger crust, where transcrustal faults extending to depths greater than 20 km are imaged. Mantle serpentinization interpreted beneath both the NLRM and the failed rift zone indicates that serpentinization is not contingent on rift success or failure but is primarily governed by rheology and the availability of transcrustal faults. For magma-poor rifted margins, in contrast to magma-assisted rifting, transcrustal faulting linked with mantle serpentinization appears to facilitate continental breakup. Our systematic mapping reveals pronounced across-strike and

along-strike variations in rift domain distributions, predominantly controlled by inherited transfer zones that segment the margin and which range from localized to diffuse, accommodating extension and giving rise to alternating strong and weak margin segments.

Mineralization associated with Carboniferous karst infill: Codroy Group limestones and implications for paleoenvironment, Port au Port Peninsula, Newfoundland

Lauren Norman, Hilary Corlett

Memorial University of Newfoundland.

E-mail: laurencpnorman@gmail.com

The Carboniferous Codroy Group limestones, deposited within several large karst fissures in the Ordovician Aguathuna Formation at Aguathuna Quarry, Port au Port Peninsula, western Newfoundland, have previously been debated as originating from a shallow marine environment or from a hydrothermal vent community. This study investigates evidence supporting either theory by examining and comparing relationships among mineral phases, trace-element contents, and stable-isotope signatures in the Codroy Group limestones and the underlying Aguathuna Formation dolostones. The results of analyses of the Codroy Group were compared with new and existing research on the Ordovician strata to determine whether they share a similar post-deposition diagenetic history with younger strata in the Upper Mississippian (ca. 340–330.9 Ma), or whether their respective parageneses are decoupled. Scanning electron microscopy with energy-dispersive spectroscopy, stable-isotope analyses ($\delta^{13}\text{C}_{\text{PDB}}$, $\delta^{18}\text{O}_{\text{PDB}}$), and petrographic techniques (including plane-polarized, cross-polarized, reflected light, cathodoluminescence, and fluorescence microscopy) were used to characterize mineral phases. Facies analyses of the Codroy Group included fossil and matrix analysis to determine the depositional environment conditions. Results indicate that there is a primary organic-rich mud with calcified worm tubes and thin-shelled brachiopods, a stage of isopachous calcite cement, a stage of pyrite mineralization, three blocky calcite cements, four barite morphologies, and an iron oxide stage in the samples. The absence of dolomite in the Codroy Group suggests that dolomitization of the Aguathuna Formation is pre-Carboniferous. The timing of sulphide-sulphate mineralization and iron-oxide alteration in the Codroy Group may indicate a shift between reducing and oxidizing conditions, reflecting the evolution of fluid composition throughout paragenesis. The sequence of the mineral phases and the origins of fluids may favour one of the two depositional environments proposed for the Carboniferous limestones. Findings will enhance understanding of western Newfoundland's geological history and provide further insights into sulphide-sulphate mineralization in its Carboniferous rocks.

Assessing regional metamorphism as a driver for LCT pegmatite formation, Dryden, Ontario

Daniel Novak¹, Fred Gaidies¹, Jamie Cutts², Tarryn Cawood³

¹Carleton University, ²Natural Resources Canada, Geological Survey of Canada, ³University of British Columbia Okanagan.

E-mail: danielnovak@gmail.com

Lithium is essential in the deployment of many modern technologies, such as lithium-ion batteries, which has driven a global increase in lithium exploration. The bulk of Li deposits occur in pegmatite-hosted systems; however, the process responsible for the formation of these resources remains debated. The Dryden area of northwestern Ontario hosts numerous lithium-bearing pegmatites that are currently the focus of active exploration. These pegmatites occur within greenschist- to granulite-facies and locally migmatitic metamorphic rocks that are spatially associated with granitoid bodies such as the Ghost Lake Batholith. Constraints on the pressure and temperature (P-T) evolution in the area are key to determining if metamorphism could have played a driving role in lithium mobilization and pegmatite formation. However, there are limited chronological data and no published P-T constraints for the metamorphism in the area. To address this gap, this investigation aims to constrain the P-T conditions and ages recorded by the metamorphic rocks that host the pegmatite bodies. Samples were characterized using secondary electron microscopy, X-ray micro-computed tomography, electron probe microanalysis and laser ablation inductively-coupled plasma mass spectrometry. P-T conditions for the sample suite were determined using thermodynamic equilibria modeling, while age constraints were obtained using Rb-Sr (mica), U-Pb (apatite), and Lu-Hf (garnet) geochronology methods. By comparing metamorphic conditions and thermal histories with the emplacement ages of the pegmatites, the competing genetic models for pegmatite formation can be tested. Preliminary results indicate that the samples underwent a Barrovian type metamorphism which likely pre-dated the emplacement of the pegmatite and attained a peak P-T of approximately 580–680°C and 7.5–9.5 kbar.

Regional metamorphism of clastic sedimentary and gabbroic host rocks to orogenic gold mineralization, east-central Newfoundland

Arielle Oeur¹, Ian W. Honsberger², Jonathan O'Neil¹, Cameron Peddle³, Hamish A.I. Sandeman⁴

¹University of Ottawa, ²Natural Resources Canada, Geological Survey of Canada, ³New Found Gold Corp., ⁴Geological Survey of Newfoundland and Labrador.

E-mail: aoeur082@uottawa.ca

Orogenic gold deposits are commonly hosted in or closely associated with greenschist-facies rocks, suggesting that deformation and metamorphic fluids produced during greenschist-facies metamorphism drive the formation of such deposits. Constraining the regional metamorphic history of terranes hosting orogenic gold deposits is therefore essential to understanding mineralizing fluid sources and pathways through time, which informs mineral exploration for these deposits. Newfoundland is rapidly emerging as a prominent gold district and producer in Canada. In east-central Newfoundland at the Queensway deposit, more than two million ounces of orogenic gold are hosted in deformed and metamorphosed, fault-bounded, Ordovician to Devonian clastic sedimentary rocks and associated gabbroic intrusions. Orogenic gold mineralization occurs within structurally controlled, sulphide-bearing quartz veins along the Appleton Fault Zone, which retains a Silurian to Devonian tectonic history involving regional

hydrothermal fluid migration and associated ankerite and sericite alteration. Systematic regional field observations and preliminary petrography of gold-mineralized and unmineralized host rocks suggest a single, lowermost greenschist- to sub-greenschist-facies, chlorite-grade regional metamorphic event. This event is poorly defined with respect to timing and pressure and temperature conditions, and it is unclear how regional metamorphism is related to local alteration of the gold-bearing host rocks. A non-auriferous amphibolite-facies terrane occurs approximately 10 km east of the mineralized rocks, raising the possibility that gold-bearing fluids may have been sourced from higher-grade rocks nearby. Alternatively, auriferous fluids were sourced from low-grade metamorphism of the host rocks themselves. This study is addressing the regional metamorphic history of the gold-bearing terrane in east-central Newfoundland through petrography, micro-analytical mineral analyses, quantitative pressure-temperature-fluid equilibrium modelling, and targeted geochronology. Additionally, the tectonomagmatic origins of the gabbroic rocks are being investigated with whole-rock geochemistry to further constrain the evolution of the terranes.

How the Late Devonian expansion of forests impacted shallow marine communities

Sasha Offin, Hilary Corlett, Michael Babechuk

Memorial University of Newfoundland.

E-mail: offinsasha@gmail.com

The punctata Event (pE) during the Late Devonian is marked by a major $\delta^{13}\text{C}$ shift observed globally in marine deposits across south and east Laurussia and north Gondwana. The pE begins with a positive shift in $\delta^{13}\text{C}$ corresponding with a rise in sea level and ends with a sharp negative shift unassociated with a fall in sea level. It has been previously proposed that this isotopic event observed in marine carbonates could be linked to the diversification of large vascular plants and the subsequent spread of forests across previously uncolonized terrestrial environments. This spread of forests occurred primarily due to the evolution of seeds, and deeper root penetration and would have increased the rates of terrestrial weathering and subsequently the amount of nutrients entering the shallow marine environment. The effect that the proposed increase in nutrients had on carbonate-secreting organisms during the Late Devonian is unclear. This study examines the biota of the Redwater reef, a well-preserved Leduc Formation reef in the Western Canada Sedimentary Basin that grew through the pE. Preliminary work on this project has identified a shift in the main framework building organisms from stromatoporoids to tabulate corals across the pE, this is built upon here by identifying the change in biodiversity at the genera level for different sections of the Redwater reef. Further, ICP-MS trace-element data are used to test for geochemical shifts in the carbonate reef, accompanying observed morphological and biodiversity changes that may reveal new insight into increases in nutrients entering the paleo-marine system of the Redwater reef and how the reef organisms responded to this change. Understanding how the pE affected marine communities will provide insight into the impacts of increasing nutrients to ancient shallow marine communities and how these communities adapted.

Using trace metals and metalloids to understand the magmatic system of the Heck seamount chain, Juan de Fuca Ridge

Sasha Offin¹, Emma Scanlan², Nancy Van Wagoner³, Matthew Leybourne^{2,4}

¹Memorial University of Newfoundland, ²Queen's University, ³Thompson Rivers University, ⁴Arthur B. McDonald Canadian Astroparticle Physics Research Institute.

E-mail: offinsasha@gmail.com

The Juan de Fuca Ridge (JdFR) is a spreading centre located in the northwest Pacific Ocean, made up of several segmented axial valleys. At the northern end of the JdFR, the Endeavour Ridge and West Valley segments form an overlapping spreading centre. West Valley is actively spreading with a light cover of sediment and fresh pillow basalts exposed on the valley floor, noted by previous deep-tow camera observations. The valley is also associated with seamount chains trending perpendicular to the central axis. One of these chains, the Heck seamount chain, has three prominent peaks, West, Heck, and East peak; unlike other seamount chains in this area such as the Heckle chain located directly south, the Heck chain relief does not progressively decrease towards the spreading centre, indicating that the magma supply does not steadily decrease over time as may be interpreted for the Heckle chain. We studied the fractionation and distribution of metalloids and trace metals across the seamount chain to try to identify the pathway and source of magma delivered to the seamounts. The seamount and spreading centre basalts are geochemically distinct; the Heck seamount chain has relatively lower concentrations of incompatible elements and higher concentrations of certain compatible elements (Cr and Ni) compared to West Valley basalts. Trace metals Ti, Mo, W, and U and the metalloid Sb behaved differently from the observed trend exhibited by the incompatible elements. Based on our data, we propose a model whereby the seamounts formed by lateral movement of the magma through the crust initiating from the mid-ocean ridge. This lateral movement resulted in further partial melting of more depleted mantle compared to the ridge axis (D-type MORB), resulting in an increase in compatible elements, and fractionation of highly incompatible metalloids and metals compared to ridge rocks (N-type MORB).

Carbon sequestration in ultramafic mine wastes, Newfoundland and Labrador

Timilehin A. Oguntuyaki, Penny L. Morrill

Memorial University of Newfoundland.

E-mail: taoguntuyaki@mun.ca

Ultramafic mine wastes represent a potential pathway to integrate carbon sequestration into mine remediation and closure strategies. This study evaluates atmospheric CO₂ removal potential in legacy asbestos tailings from the former Advocate Mine, Baie Verte, Newfoundland and Labrador, Canada, using an integrated field, experimental, and modelling approach. Field CO₂ flux measurements revealed spatial variability across tailings ponds, with net atmospheric uptake occurring in ponds where pH was the highest. Controlled laboratory experiments showed that mine tailings buffered

deionized water to pH values between 8 and 9, while MgOH-bearing systems sustained higher alkalinity and enhanced CO₂ uptake. Changes in Mg/Si and Ca/Si ratios in the water indicate early dissolution of silicate minerals, followed by declining Mg/Si and Ca/Si in flow-through systems consistent with progressive surface passivation and secondary carbonate formation. Closed-system carbon dioxide removal experiments sequestered 15 to 45 $\mu\text{mol CO}_2$ per 300 g of tailings and 300 mL of water, equivalent to 5 to 8 g CO₂ per kg per year. Although lower than rates reported for freshly crushed serpentinite, these values reflect more than three decades of weathering and carbonate surface coatings that reduce reactivity. pH-Redox-Equilibrium modelling (using PHREEQC) predicted calcite, dolomite, and magnesite precipitation under observed pond conditions, confirming the thermodynamic feasibility of carbonation. When scaled to approximately 250 Mt of exposed mine wastes, the site represents a potential sink of approximately 2 Mt CO₂. These results demonstrate how geochemical characterization of legacy ultramafic tailings can inform low-impact remediation strategies for mine waste remediation and climate change mitigation.

Application of hyperspectral drill core scanning to map alteration zones: Example from the Helmi gold deposit, the Central Lapland Greenstone Belt, Finland

V. Juhani Ojala¹, Phil Harris², Mike Donze²

¹GeoPool Ltd., ²TerraCore Co.

E-mail: juhani.ojala@geopool.fi

Drill core hyperspectral imaging used in this study (using Specim Sisurock equipment) measured reflected light in the visible-near infrared (~400–1000 nm), shortwave infrared (~1000–2500 nm), and thermal infrared (~8000–12 000 nm) ranges. Many minerals have diagnostic absorption features in these spectral regions, enabling their identification and mapping. Although sulphides do not have diagnostic features in these ranges, important hydrothermal alteration minerals such as white and dark micas and carbonates exhibit distinctive features in the shortwave infrared, while quartz, feldspars, many silicates, and carbonates can be mapped in the thermal infrared. Furthermore, compositional changes in micas and carbonates that are invisible to the naked eye can be detected. Mineral maps and spectral parameters help to define lithological units, alteration zones, and, overall, the understanding of hydrothermal systems and vectoring toward ore zones. Operationally, the Sisurock hyperspectral core scanning unit is rapid; about 200 boxes can be scanned in one eight-hour shift. Captured high-resolution RGB imagery (100 μm resolution) and spectral data (1–2 mm resolution) form a digital archive which ensures that core data remain accessible for future reinterpretation, even if the physical core is lost. The Helmi gold deposit is an orogenic gold deposit in the Central Lapland Greenstone Belt. In the Helmi deposit, mineralized intervals are mainly hosted in the Savukoski Group – altered, sheared, and/or brecciated mafic and ultramafic rocks and tuffites – structurally intercalated with Kumpu Group conglomerates and sandstones. All rocks have been metamorphosed under greenschist facies conditions. Mineralization is associated with fine-grained pyrite as disseminations, intrafolial sulphide, or within narrow quartz-magnetite veins. In Helmi, it is possible to map mineralogical changes toward the ore zone with hyperspectral scanning. The first observed change was the disappearance of epidote, followed by variations in the abundances and compositions of carbonate, chlorite, and white mica toward proximal alteration zone and ore grades.

Geological ancestry of the northeastern Canadian Shield: A window into Hadean crust and mantle evolution

Jonathan O'Neil¹, Victor B. Garcia¹, Christian Sole¹, Dan A.J. Stepner¹, Benjamin Wasilewski¹, Hanika Rizo²

¹University of Ottawa, ²Carleton University.

E-mail: jonathan.oneil@uottawa.ca

The Hadean Eon spans nearly 600 million years of Earth's earliest history, from Solar System formation at 4.567 Ga to 4.03 Ga. Although long regarded as a period dominated by catastrophic processes associated with planetary accretion that precluded the survival of solid rocks on Earth's surface, the Hadean is now known to have hosted solid crust that likely persisted into much of the Archean. However, Earth's primitive crust has largely been destroyed and reworked into younger rocks, leaving little preserved Hadean material and few ancient terranes, greatly hindering investigation of the earliest crust and the processes that formed the first continents. Despite the scarcity of pre-3.5 Ga rocks, ancient Archean terranes preserve critical information about the Hadean crust and the processes shaping the early Earth, mostly recorded indirectly through precursor source materials. These records provide rare constraints on the nature of the first crust and the early differentiation of Earth's mantle. Here, we examine some of Earth's oldest preserved rocks, primarily from the northeastern Canadian Shield, to illustrate how coupled geochemical and isotopic tracers constrain the nature of Hadean crust, its role as a precursor source for younger Archean rocks, and the early evolution of the mantle. Evidence from these rocks points to a predominantly mafic Hadean crust, rather than highly chemically differentiated rock types. This early mafic crust was subsequently reworked and remelted during the Archean, producing the more felsic compositions that dominate the present-day continental crust. Isotopic evidence preserved in mantle-derived Eo- to Paleoarchean rocks further supports the existence of early-formed enriched and depleted mantle domains, potentially generated through processes such as magma-ocean crystallization and/or early crust extraction. Together, these observations suggest that the imprint of Hadean crust-mantle differentiation persisted through the Archean, leaving a lasting geological ancestry that shaped the long-term evolution of continental crust.

Ediacaran magmatism in southern Newfoundland, Canada

Maria O'Neill¹, Donnelly Archibald¹, James Conliffe², Gregory Dunning³

¹St. Francis Xavier University, ²Geological Survey of Newfoundland and Labrador, ³Memorial University of Newfoundland.

E-mail: oneill.maria70@gmail.com

The age and petrogenesis of magmatic rocks are critical for reconstructing ancient tectonic settings. The peri-Gondwanan composite terrane Ganderia in southern Newfoundland hosts many plutons emplaced from the Ediacaran to the Devonian. In the Dolman Cove belt resides the previously undated and unstudied Top Pond pluton. This tonalite pluton is medium-grained, equigranular, and composed of major minerals plagioclase (An₃₀), quartz, biotite, pargasite, and epidote with trace amounts of titanite, and accessory minerals apatite, allanite, zircon, ilmenite, titanomagnetite, and magnetite. Euhedral epidote is clinozoisite that is commonly zoned, indicating a magmatic origin. New geochemical data show the Top Pond pluton is a metaluminous calc-alkaline tonalite. Trace element chemistry shows a slightly negative REE slope and primitive-mantle normalized trace element diagrams show depletions in Nb, Ta, Th, and Ti. Tectonic discrimination diagrams show that the Top Pond pluton is characteristic of tonalite formed in a continental margin subduction zone. Two new U–Pb zircon ages (CA-TIMS methods) for the Top Pond pluton are 540.87 ± 0.072 Ma and 540.997 ± 0.068 Ma show that it is the oldest pluton in the Dolman Cove belt. New zircon $\epsilon\text{Hf}(t)$ data are between 6.1 ± 1.0 and 9.2 ± 1.2 and indicate that magmas were derived from a juvenile source. Taken together, these ages, along with geochemistry, suggest that the Top Pond pluton can be correlated with plutons of similar age elsewhere in Ganderia in the Bras d'Or terrane in Cape Breton, Nova Scotia and in the Brookville terrane in southern New Brunswick.

What shapes geoscience communication practice? Perspectives from Canadian professionals

Courtney Onstad, Eileen van der Flier-Keller

Simon Fraser University. E-mail: courtney_onstad@sfu.ca

Geoscience communicators play a vital role in connecting Earth science with society and addressing complex socio-environmental challenges. Findings from a Canada-wide survey identified key trends in communicators' knowledge and use of science communication models and tactics, their training experiences, and the factors influencing their practice. This project builds on those findings through a thematic analysis of interview data from professional geoscience communicators to identify recurring patterns and shared experiences in practice. Together with statistical analysis of the survey data, used to summarize trends, prevalence, variance, and relationships among key variables, this mixed-methods approach provides a comprehensive picture of geoscience communication practice in Canada. These findings are used to highlight innovative and effective communication approaches that may guide the practice of other geoscience communicators, as well as to identify implications for institutional policies and training opportunities. Our findings suggest that practitioners' familiarity with, use of, and prioritization of science communication models are shaped by an interplay of individual dispositions, professional norms, and systemic constraints. Geoscience communication training in Canada emerges not as a standardized pathway but as a largely practice-driven process, with skill development heavily dependent on workplace culture, access to mentorship, and individual initiative. While communicators are motivated by well-intended goals, our results also reveal structural constructs that shape how these motivations are enacted in practice. Thematic analysis highlights an involved, detail-oriented, and audience- and context-centred approach to geoscience communication in Canada, shaped by structural, organizational, and individual factors. Results offer insights that may support and inform future geoscience communication practice.

Paleoenvironment of late Neoproterozoic volcanic and hydrothermal activity in the Avalon Zone of Newfoundland: Insights from volcanic-sedimentary interactions

Miguel Ortiz-Chaparro, Graham D. Layne, Michael G. Babechuk

Memorial University of Newfoundland.

E-mail: aortizchapar@mun.ca

Late Neoproterozoic successions in eastern Newfoundland preserve shallow-level volcanic and sedimentary rocks that record the transition from arc magmatism to regional extension. Facies including peperites and other sedimentary-matrix volcanic breccias occur within ca. 606–575 Ma arc-related volcanoclastic rocks, providing an opportunity to evaluate syn-depositional volcanic/hydrothermal processes and basin development during arc evolution. This study integrates petrography and lithogeochemistry of sedimentary-matrix volcanic breccias and volcanoclastic strata to assess (1) the nature of volcanic-sedimentary interaction, (2) the extent of any hydrothermal geochemical signature in sedimentary rocks, and (3) their paleoenvironmental and tectonic significance. Petrographic and geochemical evidence confirms syn-sedimentary intrusion of arc magmas into unconsolidated volcanoclastic sediments, demonstrating overlap between sedimentation and (sub)volcanic activity. Jasper infill extracted from volcanic breccias is interpreted as syn-eruptive and to record subaqueous hydrothermal discharge. Hydrothermal influence is indicated by Cu-sulphides and enrichments in Fe, Eu, and other hydrothermally mobile metals (e.g. Co, Ni, Cu, As, Sb, Pb, W). Conversely, the influence of non-hydrothermal fluids during jasper precipitation is seen through REE and trace element systematics (e.g. Y/Ho ratios and La–Ce–Gd anomalies suggesting fluid mixing). Subtle enrichments in hydrothermal metals within peperite-hosting strata further support contemporaneous volcanoclastic deposition and hydrothermal activity in intra-arc basins. However, detailed textural and geochemical analysis of peperitic and non-peperitic ferruginous strata shows that intrusion-related hydrothermal flow modified bulk Fe budgets only locally. At a succession scale, Fe-oxide precipitation is better explained by different early- to late-diagenetic pathways. Stratigraphic relationships and geochemistry collectively support deposition within structurally controlled intra-arc depocenters, likely lacustrine to marginal marine. These basins developed during incipient extension overlapping with arc magmatism. Volcanic-

sedimentary interactions in eastern Newfoundland thus record the shallow expression of arc evolution and refine constraints on the paleoenvironmental and tectonic context of the latest arc-related volcanic and hydrothermal activity in the Avalon Zone.

Reconstructing the depositional evolution of the Ediacaran Nama Group, Namibia, via high-precision zircon U–Pb geochronology

Maria Ovtcharova¹, Fabio Messori¹, Fred T. Bowyer², Ulf Linnemann³, Mandy Zieger-Hofmann³, Johannes Zieger³, Esther Rojo-Perez³

¹University of Geneva, ²University of Edinburgh, ³Senckenberg Naturhistorische Sammlungen Dresden.

E-mail: maria.ovtcharova@unige.ch

Temporal calibration of the terminal Ediacaran Period (roughly 550–539 million years ago) is crucial because it acts as the "chronometer" for the most significant biological and environmental revolution in Earth's history: the dawn of animal life and the run-up to the Cambrian Explosion. It is currently precluded by the limited availability of absolute age constraints. The Nama Group of southern Namibia and northwestern South Africa hosts one of the most complete and radiometrically well-constrained mixed carbonate-siliciclastic foreland basin successions of the terminal Ediacaran (ca. 550.5 Ma to $\leq$ 538 Ma). Despite nearly 100% exposure and numerous dated ash beds, uncertainties remain for precise lateral stratigraphic correlations of some intervals over distances > 20 km. Here we present high-precision zircon U–Pb geochronology (chemical abrasion isotope dilution thermal ionization mass spectrometry, or CA-ID-TIMS) for three important sections of the Nama Group succession and interpret these data within an updated stratigraphic context. The results from zircon U–Pb ages within a full lateral stratigraphic framework support a model of carbonate platform migration from north to south as a direct consequence of dynamic basin subsidence associated with ongoing compression of the Damara orogenic belt and progressive forebulge migration.

Envisaged paleotopography of the Rae and other surrounding cratons: Perspectives from Paleoproterozoic sedimentary basins and their paleoenvironments

Camille Partin

University of Saskatchewan.

E-mail: camille.partin@usask.ca

The rock record of the Canadian Shield, whilst remote and challenging to access, offers an unparalleled archive of Precambrian Earth history. Its Paleoproterozoic sedimentary record gives a basis for understanding transformative global and regional events, such as the aftermath of the initial oxygenation of Earth's atmosphere that altered the composition of Earth's surface environments, and the record of orogenic events during the closure of the Manikewan Ocean. Integrated studies and analysis of the stratigraphy, facies, and provenance of syn-orogenic sedimentary basins allow for unique insights into sediment routing systems at various stages in the evolution of the Trans-Hudson orogen. The addition of Hf isotopes to routine U–Pb detrital zircon analyses enhances our ability to assign sources. Case studies from my research on provenance analysis of sedimentary basins on the Rae craton (in both Canada and Greenland), Superior craton, as well as the Reindeer zone of the Trans-Hudson orogen, challenge established tectonic models and envisage sediment routing systems from the geological past, setting up testable hypotheses for future work. Equally important is understanding the role of sedimentary archives in recording global events, e.g. to better understand the surface oxygenation record of ca. 2.0 to 1.8 Ga units on the Canadian Shield and elsewhere. Case studies on geochemical proxies of sedimentary archives test the hypothesis that atmospheric O₂ deteriorated during the time of global orogenesis following an unusually high influx of O₂ after the Great Oxidation Event. The interplay of factors such as tectonics and/or biogeochemical feedbacks remains poorly understood but is relevant to understanding the ongoing deoxygenation of the modern ocean, as well as the trajectory of early animal evolution in Earth's history.

Geometry of indicator mineral and till geochemistry dispersal fans from the Brazil Lake lithium-cesium-tantalum pegmatites, southwest Nova Scotia

Roger Paulen¹, Beth McClenaghan¹, Chris Beckett-Brown², Denise Brushett³, Jessey Rice¹

¹Natural Resources Canada, Geological Survey of Canada, ²Ontario Geological Survey, ³Nova Scotia Department of Natural Resources.

E-mail: roger.paulen@nrcan-rncan.gc.ca

The Brazil Lake lithium-cesium-tantalum (LCT)-type pegmatites in southwestern Nova Scotia were the focus of a detailed till study to document glacial dispersal through several phases of glaciation. A total of 84 bulk (7–20 kg) till samples were collected from 77 sites near to and down-ice from the three pegmatites. Glacial dispersal of indicator minerals from the pegmatites is best defined by spodumene in the 0.25–0.5 mm fraction of the 2.8–3.2 specific gravity till concentrates, and its presence in the local till (100s to 1000s of grains per sample) confirms the existence of nearby LCT pegmatites. Results indicate that the spodumene dispersal pattern is the product of both the orientation of the source bedrock dykes, which are obliquely transverse to the main direction of glacial erosion, and the influences of multiple ice-flow events with varying trajectories. This formed a broad, fan-shaped footprint extending at least 12 km down-ice, considerably larger than the pegmatite subcrop areas. Other useful LCT pegmatite indicator minerals identified during this study include apatite and tourmaline (10 to 100s of grains), and lesser amounts of columbite-tantalite, cassiterite, and scheelite (1s to 10s of grains), although their spatial distribution in till is limited compared to that of spodumene. Geochemical analyses of three till size fractions were completed including coarse sand (1.0–2.0 mm), silt + clay (< 0.063 mm), and clay (< 0.002 mm) using various digestion and fusion methods to identify the best methods to detect LCT pegmatites. Lithium dispersal from the Brazil Lake pegmatites is best defined by the coarse fraction (using Na-peroxide fusion), which contains up to 531 ppm Li and forms a narrow, ribbon-shaped dispersal train extending 4 km down-ice.

The results presented here demonstrate that drift prospecting methods are effective tools for Li exploration in southwestern Nova Scotia and in other prospective glaciated regions in Canada.

Microsedimentological models applied to subglacial till formation and mineral dispersal trains

Roger Paulen¹, John Menzies², Jessey Rice¹

¹Natural Resources Canada, Geological Survey of Canada, ²Brock University.

E-mail: roger.paulen@nrcan-rncan.gc.ca

The application of glacial micromorphology is not necessarily a tool applied to exploration for minerals of economic interest dispersed by glaciation and buried by glacial sediments. Rather, it is a tool used to recognize the till-forming conditions in a variety of glacial environments, which then in turn can establish a suite of drift prospecting techniques. Shear deformation is ubiquitous in subglacial tills formed by traction/entrainment conditions under basal ice. Microstructures identified in till confirm the existence of such basal conditions under continental and marine ice sheets, ice streams, and alpine glaciers. When glacial erosion is subsequently followed by subglacial till traction and accretion (i.e. immobilized sediment layer), the nature of glacial dispersal is greatly impacted by the repeated cycles in which the mobile bed becomes immobile and then is remobilized cutting off the continued erosion of mineralized bedrock. Broken mineralized grains are products of cataclasis processes within till and provide additional context to glacial dispersal train models. The process is time-transgressive such that over time both pervasive and non-pervasive deformation conditions persist repeatedly within the subglacial till environment under mixed sediment matrix rheologies. Consequently, the dispersal train that forms is a product of glacial re-entrainment of portions of the immobile bed, and down-ice transport of the mobile bed until it accreted as a new immobile bed. These processes persist in a cyclic and repetitive fashion that results in a dispersal train that appears to 'climb' through a till sequence and broaden into a large fan-shape deposit down-ice.

Assessing lanthanide contents of fluorite as a function of crystal growth rate and solution NaCl content

Ben Paulic¹, Issac Jacques², Mostafa Fayek², Kurt Hangle¹

¹Seven Oaks High-School Division, ²University of Manitoba.

E-mail: BP.AULIC76@7oaks.org

The rare earth elements (REEs) consist of the lanthanide group of elements (La to Lu). The Canadian Government considers these elements critical for the economy and national defense. Fluorite is a common mineral found in a variety of geological settings, and typically occurs with critical minerals, making it useful for studying critical mineral ore deposit formation. Previous research showed that the REE patterns in fluorite often match the REE patterns of the fluids from which they precipitated. In addition, previous studies have suggested that higher Na contents facilitate the incorporation of REEs into fluorite, resulting in higher REE contents and potentially different REE patterns. Other minerals, such as garnet and pyroxene, show that fast crystal growth rates lead to REE patterns which match the fluid, whereas slow growth rates result in REE patterns different from the fluid. Therefore, the following questions remain regarding the REE patterns in fluorite: 1) does the rate of crystal growth affect the REE concentration and distribution pattern in fluorite, and 2) does the sodium (Na) concentration in the fluid affect the REE concentration in fluorite? To answer these questions, we synthesized fluorite using a syringe pump to inject 20 mL of H₂O–NH₄F solution over a duration of up to 168 hours into 20 mL of a H₂O–CaCl₂ solution bearing 2–40 mmol/L NaCl and 1.2–1.4 mmol/L of each lanthanide as REECl₃•nH₂O ($\sum \text{REE} = 18 \text{ mmol/L}$). The results show that crystal size increases with slower mixing rates. The 1 hour experiments produced fluorite crystals ranging from 62–262 nm in size, whereas in the 168 hour experiments the crystals range in size from 100–3700 nm in diameter. The REE composition of fluorite will be compared to crystal size and fluid NaCl contents to determine if the fluorite REE patterns are similar to those of the fluid.

Preservation of decametre-scale refractory domains in the ca. 488 Ma North Arm Mountain massif mantle, Bay of Islands Ophiolite Complex

Carolina Paz Jaramillo¹, Brian O'Driscoll¹, Jean H. Bédard², James M.D. Day³, Victor B. García¹, Alana Hinchey⁴, Richard J. Walker⁵

¹University of Ottawa, ²Natural Resources Canada, Geological Survey of Canada, ³University of California San Diego, ⁴Geological Survey of Newfoundland and Labrador, ⁵University of Maryland.

E-mail: dpazj025@uottawa.ca

Chemical heterogeneity is a fundamental characteristic of the oceanic mantle. However, the causes, length-scales and timing of formation of such heterogeneity remain poorly constrained because compositional variability is commonly inferred from proxy samples (i.e. mid-ocean ridge basalts) or materials with no spatial context (e.g. abyssal peridotite dredge samples). As a fragment of oceanic lithosphere emplaced during the lower Paleozoic closure of the Iapetus Ocean, the North Arm Mountain (NAM) mantle section of the Bay of Islands Ophiolite Complex provides direct access to fossil oceanic mantle. It therefore enables spatially controlled sampling to evaluate the magnitude and length-scales of mantle heterogeneity during a cycle of ocean basin opening and closure. We present new geochemical datasets including highly siderophile element (HSE) abundances and Re–Os isotopic data from grid-sampled harzburgites across the NAM mantle section. All samples have strongly depleted rare earth element (REE) patterns characteristic of residual mantle; however, individual ~10 m² grids define distinct and internally consistent chemical signatures. These range from extremely depleted to relatively fertile or melt-modified compositions, indicating extensive variability that cannot be explained solely by differences in the degree of partial melting. Our Re–Os isotope data provide a temporal framework to evaluate this spatial variability. Re-depletion ages (T_{RD}) and Re model ages (T_{MA}) ages show close agreement within individual grids, with two grids consistently revealing mid-Proterozoic melt depletion in the Paleozoic mantle section. Together with the relatively low Re abundances for most NAM peridotites ($< 0.1 \times$ primitive mantle), the intra-grid

consistency of $^{187}\text{Os}/^{188}\text{Os}$ ratios and associated model ages indicate that the NAM preserves discrete long-lived refractory mantle domains at ~ 10 m length-scales. The depleted geochemical signatures of these domains, together with their lithological and petrological similarities to the rest of the NAM mantle section, are most consistent with their long-term preservation and circulation in the asthenosphere.

Tithonian rift-related magmatism in Newfoundland: Structural inheritance, timing, and implications for North Atlantic rifting

Alexander Peace¹, Hamish Sandeman², Phil J.A. McCausland³, J. Kim Welford⁴, Emma Keefe¹, Ai Gusti Guna¹, Gregory Dunning⁴, Meixia Geng⁵

¹McMaster University, ²Geological Survey of Newfoundland and Labrador, ³Western University, ⁴Memorial University of Newfoundland, ⁵Technology Innovation Institute.

E-mail: peacea2@mcmaster.ca

Small-volume, alkaline mafic intrusions of Tithonian age (ca. 148 Ma) in north-central Newfoundland define the Notre Dame Bay Magmatic Province (NDBMP) and provide a well-exposed onshore record of early rift-related magmatism associated with opening of the North Atlantic. Over the past decade, new results from structural geology, geochronology, palaeomagnetism, geochemistry, petrology, and geophysics have substantially improved constraints on the timing, emplacement mechanisms, and tectonic context of this magmatic episode. Here, we synthesize these datasets to develop an integrated framework for the evolution of the NDBMP and its role within the Newfoundland-Iberia-Ireland rift system. High-precision CA-ID-TIMS U–Pb zircon and ^{40}Ar – ^{39}Ar phlogopite ages indicate emplacement during a short-lived Tithonian magmatic pulse at ca. 148 Ma, contemporaneous with early offshore rifting and basin development. Field and structural mapping show that lamprophyre dykes preferentially exploited inherited Appalachian structures, including faults associated with an Iapetus suture, and locally record post-emplacement reactivation. Joint inversion of airborne gravity gradiometry and magnetic data constrains the three-dimensional geometry of the intrusions at shallow crustal levels and highlights structural focusing at the intersection of inherited fault systems, with potential links to deeper lithospheric structures. New geochemical and isotopic data indicate derivation from low-degree partial melting of a metasomatized lithospheric mantle source, and palaeomagnetic results are consistent with coherent motion of the Newfoundland block with North America during Late Jurassic extension. Together, these observations emphasize the importance of structural inheritance, lithospheric architecture, and distal extension-driven mantle upwelling in generating early magmatism along magma-poor rifted margins. Outstanding questions remain regarding magma transport pathways at depth, the evolution of regional stress fields recorded by dyke swarms, and links to conjugate margin processes. Ongoing and future work integrating offshore datasets, improved geochronology, and plate-scale reconstructions will further refine models for the initiation of North Atlantic rifting and its broader implications for continental breakup.

Lithium-cesium-tantalum pegmatite emplacement at the Galaxy deposit (Superior Province, Quebec) as determined by structural analysis and in-situ U–Pb zircon geochronology

Rocio Pedreira Pérez, Stéphane De Souza, Joshua H.F.L. Davies, Benoît Saumur

Université du Québec à Montréal.

E-mail: pedreira_perez.rocio@uqam.ca

The Galaxy lithium deposit (110.2 Mt at 1.30% Li_2O ; total resources; 43–101 estimate, 2023) lies within the metasedimentary Nemiscau subprovince of the Superior Province, ~ 5 km to the south of the Lower Eastmain greenstone belt. Lithium -mineralization is hosted in a swarm of steeply west-dipping ($> 70^\circ$) lithium-cesium-tantalum pegmatite dykes composed of spodumene, muscovite, tourmaline, garnet and coltan (columbite-tantalite). The dykes were preferentially emplaced within a competent ESE-WNW-trending sandstone unit along its contact with less competent cordierite-bearing greywacke and pelitic rocks metamorphosed under amphibolite facies conditions. The contrast in rock competency likely promoted extensional fracturing within the sandstone, focusing pegmatite intrusion. The mineralized pegmatites occur along the northern edge of a larger barren pegmatite swarm rooted in an upper amphibolite- to granulite- facies migmatitic dome. Barren pegmatites include earlier E-W dykes containing muscovite-garnet-tourmaline-apatite $\pm$ biotite, and later, more evolved N-S dykes that locally contain beryl. The metasedimentary host rocks preserve a penetrative E-W-trending S_2 foliation formed during compression, that was later overprinted by an E-W to NE-SW-trending S_3 crenulation cleavage linked to dextral shearing. The lithium-rich pegmatites crosscut the S_2 foliation, but they are affected by late F_3 folding and boudinaged, suggesting that D_3 dextral transcurrent shearing was synchronous with and controlled pegmatite emplacement. Uranium-rich pegmatitic zircons were dated using LA-ICP-MS U–Pb combined with chemical abrasion to mitigate Pb-loss. The host metasedimentary rocks yielded a maximum depositional age of ca. 2725–2710 Ma. Migmatization within the dome occurred at ca. 2675 Ma, contemporaneous with emplacement of barren E-W dykes. Crosscutting later N-S beryl-bearing dykes were emplaced at ca. 2660 Ma, reflecting progressive melt evolution from anatectic leucosome to Li-rich melts over ca. 15 million years. These results highlight the combined effects of (1) district- to deposit-scale stratigraphic and structural controls; (2) early crustal anatexis; and (3) progressive melt evolution, culminating in emplacement of Li-rich pegmatites within extensional conduits during D_3 transcurrent shearing.

Defining the missing margins of the Snowbird Orogen: New detrital geochronology and stratigraphy from Rae and Hearne volcano-sedimentary sequences

Sally Pehrsson¹, Joshua Laughton¹, Jim Crowley², Jamie Cutts¹, William Davis¹, Daniele Regis¹, Lorraine Lebeau¹, Charlie Jefferson¹, Edith Martel³, James Ryan¹

¹Natural Resources Canada, Geological Survey of Canada, ²Boise State University, ³Northwest Territories Geological Survey.
E-mail: sallypehrsson@gmail.com

Deciphering cratonic margins is challenging in polyorogenic terranes associated with supercontinent assembly but is key to understanding the geodynamic evolution of Precambrian assembled cratons. This process is further exacerbated by the difficulty of temporal correlation in metamorphosed supracrustal rocks in the absence of a fossil record, and the non-unique depositional settings for many common lithofacies. These factors have hampered recognition of Rae and Hearne collisional margins related to the Snowbird Orogen and assembly of Nuna. In this contribution we present new detrital zircon age data from seven greenschist to upper amphibolite-facies volcano-sedimentary sequences along 600 km of the Snowbird Tectonic zone between Saskatchewan and Hudson Bay. We demonstrate that they collectively record initial alluvial-fluvial sedimentation, followed by marine transgression and drowning, and active bimodal volcanism, including pillowed basalts of up to 700 square km. Maximum deposition ages, most previously assumed to be Archean, range from Siderian to Orosirian and record basin filling to within 30 Myr prior to collision. Key distinct facies of these new basins include basal polyimictic conglomerates with carbonate, schist and granite clasts, followed by graphitic and black shales, and debris-flow-bearing greywackes interbedded with basalts. Where best preserved at lowest metamorphic grades they also contain spectacular breccia dykes with macro-scale geopetal structures interpreted to record active tectonism during basin filling and succeeding volcanism. Integration of these results with those of a dozen Paleoproterozoic sedimentary packages from both Rae and Hearne shows that greatest basin deepening is localized along the facing margins but that the hinterland extent of the basins has been vastly underestimated. Preliminary timing constraints between initial rift-drift transition and basin collisional inversion suggest lifecycles of 400 to 100 Myr for Rae and 100 Myr for Hearne, hinting at disparate geodynamic histories possibly relating to their involvement in different preceding Neoproterozoic supercratons.

Draft exploration guide using reflectance spectroscopy for critical minerals

Jeanne B. Percival¹, David Turner², Jessica M. Tomacic³, Jean-Sebastien Bouffard¹

¹Natural Resources Canada, Geological Survey of Canada, ²Industry, ³University of Toronto.
E-mail: Jeanne.Percival@nrcan-nrcan.gc.ca

As part of a Method Development project under the Targeted Geoscience Initiative (TGI-6) of the Geological Survey of Canada (Natural Resources Canada), a collaborative project was initiated to evaluate a spectral library for exploration of critical minerals and build a practical guide for field work. With over 600 naturally occurring rare earth element (REE)-bearing mineral species, rapid identification and evaluation provides significant value during geological mapping and exploration. Many of these minerals occur as accessory phases, commonly of low abundance. In examining over 1300 REE-, Nb-, U- and Th-bearing minerals from the Geological Survey of Canada's National Mineral Collection and analyzing close to 500, as well as examining other public and proprietary academic and industry databases, a conceptual workflow model is being developed and tested to assist field activities employing reflectance spectroscopy. Using a decision tree structure, a classification based on distinctive absorption features in the near-infrared region is utilized. The workflow begins with three basic questions on the presence or absence of key spectral features: (1) at 975 nm ($\text{Er}^{3+}/\text{Yb}^{3+}$); (2) 745–800–870 nm (Nd^{3+} triplet); and (3) a 640 nm feature located at ~653/654 nm (U^{4+} related). Outputs include positive mineral identifications or associations to mineral groups with similar features. The spectral library and the workflows are also being evaluated using machine learning approaches under the Critical Minerals Data Geoscience (CMDG) Program, providing insights for optimizing classification outputs and alternative data processing methods. This integration and assessment of government-, academic- and industry-developed libraries is an example of a partnership that has leveraged different approaches to provide useful workflows for professionals using reflectance spectroscopy. This presentation will demonstrate a beta version of the application with key examples of important economic minerals. A practical visual guide (handout) will be provided for testing in the field and to solicit feedback on its use.

Raman spectroscopy investigation of space weathering of Apollo rock samples

Kristi Peters, Ed Cloutis, Dan Applin, Tegan Ledoux

University of Winnipeg.

E-mail: peters-k98@webmail.uwinnipeg.ca

The Moon, being an airless body, experiences space weathering from processes such as solar wind irradiation and micrometeoroid bombardment. This leads to varied physical and chemical alteration of lunar soils and rocks. This alteration affects the spectral and compositional properties of lunar materials. To aid future lunar exploration, we have spectrally characterized a suite of Apollo rock samples using Raman spectroscopy. These samples were collected from the Moon's surface by Apollo astronauts. The samples were selected to enable spectroscopic characterization of a space-exposed surface, as well as an interior. We received chips of the upper and lower surfaces from three rocks from NASA's astromaterials facility. We have spectrally characterized these rock chips using a Raman spectrometer, to understand space weathering effects on lunar rocks. Space weathering can be caused by many factors, such as impact-induced metamorphism and microparticle flux (causing melting, vapourization and regolith gardening), solar flares and solar wind. These factors can cause the breaking of molecular bonds, amorphization, and formation of nanophase iron. Samples that have been irradiated in the laboratory show reduced reflectance and redder spectral slopes compared to non-irradiated samples. Such irradiation can promote the formation of nanophase iron, which is concentrated on the surfaces of Fe-bearing silicates. This study on rocks from the Apollo missions

will provide valuable insight into space weathering as it relates to Raman spectroscopy. The information found within this study will aid future and current lunar rover missions.

Investigating carbonate precipitation in ultramafic-hosted springs for CO₂ storage

Emma Petersen, Hilary J. Corlett, Kristin M. Poduska, Jake J. Breen, King King Ting, Penny L. Morrill

Memorial University of Newfoundland.

E-mail: ejpetersen@mun.ca

To meet global CO₂ reduction targets various methods of CO₂ mitigation are required. One method is carbon sequestration through the precipitation of stable solid carbonates. This method relies on an understanding of the controls of carbonate precipitation and the stability of carbonate phases for long-term storage and sequestration. Our study examines the correlations between varying morphologies and phases of carbonates, and the corresponding aqueous geochemistry from three serpentinite-hosted springs: (i) The Cedars, California; (ii) Blow Me Down Massif, Newfoundland; and (iii) the Tablelands, Newfoundland. Multiple analytical methods were conducted on the samples collected at each site to determine the mineralogy of the solids, chemistry of the water, and isotopic fractionations within the system. Various carbonate precipitates were examined using a scanning electron microscope and two distinct crystal systems were identified (orthorhombic and hexagonal) inferring the presence of aragonite and calcite. Fourier transform infrared spectroscopy analysis revealed varying polymorphs of carbonates precipitating at each spring. Stable isotope compositions of the carbonates were measured. Their $\delta^{13}\text{C}_{\text{VPDB}}$ ranged from -25.5 to -3.2‰ and their $\delta^{18}\text{O}_{\text{VPDB}}$ ranged from -19.7 to -8.8‰. The stable oxygen isotope compositions of H₂O were also measured. Their $\delta^{18}\text{O}_{\text{SMOW}}$ ranged from -10.9 to -7.2‰ across the three springs. Results from stable isotope thermometry estimated formation temperatures of 4–76°C across the three sites. These estimated temperatures fall within and outside the range of measured temperatures at the sites, reflecting carbonate precipitation at equilibrium and nonequilibrium with spring water. Nonequilibrium fractionation, i.e. kinetic fractionation, may indicate carbonate precipitation by microbes. Together these analyses will help to understand the stability of carbonate phases precipitated in association with ultramafic rocks, to evaluate their potential for long-term storage of CO₂.

Investigating zero-valent iron and biochar for decreasing the mobility of arsenic and mercury in a gold-mine-tailings-impacted wetland

Logan Phillips, Emily Chapman, Linda Campbell, Heidi Gavel

Saint Mary's University.

E-mail: logan.phillips@smu.ca

Historical gold mining across Nova Scotia resulted in significant amounts of arsenic- and mercury-rich tailings being deposited into freshwater wetlands between the 1860's and 1940's. The contaminants are from As-bearing minerals within auriferous quartz veins throughout slates and meta-sandstones in the Meguma Supergroup and the mercury amalgamation method used to extract the gold from finely crushed ore. Consequently, many tailings-impacted wetlands across Nova Scotia have elevated As and Hg concentrations within surface waters due to decades of weathering, and subsequent leaching of As and Hg. Considering the integration of the tailings into the wetlands over time, many treatment options are unviable due to high environmental impacts, complexity, and/or cost. Amendments are a cheap and minimally invasive alternative which can help decrease the mobility of contaminants such as As and Hg through various mechanisms. Some amendments such as zero-valent iron (ZVI) and biochar have been tested and proved highly efficient in short-term, small-scale laboratory testing. However, long-term, large-scale, and environmentally realistic studies using these materials are lacking. Therefore, this study plans to investigate the efficiency and longevity of these materials in simulated wetland microcosms over a 6-month period. These microcosms will contain site-collected tailings and water from an As- and Hg- contaminated wetland in the Waverley historical gold mine district. Amendment efficiency will be examined via regular water sampling to determine the change in total and dissolved As and Hg concentration over time. Preliminary investigations of these treatments from a pilot study suggest that ZVI is highly effective for lowering dissolved As and Hg concentrations, but biochar has several shortcomings that impair its efficiency within the microcosms. However, a composite of ZVI and biochar has shown great promise as an efficient, long-lasting material for decreasing the mobility of As and Hg in wetland systems.

Paleogeographic constraints on West Africa during the late Ediacaran: Do you have a moment to talk about GAD?

James Pierce¹, Phil McCausland², David A.D. Evans¹, Lyle Nelson³

¹Yale University, ²Western University, ³Massachusetts Institute of Technology.

E-mail: james.pierce@yale.edu

Paleomagnetic studies of Ediacaran rocks from several cratons have confounded researchers for decades, prompting several hypotheses to explain these data, including anomalously fast plate tectonics, hyperactive or irregular magnetic field behavior, and dramatic true polar wander episodes. Recent paleomagnetic data from late Ediacaran rocks of the Ouarzazate Group in the Anti-Atlas Mountains of Morocco suggest rates of apparent polar wander that are incompatible with plate tectonics and suggest a non-uniformitarian magnetic field between 568 and 565 Ma. Using Bingham statistics and integrating paleomagnetic data from different magnetic recorders with distinct lock-in times, workers placed West Africa at high paleolatitude. Extending the paleomagnetic record from 565 Ma until the Ediacaran-Cambrian boundary is crucial for understanding paleogeography during an interval in Earth's history that witnessed the first appearance of macrofauna. Complicating prospective paleomagnetic studies further are paleointensity data indicating that the magnetic field became extremely weak during the latest Ediacaran and early Cambrian. We present preliminary paleomagnetic and geochronological data from the Bou Azzer and Saghro inliers of Morocco, extending the paleomagnetic record from the West African Craton

towards the Cambrian boundary. This data will help to assess the behaviour of the Ediacaran magnetic field and evaluate the validity of the geocentric axial dipole (GAD) hypothesis. Furthermore, this data will help determine the location of the West African Craton during this crucial period, and work toward a geomagnetic field model applicable globally to rocks of similar age. Establishing a reliable paleogeography for this interval is crucial for understanding the conditions that led to the emergence of the modern fauna, including the lineages that gave rise to hominids.

Controls on grade and tonnage in volcanogenic massive sulphide deposits

Stephen Piercey

Memorial University of Newfoundland.

E-mail: spiercey@mun.ca

Volcanogenic massive sulphides (VMS) are global sources of Cu, Zn, Pb, Au, Ag with many other elements produced as by-products, including critical minerals. Their grade and tonnage are influenced by plate- to micro-scale factors. From a plate- to belt-scale, the largest VMS systems occur in belts associated with rifted environments that are dominated by volcanoclastic- and/or sedimentary rocks and high temperature magmatism, often along continental or peri-continental margins. Substrate influences metals in deposits with continental settings exhibiting enrichments in Zn–Pb > Cu, whereas more mafic/ultramafic substrates exhibit enrichments in Cu > Zn–Pb. Some by-product and critical metals are also strongly influenced by substrate composition (e.g. indium associated with shale-rich sequences; Co–Ni associated with primitive arc rocks). At the deposit scale, zone refining processes lead to enhanced metal zonation and can result in increased Cu–Zn–Pb grades. Sub-seafloor replacement processes facilitate the formation of larger VMS deposits compared to exhalative deposits, while also enhancing zone refining and potential grade increases. Many large deposits, including those enriched in precious metals (Au–Ag) and magmatophile elements (e.g. As–Bi–In–Sb–Sn–Te–W), have evidence for input from magmatic-hydrothermal fluids. Magmatic fluids are possibly important contributors to the metals in many deposits but it is often challenging to identify the record of these processes in many ancient deposits. Post-VMS deformation and metamorphism are also important in leading to recrystallization, remobilization, and redistribution of metals in massive sulphides. Coarsening of sulphide grains, formation of deformation-induced compositional banding, remobilization of rheologically weak materials, and potentially partial melting of low-melting-point components in sulphides, can lead to localized grade increases, including the enrichment in precious metals and some critical minerals (e.g. Bi–Co–Te). Despite VMS being one of the best understood deposit types globally, many fundamental questions remain regarding the causes of large and/or high-grade deposits.

Automated mineralogy: Testing precision of compositional maps using the mineral liberation analyzer

Dorota K. Pietruszka, Stephen J. Piercey, Dylan Goudie

Memorial University of Newfoundland.

E-mail: dkpietruska@mun.ca

Automated mineralogy (AM) utilizes a scanning electron microscope (SEM) paired with an energy-dispersive spectroscopy (EDS) detector to collect information on the modal composition and textural relationships in a sample. The combination of back-scattered electron (BSE) image analyses and X-ray EDS spectra produces false-colour compositional maps and provides primarily quantitative modal mineralogical data. The accuracy of the classified mineralogical dataset is checked during post-processing using in-house mineral standard libraries and verified by BSE/EDS testing and other techniques, such as electron probe microanalyzer. However, few studies have checked the repeatability, i.e. precision, of the maps produced by AM. Since the compositional and textural information provided by automated mineralogy is vital in many petrographic, petrogenetic, and metallogenic studies, the demand for compositional maps has increased, necessitating some estimate of reproducibility of results. Here, we use three samples from volcanogenic massive sulphide deposits with stringer and massive ore mineralization to test the precision of automated mineralogy maps. We repeat data collection of three compositional maps for each sample using SEM-mineral liberation analyzer (MLA) in grain-based X-ray mapping (GXMAP) measurement mode under the consistent instrument conditions used in routine thin section analysis. All maps show very good precision for major and minor minerals, i.e. those having > 0.1 area%. Trace minerals with area < 0.1%, especially those with very low abundance (< 0.001 area%) are less consistent across re-analyzed maps, which highlights the importance of choosing the right step size and map resolution of the sample analyzed, especially if the sample has a fine-grained texture, while balancing the time consumed for analysis. The results show that MLA is a robust, precise technique for obtaining quantifiable mineralogical and textural data, but specific study design and in-depth post-processing verification are needed when trace minerals are the focus of the study.

From basin to mineral: Rethinking stratabound Cu variability in the Maritimes Basin

Nicolas Pinet, Virginia Brake, Omid Haeri Ardakani, Josué Jautzy, Guillaume Mathieu

¹Natural Resources Canada, Geological Survey of Canada.

E-mail: nicolas.pinet@nrcan-rncan.gc.ca

Most genetic models for sediment-hosted stratabound copper (SSC) deposits involve: 1) a Cu source associated with thick red-bed sequences or volcanic units; 2) Cu transport through brines that interacted with evaporites, and 3) Cu deposition at redox interfaces commonly linked to the presence of organic matter. In the Maritimes Basin, SSC mineralization occurs at several levels within the Late Devonian to Early Permian sedimentary succession, either above or below the regional Windsor salt and the overlying red-bed units, suggesting that multiple types of mineral systems may coexist. Among the more than 150 SSC occurrences in eastern New Brunswick and northern Nova Scotia, the Dorchester, Canfield Creek, and Goshen drilled prospects illustrate three distinct mineral systems. The Dorchester prospect is located above a salt dome, within the Boss Point Formation, near the regional-scale disconformity/unconformity with the underlying Mabou Group. Mineralization is hosted in green ("reduced")

conglomerates and sandstones deposited in a large braided-river system that includes channels containing plant debris. The Canfield Creek prospect lies on the flank of a salt diapir and is hosted by reduced, medium-grained grey fluvial sandstones within a sequence including red mudstones (Malagash Formation). The best-mineralized sandstones contain laminae with very fine plant fragments. The Goshen prospect contrasts with the previously described SSC systems, as it is hosted within a thick polymictic conglomerate unit (Sussex Group) located below the Windsor salt. In this case, the redox interface is not related to autochthonous plant material but to migrated hydrocarbons (bitumen). The absence of thick red-bed sequences beneath the host unit suggests that the Cu source may be associated with basement rocks. The variability of SSC mineral systems has major implications for exploration strategies, which may need to target a regional-scale marker (Dorchester), stacked local depocenters potentially linked to halokinesis (Canfield Creek), or paleo-hydrocarbon reservoirs (Goshen).

Apatite-titanite-zircon geochronology and magmatic sources of the Rivière Noire Intrusive Suite: New insights on the pre-Grenvillian magmatism from REE-rich ultramafic rocks in the central Grenville Province

Federico Pingitore¹, Bertrand Rottier¹, Abdelali Moukhsil², Marc Constantin¹, Kyle Larson³

¹Laval University, ²Ministère des Ressources naturelles et des Forêts, ³University of British Columbia.

E-mail: federico.pingitore.1@ulaval.ca

The Rivière Noire Intrusive Suite (RNIS) outcrops in the central-western Grenville Province (Québec), crosscutting the Lac Saint-Jean Anorthosite Suite (LSJAS, 1157–1142 Ma). This magmatic event, part of the voluminous anorthosite–mangerite–charnockite–granite (AMCG) magmatism that postdates the Shawinigan Orogeny (1190–1140 Ma) and predates the Grenvillian orogeny (1090–980 Ma), is still poorly constrained in geodynamic and petrologic terms. The RNIS is an alkaline complex formed by Ba–Sr-enriched ultrapotassic rocks, consisting of clinopyroxenitic cumulates enriched in titanite, apatite, and allanite, with REE concentrations up to 0.3 wt.%. These cumulates are crosscut by mafic- to alkali-syenite dykes and pegmatitic-aplitic syenite dykes. According to recent models, these types of REE-rich ultramafic cumulates may represent the deep portions of alkalic-carbonatic systems in post-orogenic geodynamic settings. LA-ICP-MS U–Pb dating on titanite and apatite grains from clinopyroxenite revealed distinct age populations, with titanites yielding dates of 1132 ± 20 Ma, interpreted as crystallization ages, whereas younger ages recorded by other titanite (1067 ± 8 Ma) and apatite (933 ± 8 Ma) grains are interpreted respectively as resetting and cooling events during and after the Grenvillian orogeny. LA-ICP-MS U–Pb–Hf isotopic analyses of zircon from alkali-syenite and pegmatitic-aplitic syenite dykes yield a crystallization age at ca. 1120 Ma and $\epsilon_{\text{Hf}} \sim +4.5$. Based on its high-LILE, low-HFSE composition and Hf isotope signature, the RNIS is interpreted to be generated by low-fraction melting of a metasomatized mantle previously enriched in Ba–Sr–LREE, with a negligible contribution from the Quebec terrane. The ϵ_{Hf} values of the RNIS follow the same evolutionary array as Hf isotope data from other LSJAS-related rocks. Together with their spatial and temporal proximity, these data point toward a shared magmatic source for these events. The RNIS represents the earliest pre-Grenvillian REE-rich alkaline intrusion in the Lac-Saint-Jean region, offering new insights into the geodynamic setting preceding the Grenvillian orogeny.

REE-enrichment in alkaline ultramafic cumulates: New insights on the carbonatite-ultramafic rock paradox from the Rivière Noire clinopyroxenite, Grenville Province, Québec

Federico Pingitore¹, Bertrand Rottier¹, Abdelali Moukhsil², Marc Constantin¹, Alexandra Tsay³, Zoltan Zajacz³

¹Laval University, ²Ministère des Ressources naturelles et des Forêts, ³University of Geneva.

E-mail: federico.pingitore.1@ulaval.ca

The Rivière Noire Intrusive Suite (RNIS) crops out in the central-western Grenville Province (Québec), and its emplacement time (ca. 1130 Ma) predates the Grenvillian orogeny (1090–980 Ma). The RNIS is an alkaline complex formed by Ba–Sr-enriched ultrapotassic rocks, consisting of titanite-apatite-allanite-bearing clinopyroxenite, with REE concentrations up to 0.3 wt.%. Local presence of carbonate-amphibole-rich pockets is interpreted as a result of the crystallization of a late carbonatitic melt. These cumulates are crosscut by syenite dykes and pegmatitic-aplitic syenite dykes. Diopside grains from the clinopyroxenitic cumulates are rich in primary complex inclusions formed by a fluid phase (20–80 vol.%) and solid phases. Microthermometry, Raman spectroscopy, and LA-ICP-MS were performed on these inclusions. The fluid phase appears to be of intermediate salinity (< 18 wt.% NaClEq) K–Na–Cl–H₂O-bearing fluids, and Raman spectroscopy indicates that the daughter phases are dominated by hydrated carbonates and titanites. The LA-ICP-MS analyses of those complex inclusions reveal strong enrichment in K, Ca, Sr, Ba, S, Cl, and Ti with low concentrations of Si, Mg and Fe. These results imply that the diopside crystals have crystallized from a Si-poor melt enriched in CO₂, LILE (large ion lithophile elements) and sulphates. In addition, analyses of diopside, titanite, apatite, and allanite have an unusual sinusoidal REE pattern marked by La and Ce depletion compared to Pr and Nd, and by Yb and Lu enrichment. This is characteristic of crystallization of those minerals by carbonatite metasomatism. Carbonatite metasomatism is a proposed model in which carbonatitic melt acts as an agent of metasomatism, interacting with silicic host rock types to form “antiskarns” dominated by diopside, apatite, and titanite. This model explains the sinusoidal REE patterns of the minerals and the complex fluid inclusions observed in diopside. Nevertheless, the euhedral aspect of diopside grains, their Mg–Fe compositional core-rim zoning, the lack of aegirine compositions and the absence of any evidence of metasomatic reactions with the host rock challenge the metasomatic model.

Refining the timing of the Late Ordovician sediment deposition in southern Québec and Ontario using K-bentonite tephrochronology

Héloïse Pinon¹, Claire Musajo², Andrea Boscaini¹, Morgann G. Perrot², Alain Tremblay¹, Galen P. Halverson², Joshua H.F.L. Davies¹

¹Université du Québec à Montréal, ²McGill University.

E-mail: pinon.beloise@courrier.uqam.ca

The St. Lawrence Platform in southern Québec, Ontario and New York State comprises Cambrian–Ordovician carbonate and siliciclastic units interbedded with altered volcanic ash layers, called K-bentonites. The sequence reflects the opening of a large ocean basin in response to extensional tectonics following the Grenville orogeny, and its closure during the Appalachian orogeny. In the Montreal area, the Late Ordovician stratigraphic sequence includes the Black River and Trenton groups, in which alternating limestones, dolomites and shales record a stepwise deepening from restricted lagoonal conditions through shallow open marine to deep outer shelf environments. These units and their equivalents all host bentonite beds. However, correlation between formations across the different areas is sometimes difficult to achieve. To improve these regional correlations and to understand the complex tectonomagmatic and stratigraphic evolution of the St. Lawrence Platform, precise temporal constraints for the deposition of Cambrian–Ordovician sedimentary sequences is required. We have attempted to generate these temporal constraints using bentonites as these units contain pristine zircon crystals. Eight bentonite beds have been sampled in the Trenton Group within Montreal Island, whereas two beds were collected further north in Québec and ten beds in Ontario. LA-ICP-MS data (320 grains dated) from Montreal bentonites show mostly Ordovician ages (ca. 450 Ma) and few inherited ages (1202–998 Ma) suggesting contamination by Laurentian basement rocks (Grenville orogeny). Zircons from Québec and Ontario were selected for high-precision CA-ID-TIMS U–Pb geochronology. Even though all samples show dispersed age spectra, suggesting antecrystic and xenocrystic recycling of zircons in the magmatic system, our data suggest that the deposition of the Black River Group occurred over a longer period of time than previously estimated and that the Trenton Group is younger than currently suggested by biostratigraphy. Our results re-evaluate the time frame of basin evolution, as well as late Ordovician climatic and biological events in eastern North America.

Constraining the thermal history of the Liard Basin, Northwest Territories

Tais F. Pinto¹, Eva Enkelmann¹, Elco Luijendijk², Talha Qadri³

¹University of Calgary, ²University of Bergen, ³Northwest Territories Geological Survey.

E-mail: tais.fontespinto@ucalgary.ca

The Liard Basin is located within a complex structural setting, including the Paleozoic Liard Transfer Zone and Bowie Structure, and Mesozoic–Cenozoic structures related to the Cordilleran orogeny. These structures played an essential role in the basin's evolution by controlling sedimentation and erosion. However, the extent to which these structures influenced the development of the current hydrocarbon and geothermal energy resources observed in the basin remain unknown. Our objective is to constrain the thermal history of the Liard Basin and explore the relationship between tectonic evolution and energy resources using low-temperature thermochronology. We use zircon (U–Th)/He dating to constrain when rocks last experienced temperatures between 140–200°C. We then perform thermal history modeling to resolve the timing of maximum heating, often associated with burial or hydrothermal activity, and the timing and rates of cooling, often linked to exhumation. Samples were collected from the undeformed basin east of the Cordilleran deformation front and the deformed basin within the Cordilleran fold-and-thrust belt to the west. We analyzed 19 sedimentary samples from outcrops and boreholes, with depositional ages encompassing Devonian, Carboniferous, Triassic and Cretaceous. Most rocks (Devonian, Carboniferous) yield single-grain dates both younger and older than their depositional ages, suggesting post-depositional burial to 140–200°C (partially reset). Some samples (Carboniferous, Cretaceous) yield dates that are mostly older than deposition, suggesting maximum burial < 140°C (not reset). Three samples (Carboniferous, Triassic) yield dates that are younger than deposition, indicating burial to > 200°C (reset). Overall, samples in the west of the fold-thrust belt yield younger dates than the eastern samples. Preliminary thermal history modelling of western reset samples show that Carboniferous strata experienced peak heating in the Jurassic, followed by rapid earliest Cretaceous cooling. Triassic strata show similar Jurassic burial but with Early Cretaceous peak heating and rapid earliest Late Cretaceous cooling. Further thermal history modelling will determine if similar patterns exist across the Liard Basin.

Influence of basement structures on the burial and exhumation histories of the Western Canada Sedimentary Basin and Canadian Shield, Northwest Territories

Tais F. Pinto¹, Eva Enkelmann¹, Tobias Stephan², Luke Beranek³, Joel Padgett¹, Viktor Terlaky⁴, Talha Qadri⁴

¹University of Calgary, ²Lakehead University, ³Memorial University of Newfoundland, ⁴Northwest Territories Geological Survey.

E-mail: tais.fontespinto@ucalgary.ca

Inherited basement structures influence the evolution of overlying basins by controlling accommodation space and driving differential exhumation. In the Western Canada Sedimentary Basin, the role of underlying Canadian Shield structures on the basin's evolution remains poorly understood. Such influence is expected given the complex Phanerozoic history of western North America, which includes rifting, passive margin establishment, development of an active margin, and Cordilleran orogeny and foreland basin evolution. To investigate how inherited structures controlled the basin response, we combine stratigraphic cross-sections that identify fault reactivations with low-temperature thermochronology on basin strata and basement rocks from the eastern basin edge in the Northwest Territories. This approach allows us to constrain upper-crustal processes such as burial, exhumation, and hydrothermal activity that thermally affected the area within a temperature range of 55–200°C. Our thermal history models reveal that both basin and shield experienced Late Devonian–Mississippian peak burial to > 120°C, attributed to a combination of sedimentary burial and elevated geothermal gradients. Subsequent exhumation phases differ based on the position relative to the modern basin edge: the exposed basement to

the east records slow exhumation starting in the Mississippian, while strata and basement to the west remained at high temperatures until Late Cretaceous–Cenozoic exhumation. This contrasting pattern reflects Phanerozoic reactivation of basement structures such as the Wopmay fault zone and Great Slave shear zone, influences from basin subsidence and differential exhumation. The slow exhumation matches previous shield observations, while the later exhumation relates to Cordilleran-related unconformities in the foreland basin. These findings reveal greater Late Devonian heating than previously recognized and suggest that the Cordilleran orogeny influenced the basin > 400 km east of the ancient convergent margin. This demonstrates that inherited structures controlled the basin's response to Phanerozoic tectonic events and highlights the ability of thermochronology to reconstruct basin evolution in settings of sparsely preserved stratigraphic records.

Mineral paragenesis and implications for timing of mineralization at the Lac Cinquante U deposit, Nunavut

Ryan Pippy¹, Erin Adlakha¹, Gracie Avery¹, Jeremy Powell², Victoria Tschirhart²

¹Saint Mary's University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: ryan.pippy@smu.ca

The Lac Cinquante uranium deposit in Nunavut is hosted in Archean basement rocks of the Hearne Craton and overlying basal conglomerates of the 1850–1750 Ma Baker Lake Basin. Previous work classified the deposit as a structurally controlled, simple vein-hosted uranium deposit that formed at 1828 ± 29 Ma (U–Pb uraninite) at temperatures of 230–350°C (chlorite geothermometry). However, our initial results indicate that the deposit is better classified as a Na-metasomatic uranium deposit considering the mineral paragenesis revealed by micro-X-ray fluorescence mapping and classic petrographic techniques. This work provides an updated mineral paragenesis of the deposit, in conjunction with in-situ U–Pb dating on paragenetically constrained apatite and carbonates using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Additionally, electron probe micro-analysis provides major element data for chlorite and uraninite to constrain mineral species, and to calculate alteration assemblage temperatures of formation using established geothermometers and potential chemical ages, respectively. These results will provide important constraints on the timing and temperature of different stages of mineral paragenesis during the formation of the deposit and add to our understanding of the duration of hydrothermal activity in albitite-hosted uranium systems. Early alteration is characterized by albitization alteration of host rock plagioclase. This is followed by potassic-iron alteration of alkali feldspars producing hydrothermal muscovite with base metal (Fe–Cu–Zn–Pb) sulphides. Lastly, albite, dolomite, hematite, apatite, uraninite, zircon, brannerite, chlorite, and calcite formed as open-space infilling. Uranium is present as uraninite, brannerite, and becquerelite, as well as in hydrothermal U-rich zircon crystals (up to 25 wt.% U). Textural evidence indicates the replacement of base metal sulphides by uraninite, suggesting that reduced Fe from sulphides provided a redox trap for uraninite deposition at low temperatures (250–360°C based on Al-in chlorite geothermometry).

Petrogenesis of lithium-cesium-tantalum pegmatites in the northwest Superior Province, Ontario

Emma Pluister^{1,2}, Steve Beyer², Christopher Spencer¹, Evelyne Leduc¹, Aaron Shugar¹

¹Queen's University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: e.pluister@queensu.ca

The research presented will outline how the petrogenesis of multiple lithium-cesium-tantalum (LCT) pegmatites in the northwest Superior Province is being studied. Three pegmatites are being studied, namely Pennock, Spark and PAK, which are emplaced along the Bearhead shear zone. To determine if the nearby granite is the host source, a variety of geochemical analytical techniques are underway. Analyses of spodumene, quartz and micas use X-ray fluorescence, silicate line BrF₃ extraction and electron probe micro-analysis (EPMA), along with several other techniques. The $\delta^{18}\text{O}$ values in the quartz vary, ranging from 8.9 to 13.2‰. $\delta^2\text{H}$ from mica grains varies widely between pegmatites (ranges of up to -40‰). Additionally, within individual pegmatites, there is variability in $\delta^2\text{H}$ values, e.g. -43 to -95‰ in the Spark pegmatite. Preliminary findings suggest that the Pakeagama Lake granite is likely the host to the pegmatites. Determining the source of these pegmatites will help guide exploration to discover if more examples exist in this area and better understand their origins.

Mitigating ocean acidification with alkalinity: Roles for mineral chemistry

Kristin M. Poduska

Memorial University of Newfoundland.

E-mail: kris@mun.ca

Even though large-scale carbon dioxide removal (CDR) technologies are not yet well-developed and bring a range of risks, they are also recognized as an integral part of any strategy to successfully limit global warming. There is a critical knowledge gap in understanding the kinetics and mechanisms of mineral formation and degradation in the context of potential technologies that are targeted for CDR. For example, different approaches to ocean-based alkalinity enhancement involve processes that depend on mineral surface and interfacial chemistry in order to increase water pH with concomitant atmospheric carbon removal. Crystallization and dissolution of oxide, hydroxide, and carbonate minerals figure very prominently in these processes. In this context, I will describe my team's work related to tracking changes in carbonate mineral phases, including surfaces and bulk structures, due to dissolution and recrystallization processes. In doing so, I will emphasize the urgent need for collaborations between researchers who do foundational mineral chemistry studies with those involved in developing monitoring, reporting, and verification protocols for potential carbon dioxide removal strategies that could also mitigate ocean acidification.

Petrogenetic implications from the Mercer and St Charles anorthosites in the Central Metasedimentary Belt, western Grenville Province, Ontario

Stephen Prevec

Rhodes University.

E-mail: s.prevec@ru.ac.za

Two small massif-type anorthosites intrude the ca. 1.24 Ga West Bay Pluton, hosted in Mesoproterozoic paragneisses of the Parautochthonous Belt in the Grenville Province, along the Nd model age boundary between Barilia and Laurentia defined by other researchers. The St Charles anorthosite lies to the north and west of the Barilia-Laurentia model age boundary, in notionally an Archean foreland, whereas the Mercer anorthosite, about 20 km to the southeast, lies to the east and south of the model age boundary in Paleoproterozoic accreted arc basement. The geochemistry of the anorthosites is entirely consistent with their composition as plagioclase cumulates, but with somewhat more trace element enrichment in the Mercer body. The U–Pb zircon geochronology indicates that the two intrusions were emplaced simultaneously at ca. 1245 Ma with concordant but very imprecise ages as a consequence of Grenville-aged episodic lead-loss resulting in very shallow discordia. The Sm–Nd isotopic compositions are consistent with contamination of a lightly enriched mantle source ($\epsilon_{\text{Nd}} \sim 0$) for the St Charles anorthosite by < 10% bulk average Archean crust, and contamination of the Mercer anorthosite by ~20% or less Proterozoic crust, consistent with their spatial positioning and their trace element geochemistry. The anorthosites apparently sampled distinctly different-aged crustal basements as proposed based on the surrounding Nd model ages. The geochemistry is consistent with derivation of the anorthosites from a basaltic parent magma composition. The composition of the contemporary Sudbury dyke swarm could represent residual liquids from this process. The anorthosite massifs have been extensively deformed and show evidence for metamorphic replacement of primary intercumulus pyroxenes by amphiboles, now mantled in some cases by garnets as a result of high-grade prograde metamorphism. This is consistent with emplacement of elements of an anorthosite–mangerite–charnockite–granite suite at ca. 1.24 Ga in a late- or post-orogenic setting.

Revised interpretations of low-grade domains along the Snowbird tectonic zone at Angikuni Lake, Nunavut, based on new U–Pb geochronological and C isotopic data

Taggart Priddell¹, Kathryn Bethune¹, Jamie Cutts², Sally Pehrsson², Joshua Laughton², Andrey Bekker³

¹University of Regina, ²Natural Resources Canada, Geological Survey of Canada, ³University of California Riverside.

E-mail: taggart.priddell@gmail.com

The Snowbird Tectonic Zone (STZ) is a major crustal-scale structure separating the Archean Rae and Hearne cratons of the western Churchill Province. In the Angikuni Lake area, several low-grade supracrustal assemblages are preserved within fault-bounded domains along this structure. However, whether these sequences are Archean or Paleoproterozoic, and how they relate to the evolution of the STZ, remain uncertain. This study utilizes legacy mapping and new field observations (2025), U–Pb zircon geochronology, and carbon isotope data, to revise existing maps and the related lithostratigraphic framework of the supracrustal domains termed Domain 1 and Domain 3. Previous studies identified domains 1 and 3 as structurally bounded, low-grade supracrustal domains composed mainly of volcanogenic, metasedimentary and local carbonate units, separated by a high-grade domain, making them key targets for investigating stratigraphic relationships along the STZ. Felsic volcanic units from domains 1 and 3 yielded ages of 2667 ± 8 and 2678 ± 8 Ma, respectively; the Domain 1 age is consistent with ages from the Yathkyed Greenstone Belt, whereas the comparable age in Domain 3 suggests shared timing of volcanism between the two domains. Detrital zircon analyses from psammitic-metagreywacke units intercalated within the Domain 1 volcanic rocks return maximum depositional ages (MDA) between 2705 and 2680 Ma, whereas a basal metaconglomerate in Domain 3 returned a MDA of 2709 ± 7 Ma. Relatively thick carbonate units in domains 1 and 3 display $\delta^{13}\text{C}$ values inconsistent with the ca. 2.22–2.06 Ga Lomagundi carbon isotope excursion, although early Paleoproterozoic deposition cannot be excluded. Two metaplutonic samples from Domain 1 record overlapping crystallization ages of ca. 2700 Ma, suggesting emplacement prior to deposition of supracrustal successions. Together, these results provide new constraints on the stratigraphic architecture and timing of supracrustal deposition in the Angikuni Lake area, contributing to improved understanding of the tectonic significance of the STZ within the Archean–Paleoproterozoic assembly of Laurentia.

Trace elements and volatiles in apatite from the Galaxy and Whabouchi pegmatite fields, Eeyou Istchee Baie-James, Québec

Marie Quénéa, Stéphane De Souza, Joshua H.F.L. Davies, Rocio Pedreira Pérez

Université du Québec à Montréal.

E-mail: quenea.marie@courrier.uqam.ca

Galaxy and Whabouchi are two major spodumene-rich pegmatite deposits in the Eeyou Istchee (James Bay) area of Quebec, which are poorly known in terms of magmatic evolution and mechanisms of Li concentration. Apatite, which is ubiquitous in these pegmatites, is a key mineral for tracing their magmatic and hydrothermal evolution due to its ability to incorporate F, Cl, S and certain rare earth elements (REE). The pegmatites and granites of the Galaxy deposit area were sampled along a north-south section (30 km), together with granitic pegmatites of the Whabouchi deposit, to characterize and compare the chemical composition of apatite. In the Galaxy area, two generations of pegmatites are defined on the basis of field mapping, with an older group oriented east-west and a younger group oriented north-south. The pegmatites are hosted in metasedimentary rocks ranging from migmatites derived from paragneiss (in the south), to greenschist- and amphibolite-facies clastic sedimentary rocks (in the north). The pegmatites exhibit mineralogical zoning from south to north, evolving from biotite-muscovite-garnet-tourmaline to muscovite-garnet-tourmaline $\pm$ beryl and to

spodumene-columbite-tantalite. At Whabouchi the pegmatites intrude amphibolite-facies mafic volcanic rocks. All apatite grains are composed of Cl- and S-poor, OH-rich fluoroapatite. In the spodumene-barren E-W and N-S pegmatites, they are REE-rich and show a strong negative Eu anomaly ($\text{Eu}/\text{Eu}^* \sim 0.03$), whereas those from spodumene-bearing pegmatites are less enriched in REE and show a strongly positive Eu anomaly ($\text{Eu}/\text{Eu}^* \sim 12.90$). Apatite from the E-W pegmatites has the highest REE content with enrichment in heavy REE ($(\text{La}/\text{Yb})_N \sim 0.65$), whereas the N-S spodumene-barren and spodumene-bearing pegmatites show the opposite, with enrichment in light REE ($(\text{La}/\text{Yb})_N \sim 23.25$). The chemistry of the apatites suggests that they crystallized from a fluid rather than a magma ($\text{Sr}/\text{Y} = 0.002\text{--}56.32$; total light REE < 1800 ppm). The strongly positive Eu anomaly in apatites from the spodumene-bearing pegmatites is unexpected and determining its origin will help elucidate the mechanisms of formation of these important mineralized rocks.

Optimizing mineral phase discrimination and identification in ore samples using micro-X-ray computed topography

Maja Radisic Hoang¹, Steven Li¹, Mya Caverson², Kristin Goodger¹, Ivan Barker¹, Baian Almusned¹, Carolyn M. Hill-Svehla¹, Mark C. Biesinger¹

¹Western University, ²Brock University.

E-mail: chill59@uwo.ca

Micro-X-ray computed tomography (micro-CT) offers a non-destructive means of visualizing the 3D distribution of minerals, grain size, porosity, and textures within geological samples and has significant potential for applications in economic geology and mineral processing. While the technique is often used for structural and textural characterization of rock samples, its use for mineral phase identification remains limited due to difficulties associated with a lack of chemical information (it depends on grey-scale imaging) and standardization of experimental parameters, in addition to imaging artifacts. This ongoing project aims to systematically evaluate the feasibility of using micro-CT to supplement mineral phase identification in various types of ore samples and different sample preparation methods. Progress made and insights gained to date will be presented. The primary goals of the project are to: 1) assess the factors influencing observed variations in X-ray attenuation among common rock-forming and ore minerals, 2) determine optimal, generalized micro-CT operating and processing parameters for different ore samples, and 3) consider sample dimensions and preparation procedures for different mineralogical applications. Key variables investigated include sample grain size and material density, X-ray energy and filtration, voxel size, minimizing beam hardening effects, and segmentation approaches, all of which can influence greyscale contrast and phase discrimination. Micro-CT datasets are calibrated and validated using in-house micro-CT mineral standards prepared at Surface Science Western, in addition to complementary SEM/EDX analyses performed on the same samples to calibrate micro-CT greyscale values against known mineral compositions. The ultimate goal is to support the routine application of micro-CT in mineralogy and mineral processing studies, including gold deportment workflow, as well as geological studies, particularly where 3D mineral associations and textural context are critical to inform interpretations of ore genesis and anticipated mineral processing behaviour.

Re-equilibration of pollucite at the Tanco pegmatite, southeastern Manitoba: Insights from K-feldspar inclusions and pollucite-quartz symplectites

ZaneAldeen Rahabi¹, David Lentz¹, Tania Martins^{1,2,3}, Lee Groat³

¹University of New Brunswick, ²Manitoba Geological Survey, ³University of British Columbia.

E-mail: zanealdeen.rahabi@unb.ca

The Tanco pegmatite in southeastern Manitoba contains multiple lenses of nearly monomineralic massive pollucite and is the site of Canada's only active pollucite mine. However, the origin of massive pollucite mineralization at Tanco and in similar pegmatites worldwide remains enigmatic. To investigate this matter, thin section petrography, micro-XRF analysis, and Raman spectroscopy were performed on samples from Tanco's massive pollucite lenses and from their contacts with common spodumene-quartz intergrowths (SQUI). Thin section petrography revealed two types of K-feldspar inclusions within pollucite, i.e. rare blocky microcline inclusions featuring distinct cross-hatched twinning with only minor white mica alteration and more abundant anhedral, untwinned adularia-like inclusions that contain many white mica inclusions and are surrounded by visible alteration rims in the host pollucite. Standardless quantitative micro-XRF analysis of inclusions and their host pollucite show that microcline inclusions contain more Na and K, but less Rb and Cs than the adularia-like inclusions. Pollucite with microcline inclusions contains more Cs and Al, but less Si, Na, K, and Rb than pollucite with adularia-like inclusions. The former pollucite variety is therefore closer in composition to pure end-member pollucite. Thin section petrography followed by Raman spectroscopy also revealed complex pollucite-quartz symplectites (PQS) along pollucite-SQUI contacts. These observations provide insights into sub-solidus re-equilibration processes in massive pollucite lenses. Much of the pollucite at Tanco was seemingly subjected to low temperature re-equilibration with microcline inclusions, causing Cs loss in pollucite and alteration of microcline to Rb- and Cs-enriched adularia and muscovite. The occurrence of PQS along pollucite-SQUI contacts also suggests the existence of an unstable Al-, Si-, and Cs-enriched phase that broke down into pollucite and quartz during late-stage re-equilibration, which is akin to what has been proposed by other researchers for similar spodumene-quartz symplectites reported at Tanco.

Origin of high pollucite contents in processed quartz from the Tanco pegmatite, southeastern Manitoba

Zane Aldeen Rahabi¹, David Lentz¹, Tania Martins^{1,2,3}, Lee Groat³

¹University of New Brunswick, ²Manitoba Geological Survey, ³University of British Columbia.

E-mail: zanealdeen.rahabi@unb.ca

The Tanco pegmatite in southeastern Manitoba is the site of an active Li and Cs mine, with an on-site ore-processing facility. To investigate whether quartz left over after ore processing could constitute a high-purity quartz product, previous workers assessed the mineralogy of this material using quantitative electron microscope scanning (QEMSCAN). This analysis revealed that the processed material comprises 99.39% quartz, 0.417% pollucite, and 0.193% other minerals. Uniquely high pollucite and Cs contents in processed quartz would make this material unsuitable for high-purity quartz production without additional processing. They also suggested that a non-negligible amount of Cs ore is lost to tailings in association with quartz and possibly other minerals. To determine the origin of high pollucite and Cs contents in processed quartz from Tanco, thin section petrography, micro-X-ray fluorescence (XRF) analysis, Raman spectroscopy, and portable XRF analysis were performed on quartz and pollucite samples from the pegmatite. Thin section petrography and micro-XRF analysis revealed small inclusions of an isotropic Cs-, Al-, and Si-bearing mineral (currently thought to be pollucite) in quartz from Tanco's wall zone. Finely intergrown pollucite-quartz symplectites were also identified along contacts between pollucite and spodumene-quartz intergrowths using a combination of petrography, micro-XRF analysis, and Raman spectroscopy. Finally, calibrated portable XRF analysis of monomineralic quartz samples revealed Cs contents up to 300 ppm, which have no immediately apparent mineralogical source based on petrography and micro-XRF analysis. We theorize that these high Cs values could be related to daughter minerals within melt inclusions, which are abundant in high-Cs samples. These three factors – i.e. Cs–Al–Si inclusions in quartz, pollucite-quartz symplectites, and possible Cs-bearing phases in melt inclusions – are the most probable causes for high Cs contents in processed quartz from Tanco. The observed inclusions have a maximum diameter of ~250 µm, and likely survived processing due to being smaller than the size fraction of the processed material (< 300 µm).

Prograde metamorphic symmetry in the Quetico belt, Superior craton: Insights into the evolution of late Archean ultra-hot orogens

Adrian Rehm¹, Antoine Godet², Doug Tinkham¹, Carl Guilmette³

¹Laurentian University, ²Natural Resources Canada, Geological Survey of Canada, ³Université Laval.

E-mail: adrian.rehm@gmail.com

The 2.7 Ga Quetico subprovince is a prominent 1200 x 100 km metamorphic belt in the central Superior Province and represents one of the largest exposures of siliciclastic metasedimentary rocks globally. It has historically been a centrepiece in advancing subduction-accretion models for the assembly of Neoarchean crust, which numerous recent studies now challenge in favour of plume-sagduction models. Part of the confusion stems from poor constraints on the regional architecture of these belts and the nature and timing of tectonometamorphic events. One of the belt's outstanding features is the symmetry across its long axis: lithotectonic units have similar composition, age, and distribution on its north and south margins and stratigraphy is largely outward facing. The metamorphic sequence, geometry and isograds are mirrored, and strain fabrics remain subvertical from its greenschist-grade margins through its vast granulitic core. Textural relations and phase equilibria modelling indicate that the metamorphic sequence of chlorite, biotite, garnet, staurolite, andalusite, cordierite, sillimanite, in-situ melt, K-feldspar and orthopyroxene is defined by a single protracted clockwise P-T path that is syn- to post-tectonic with respect to the main regional deformation, rather than a series of discrete, contrasting tectonic events. Garnet Lu–Hf ages from the western portion of the belt show symmetry and constrain prograde metamorphism through the garnet to sillimanite zones from ~2680 to 2660 Ma. In the eastern Quetico subprovince, garnet ages in equivalent metamorphic zones appear to be ~10 Ma younger, and peak temperatures in the migmatite zones were reached simultaneously with those in the subsolidus zones. These spatiotemporal features indicate a regional eastward-propagating anticlinorium structure in an ultra-hot orogen setting, characterized by near-field sedimentation, subsidence, and advective ductile flow in the middle and upper crust.

Deep-trench explosive volcanism at the Challenger Deep Forearc Segment, Mariana Trench

Shumyla Rehman¹, Julia Kay Anderson², Renee Rosselot², Matthew Leybourne¹, Robert Stern², Ignacio Pujana²

¹Queen's University, ²The University of Texas at Dallas.

E-mail: 20sr59@queensu.ca

The Challenger Deep, in the southern Mariana Trench, is the deepest point on Earth's solid surface, yet the processes responsible for its extreme depth are poorly understood. During the TN438 research cruise in late 2024, we investigated the northern trench slope of the over-riding plate using the remote operating vehicle Jason/Medea. This area, referred to as the Challenger Deep forearc segment yielded 164 rock samples, most of which are igneous. Forty are young pyroclastic deposits formed by explosive volcanic eruptions at water depths of 5–6.5 km. Volcanism in an oceanic trench is very unusual and these eruptions occurred at depths significantly greater than any previously documented submarine pyroclastic activity. Explosive volcanism at such depths is expected to differ from shallow eruptions due to extreme hydrostatic pressures of ~50–65 MPa. These pressures inhibit the expansion of exsolved magmatic volatiles, particularly H₂O and CO₂, which exist as supercritical fluids with small molar volumes rather than as steam. Six breccias collected during Jason/Medea dives 1674–1676 were studied by undergraduate researchers at Queen's University and University of Texas at Dallas using petrography, electron microprobe analysis, and whole-rock major and trace element geochemistry. Thin sections reveal distinctive clasts and matrices indicating one or two brecciation events, along with abundant fresh and altered glass. Glass comprises approximately 70% of the samples, with roughly equal proportions of fresh and altered material. The mineral assemblage consists of orthopyroxene, clinopyroxene and plagioclase. Electron microprobe analyses of glass indicate SiO₂ contents ranging from 55–75 wt.%, reflecting significant compositional variability

from basaltic to andesitic-dacitic compositions. Electron microprobe analyses ($n = 78$) indicate predominantly subalkaline compositions spanning basaltic andesite to rhyolite (76 analyses), with two trachytes. The formation mechanism of these unusual “double breccias” is unknown, and this study aims to clarify processes driving this atypical deep-trench volcanism within the western Challenger Deep forearc segment.

Timing and geometry of Laurentide Ice Sheet retreat along the Labrador coast

Jessey Rice¹, Roger Paulen¹, Heather Campbell², Maria Schaarschmidt³, Olav Lian³, John Gosse⁴, Pierre-Marc Godbout¹, Etienne Brouard¹

¹Natural Resources Canada, Geological Survey of Canada, ²Geological Survey of Newfoundland and Labrador, ³University of the Fraser Valley,

⁴Dalhousie University.

E-mail: jessey.rice@nrcan-mrcan.gc.ca

Over three field seasons (2022–2024), surficial mapping was conducted across a ~58 000 km² area of coastal Labrador centred on Hopedale, Postville, and Makkovik as part of NRCan's Geo-mapping for Energy and Minerals GeoNorth program, in collaboration with the Geological Survey of Newfoundland and Labrador. One goal of this activity was to fill knowledge gaps and better constrain the timing and geometry of ice-marginal positions during deglaciation of the Labrador coastline. To better constrain the timing of deglaciation along the Labrador coast, geochronological samples were collected, and ages were obtained from multiple dating methods. Optical dating of K-feldspar with infrared stimulated luminescence methods ($n = 12$) was applied to fine-grained aeolian and littoral sediments. Terrestrial cosmogenic nuclide exposure dating (using ¹⁰Be; $n = 18$) was applied to erratic boulders at seven different sites. Radiocarbon (¹⁴C) dating was applied to marine shells from a single deposit of raised glaciomarine silts near Makkovik. Additionally, surficial mapping using aerial photographs and remote sensing data was supplemented with field investigations to identify geomorphological constraints on ice-margin position, and samples were collected to geochemically assess differing depositional environments (i.e., marine versus lacustrine). Preliminary geochronological results indicate that deglaciation occurred 1–3 ka later than previous reconstructions suggest, but results are consistent with previously reported ¹⁴C dates. Additionally, surficial mapping results indicate a more complex pattern of deglaciation than previously inferred, with the identification of a previously unreported proglacial lake, named Glacial Lake Siugak (from the Inuktitut word for “sand”). The pattern of ice-margin retreat was asymmetrical throughout glaciation, influenced by regional topography, variations in marine limit, and ice dynamics within the Québec-Labrador sector of the Laurentide Ice Sheet. These findings have implications for refining regional deglacial models and our overall understanding of deglacial dynamics along coastal settings.

Advances in quantitative X-ray diffraction for mineralogical fingerprinting and domain classification in complex ore systems

Ivan Rodriguez Duran, Marie-Eve Provencher, Sheida Makvandi, Uwe Konig

Malvern Panalytical Co.

E-mail: ivan.rodriguez.duran@malvernpanalytical.com

Quantitative X-ray diffraction (QXRD) has become a key analytical technique for generating reproducible, high-resolution mineralogical datasets that inform both structural and textural interpretations of ore systems. Its ability to rapidly quantify crystalline phases with minimal sample preparation, coupled with recent advances in automated pattern recognition, makes QXRD uniquely suited for mineralogical fingerprinting and spatial domain classification across diverse geological environments. When combined with multivariate statistical tools such as cluster analysis and principal component analysis, QXRD enables objective identification of mineralogical domains that complement petrographic and geochemical observations. This presentation highlights recent applications of QXRD in geologically complex systems where mineralogical variability governs ore distribution and alteration processes. In volcanogenic massive sulphide deposits, extended cluster analysis applied to QXRD datasets reveals subtle gradients in chlorite-sericite-quartz assemblages that define alteration halos and zoned hydrothermal footprints. In epithermal-porphyry deposits, mineralogical fingerprints derived from QXRD analyses show systematic shifts in clay, feldspar, and carbonate phases that correspond to crystallographically diagnostic alteration stages. Case studies on heavy mineral sands and copper ore processing demonstrate how real-time diffraction-based mineral quantification can be used to support operational decision-making, including assessment of mineral liberation and optimization of feed blending strategies. For lithium and nickel ore deposits, rapid identification of key phases such as spodumene, smectite or serpentine improves process control and recovery prediction. Since QXRD can be performed on compact X-ray diffraction instruments, mineralogical data can be generated directly in field laboratories or core sheds, enabling near-real-time support for geological logging and mineral domain modelling. These examples highlight the growing role of QXRD as an essential crystallography-driven tool for mineralogical characterization and domain definition in modern geoscience.

Trace element chemistry of arsenopyrite in orogenic Au deposits: A global-scale study

Martin Roglic, Georges Beaudoin, Bertrand Rottier

Université Laval.

E-mail: martin.roglic.1@ulaval.ca

Arsenopyrite is one of the dominant sulphide minerals, alongside pyrite, in orogenic gold deposits. It is an important indicator of gold mineralization with great potential to host gold in its crystal lattice, which has been the focus of previous studies. It has also been investigated for its capability to host significant amounts of other trace elements, reflecting ore-forming conditions and acting as an indicator mineral for gold deposits on a district to regional scale. The purpose of this study is to determine the trace element composition of arsenopyrite from orogenic gold deposits on a global scale, with implications for provenance recognition. This was accomplished by in-situ laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) spot analyses of 107 arsenopyrite-bearing samples sourced from 51 orogenic gold deposits worldwide. Arsenopyrite was examined for zonation

and microinclusions by scanning-electron microscopy (SEM), and major element variations were determined by electron probe microanalysis (EPMA). The pre-processing of geochemical data ($n = 1143$ LA-ICP-MS spots) yielded nine key trace elements important for statistical analyses: Co, Ni, Se, Mo, Sb, Te, Au, Pb and Bi. Behaviour of these trace elements was compared to host rock composition (felsic, intermediate, mafic-ultramafic, sedimentary), host rock age (Archean, Proterozoic, Phanerozoic) and metamorphic facies (amphibolite, greenschist, unmetamorphosed) through principal component and partial least-square discriminant analyses (PCA and PLS-DA). The PCA method revealed clustering of chemical element data into three groups: 1. Co–Ni, 2. Pb–Mo–Bi, and 3. Sb–Au–Se–Te. The PLS-DA method discriminated trace element groups whose variation is primarily driven by different host rock types, rather than by metamorphic grade or age. In conclusion, this study demonstrates the potential of arsenopyrite trace element chemistry for constraining provenance, and its development into an indicator mineral methodology in exploration for orogenic Au deposits.

Automation of potential carbon storage reservoir identification using density based semi-supervised machine learning

Ben Roque, Alison Malcolm, J. Kim Welford, Kate A. Waghorn

Memorial University of Newfoundland.

E-mail: broque@mun.ca

Carbon storage in the subsurface is a major avenue for the global energy transition to net zero. The offshore of Canada contains several promising regions for carbon storage, notably the Jeanne d'Arc Basin, offshore Newfoundland. Due to the Jeanne d'Arc Basin being rich in oil and gas reserves, highly detailed 3D seismic records have been acquired by industry, with direct information (ground truth) available from regularly spaced exploratory wells. Using machine learning, we have automated the procedure for identifying the tops of reservoirs with strong potential for carbon storage based on seismic data character. We employ a semi-supervised machine learning model incorporating a density-based algorithm. The model is trained using lithological data extracted from well logs which are tied to the seismic data.

Design and automated detection of multimodal calibration targets for drill core imaging spectrometry

Michel Rosener, Randal Power, Nicholas Kelly, Kele Miguel, Stewart Sharpe

College of the North Atlantic.

E-mail: michel.rosener@cna.nl.ca

Imaging spectrometry of drill core is increasingly being used for mineral mapping and deposit characterization. At the College of the North Atlantic, we operate a container-based hyperspectral core scanner that integrates five imaging spectrometers (covering visible near-infrared, shortwave infrared, medium wave infrared and long-wave infrared domains), a high-resolution digital (RGB) camera, and a 3D laser profiler. During acquisitions, a calibration panel runs every 40 minutes to account for drifts and changes in operational conditions. Past acquisition campaigns did not systematically embed reference materials within individual scans, and challenges in co-registering datasets acquired by sensors with different geometries and spatial resolutions were also encountered. To address these limitations, we developed calibration and referencing targets inspired by conventional imaging practices. These targets were designed for detection by all sensors and combine reference materials arranged in a structured layout for automated extraction and quality assurance/quality control, with purpose-built 3D binary markers that enable robust spatial detection and inter-sensor co-registration. A python-based processing pipeline (operating software) was implemented to automate target detection, reference spectrum extraction, and geometric alignment of multimodal datasets. The first prototype was deployed during a 2025 acquisition campaign, and preliminary results will be presented here.

Till provenance and dispersal analysis using statistics and machine learning techniques: Implications for mineral exploration

Martin Ross¹, Oliver Baker¹, Jessey Rice², Roger Paulen², Eric Grunsky¹, Beth McClenaghan²

¹University of Waterloo, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: maross@uwaterloo.ca

Numerous case studies using glacial sediments show clear surficial dispersal patterns of selected indicator minerals and geochemical pathfinders extending in the dominant down-ice direction from a known source. The surface area of these dispersed pathfinders is often several times the size of the mineralized body. The approach seems straightforward, but it can be challenging in regions that experienced major shifts in ice-flow direction or contrasting subglacial conditions or are characterized by variable bedrock geology. Establishing the relative contribution of different bedrock source regions to the overall till composition, as opposed to focusing exclusively on specific dispersal patterns of interest, is one strategy to improve till dispersal analysis and interpretation to potentially increase exploration success in such regions. The goal of our study was to test the application of multivariate statistical analysis and machine learning techniques in such complex settings to map surficial till compositional assemblages and estimate the relative proportions of contrasting bedrock source rock types (e.g., felsic versus mafic igneous) in the till's geochemical makeup. Specifically, we used principal component analysis and a 'soft' clustering technique, the Gaussian Mixture Model, as well as Random Forest (a supervised classification method), to map tills with distinct compositions and provenance. We used till matrix geochemistry, whole-rock geochemistry, and airborne radiometric data from government datasets as input. Results are interpreted in their spatial and geological context, both in terms of bedrock geology sources and glacial history. We also compared our results with the traditional approach of mapping selected pathfinders. Tills with contrasting composition are identified, and results provide insights into the relative contributions of different bedrock source regions, which help determine whether the till is mostly derived from proximal or distal sources (a common key question in mineral exploration) and whether it contains low or high levels of compositional inheritance from older ice-flow phases.

Mineral textures in orogenic gold systems: Still more to learn

Bertrand Rottier¹, Maxime Bertauts¹, Giovanni Pedemonte Castro^{1,2}, Georges Beaudoin¹, Crystal Laflamme¹

¹Université Laval, ²GFZ Helmholtz Centre for Geosciences.

E-mail: bertrand.rottier@ggl.ulaval.ca

Orogenic Au veins are generally interpreted as having formed according to the well-established fault-valve model, typically under greenschist facies P-T conditions. In this model, cyclic seismogenic ruptures allow deep hydrothermal fluids to ascend, whereas vein sealing during aseismic periods leads to progressive fluid-pressure build-up. As a result, orogenic Au veins record multiple successive episodes of crystallization and deformation. Both types of episodes are critical for Au mineralization: crystallization is associated with primary gold deposition, whereas deformation is linked to gold remobilization and upgrading. However, distinguishing these successive episodes within vein minerals is challenging due to the cyclic nature of the fault-valve process. Nevertheless, such identification is essential for interpreting trace-element and isotopic data of vein minerals within the framework of the fault-valve model. Quartz, tourmaline, and pyrite are among the most important minerals in orogenic Au veins, and each is characterized by distinct physical behaviour during deformation and fluid circulation under greenschist P-T conditions, and therefore each mineral records different aspects of vein evolution. Quartz deforms plastically, and euhedral zoned grains – evidence of crystallization episodes – are rarely preserved as most quartz grains are strongly deformed and thus primarily record deformation events. In contrast, tourmaline typically forms well-zoned grains, behaves in a brittle manner, and is relatively unreactive during deformation, meaning it preserves information about crystallization episodes rather than deformation. Pyrite, like tourmaline, forms well-zoned grains and is more brittle than quartz, but unlike tourmaline it is affected by dissolution-recrystallization processes during or after active fault-valve deformation. This is expressed by minor grain deformation and prominent dissolution-reprecipitation textures associated with Au remobilization. Using examples from orogenic gold veins in the Val-d'Or vein field, we highlight the importance of deciphering mineral textures to properly interpret trace-element and isotopic data, as well as the mechanisms of Au precipitation and remobilization.

The structural evolution of the South Tibetan Detachment System, Nar Valley, central Nepal Himalaya: Insights from microstructures and in situ geochronology

Shreya Roy, Danny Richard, Kyle Larson

University of British Columbia Okanagan.

E-mail: shreya.roy@ubc.ca

The South Tibetan Detachment System (STDS) in the Himalaya comprises a series of orogen-parallel, normal-sense shear zones that accommodated tens of kilometres of crustal displacement during the continental collision. The STDS typically occurs as a structurally lower ductile shear zone and a discrete brittle upper fault, although the discrete brittle fault does not occur everywhere along the strike of the Himalaya. What conditions favour the generation of the upper structure are not yet known. Field observations reveal that the STDS in the Nar Valley, central Nepalese Himalaya, is a distributed ductile shear zone predominantly composed of calc-silicate gneiss, marble, and leucogranitic dykes, along with subordinate garnet-mica schist and migmatite. Although small-scale brittle structures are locally observed at higher structural levels, no discrete brittle structure was identified. At lower structural levels, major rock-forming phases, including diopside, amphibole, and plagioclase, exhibit retrograde microtextures. Flow stress estimated using sub-grain size piezometry of these phases range from 5–19 MPa. At higher structural levels, calcite is the dominant phase and records a transition from high-temperature dynamic recrystallization to low-temperature mechanical twinning, likely during progressive exhumation. Calcite flow stresses calculated via grain-size and twin density paleopiezometry increase from 13–30 MPa to 80–134 MPa during apparent cooling. Finally, in situ titanite U–Pb geochronology yields dates between 23–18 Ma, consistent with STDS movement elsewhere in the region. Variations in deformation mechanisms, temperature, and flow stress are consistent with progressive strain hardening of the STDS during exhumation. However, the presence of calcite at higher structural levels facilitated continued ductile deformation at relatively low temperatures and shallower crustal levels, precluding the widespread development of a discrete brittle fault. These findings show that lithological heterogeneity was a critical control in the structural evolution of the STDS in the Nar Valley.

Could the lunar magma ocean have been sulphur rich?

Swaraj Roy¹, Don R. Baker¹, Sara Callegaro², Francesco Caraffini²

¹McGill University, ²University of Bologna.

E-mail: swaraj.roy@mail.mcgill.ca

Volatile elements such as sulphur (S) are key to understanding the Moon's interior evolution. We report preliminary sulphur measurements in plagioclase crystals from a lunar meteorite recovered in northwest Africa (NWA 2200). This is a feldspathic breccia in which plagioclase acts as a proxy for the lunar highland crust. These plagioclase crystals are thought to have formed by flotation during the late-stage crystallization of the lunar magma ocean (LMO). Synchrotron X-ray microfluorescence analyses (at the Diamond synchrotron, England) indicate sulphur concentrations in plagioclase of 42 ± 10 ppm. Using an anorthite-melt sulphur partition coefficient (plagioclase/melt Ds) of 0.036 we estimate that the silicate melt from which the plagioclase crystallized had around 1150 ± 200 ppm of sulphur. Adopting published lunar magma ocean cumulate stratigraphy models, in which plagioclase began crystallizing at ~20% residual melt and continued until the very last stage, we infer a primary LMO melt sulphur concentration in the range of ~230 ppm (20% residual melt, after plagioclase crystallization) to ~78 ppm (6% residual melt after plagioclase crystallization). This inferred concentration range is within the existing estimates for the bulk lunar mantle sulphur inventory, which span from 81 ± 15 ppm to ~350 ppm based on results from other published studies. Notably, the evolution of the sulphur content of the residual LMO melt implies that the magma ocean might have been close to sulphide saturation during plagioclase crystallization. These early results suggest that substantial amounts of sulphur could have

remained in the lunar magma ocean even after large-scale sulphur removal during the core formation process, shedding new light on the volatile budget of the Moon and supporting models of limited sulphur loss during lunar differentiation.

Sedimentary and paleontological research in the Tumbler Ridge Global Geopark

Roy Rule

Tumbler Ridge UNESCO Global Geopark.

E-mail: roy.rule@tumbleridgegeopark.ca

The Tumbler Ridge UNESCO Global Geopark, Peace River District, British Columbia, has a long geological record from the Ediacaran all the way to Recent glacial deposits. However, the most complete stratigraphic record within the park belongs to sedimentary strata of the Cretaceous Period (~145–66 Ma). These rocks preserve numerous sites of dinosaur and reptile trackways, providing paleoecological data which greatly expand our understanding of the diversity of life over the course of this time period. In addition, coal-bearing units contain diverse plant fossils recording the botany of the Early Cretaceous, and Triassic rocks contain several fish and marine reptile species including Ichthyosaurs and Coeleacanths. Older Paleozoic rocks include karstic limestones of the Carboniferous Rundle Group, and the Ordovician Skoki Formation. Within the Geopark, we work collaboratively with the Tumbler Ridge Museum Foundation and speleologists to expand our knowledge of the sedimentary and paleontological record. These projects also include the exploration of the basal Kaskapau Formation ichnotaxa (trace fossils), locating and identifying skeletal fossil material, and monitoring cave systems.

Creating a hub for research, industry, education, and culture in Tumbler Ridge UNESCO Global Geopark, British Columbia

Roy Rule, Manda Maggs

Tumbler Ridge UNESCO Global Geopark.

E-mail: roy.rule@tumbleridgegeopark.ca

The Tumbler Ridge UNESCO Global Geopark is a not-for-profit organization that acts as a connective hub where geology, culture, industry, and community life intersect, using its designation as a platform to strengthen both local identity and collective well-being. The Geopark's partnerships extend well beyond conservation and tourism. Collaborations with schools, health and social organizations, local government, industry, academia and cultural groups allow the Geopark to act as a central resource for projects and programs that improve quality of life and our understanding of Earth's history. Industry partnerships help align economic activity with stewardship and community benefit. Through these relationships, the Geopark supports responsible recreation planning and tourism development, demonstrating that industry and working landscapes can coexist alongside UNESCO recognition. UNESCO Global Geoparks are not simply a destination or a conservation label; they are an active social infrastructure that supports community pride, strengthens relationships, and contributes meaningfully to the well-being and identity of a defined area with cultural and geological significance.

Reducing barriers in geoscience education through immersive Virtual Reality (VR): The VR crystals, VR fossils and VR Wainfleet environments

Phillip Ruscica, Nahin Kadery, Alexander Nicholson, Alen Hadzovic, George Arhonditsis, Heidi Daxberger

University of Toronto Scarborough.

E-mail: heidi.daxberger@utoronto.ca

Traditional science instruction relies on 2D images, static models, samples, field trips, or desktop simulations – all essential yet constrained by cost, access, time, and insufficient visualization of complex 3D systems. In disciplines such as mineralogy, inorganic chemistry, and geoscience, students must mentally translate flat representations into 3D structures, limiting spatial reasoning, retention, and confidence. Fully immersive Virtual Reality (VR) offers a transformative experience by enabling interaction with complex 3D systems, VR strengthens spatial understanding, engagement and spatial immersion – at development costs comparable to advanced desktop simulations. Unlike screen-based tools, immersive VR allows learners to move around, manipulate, measure, and interrogate structures from atomic to landscape scales in 3D space. It is not envisioned as a replacement for hands-on science activities, but as an additional tool that also provides opportunities to expand access and advance equity, diversity, and inclusion. The Department of Physical and Environmental Sciences (DPES) at the University of Toronto–Scarborough established the Highly Immersive Virtual Experiences (HIVE) Lab. This initiative integrates affordable, immersive VR into undergraduate geoscience and chemistry curricula and community outreach to serve a highly diverse student population. We present three student-developed VR applications. VR-Crystal is an atomic-scale exploration of crystal structures in which students manipulate lattices, measure parameters, and classify minerals. VR-Fossil uses interactive 3D fossil scans, reconstructions of extinct organisms, and paleoenvironments supporting identification and interpretation. Wainfleet Virtual Fieldwork is a simulated quarry experience using 3D models and drone imagery, in which students map features and identify fossils, preparing for real field trips. Each application lowers physical, financial, and geographic barriers while incorporating inclusive design (e.g. multimodal instructions, inquiry-based tasks, assessments). By complementing laboratory activities and field work, immersive VR enhances accessibility, supports diverse learning styles, and fosters deeper conceptual understanding. Learning outcomes are evaluated through pre- and post-activity surveys, in-laboratory assessments, and reflective exercises.

Revealing exposed and buried seamounts in the northern Atlantic using integrated bathymetric, gravity and seismic data

Md Abdullah Salman, Irina Filina

University of Nebraska Lincoln.

E-mail: asalman4@huskers.unl.edu

Seamounts are prominent geological features that provide important insights into magmatic, tectonic and geodynamic processes. In this study, we present systematic mapping and classification of seamounts across the Northern Atlantic by integrating publicly available bathymetric, gravity and seismic reflection datasets. Seamounts are classified based on their exposure relative to the seafloor (bathymetric or buried). Bathymetry reveals exposed seamounts primarily near the spreading centre while we use gravity data to identify buried or sediment-covered edifices. We filter gravity data to highlight the signal from known bathymetric seamounts. We then identify similar filtered anomaly responses as “gravity seamounts”. To validate these features, we analyzed seismic reflection profiles obtained from the GeoMap App. This allows us to confirm “seismic seamounts” where the structures rise above the basement but within the sedimentary cover. Due to limited seismic coverage, not all gravity anomalies could be validated. Therefore, we categorize seamounts into bathymetric, gravity and seismic ones and compare them with previously published bathymetric seamounts and igneous complexes. Most identified seamounts are predominantly located within the oceanic domain, particularly along the active Kolbeinsey Ridge and the extinct Aegir Ridge. Representative examples from each seamount category are presented to illustrate variations in morphology and geophysical signatures. Comparison with previously documented seamounts and igneous complexes in the Northern Atlantic reveals a greater number of features than previously recognized. This integrated geophysical approach enhances seamount detection and classification and provides a refined framework for future tectono-magmatic investigations in the region.

Topographically controlled deposition and mobility of metal contaminants around a Pb smelter

Sisara Samaradiwakara, Michael Schindler

University of Manitoba.

E-mail: samarads@myumanitoba.ca

Smelting activities contribute to severe metal and/or metalloid contamination in the soil. Particulate matter emitted from a smelter is deposited either via wet or dry deposition. Wet deposition results from the scavenging of finer, more soluble particles during precipitation events, while dry deposition occurs through the gravitational settling of coarser particulate matter. At sites predominantly affected by wet deposition, deposited elements are commonly more mobile, whereas sites impacted predominantly by dry deposition have higher concentrations of emitted elements. There is an additional shadow effect around the smelter, where the peak of the deposition depends on the height of the smelter and occurs circa 5 km from the smelter. High-resolution soil sampling around the Pb smelter in Trail, British Columbia, Canada indicated that spatial distribution, deposition and mobility of Pb, Zn and As in the surficial soils were controlled by the valley topography. Concentrations of Pb, Zn and As in the surficial soils and in leachates allowed us to identify sites predominantly affected by wet and dry deposition. Furthermore, they indicated that the extent of the shadow zone was controlled by valley topography, leading to a shorter shadow zone than in flat terrain. The vertical distribution of Pb, Zn and As was governed by the type of atmospheric deposition (wet or dry) and was most likely also controlled by pH-dependent sorption, co-precipitation or the formation of sorption complexes with Fe oxides and hydroxides, as well as by incorporation into pedogenic minerals.

Nuclear magnetic resonance mineralogy of plagioclase

Luis Sánchez-Muñoz¹, Pierre Florian², José Ignacio Santos González³

¹Museo Nacional de Ciencias Naturales, ²Université d'Orléans, ³University of the Basque Country.

E-mail: lsm@mnncn.csic.es

Plagioclase feldspars ($\text{Ca}_x\text{Na}_{1-x}\text{Al}_{1+x}\text{Si}_{3-x}\text{O}_8$) are among the most abundant minerals in the solar system, yet remain poorly understood because their non-homogeneous, multiscale structural arrangements are obscured by the averaging inherent to conventional diffractometric techniques. These methods yield only “ideal” periodic structures, which fail to capture the true atomic configurations. Nuclear magnetic resonance (NMR), by contrast, reveals “real” structures defined by local order-disorder schemes and site-specific chemical environments. Thirty pristine low-plagioclase specimens, primarily from pegmatites and anorthosites, were characterized using electron microprobe analyses (EMPA), optical microscopy (OM), field-emission scanning electron microscopy (FESEM), powder X-ray diffraction with Rietveld refinement, and multinuclear NMR spectroscopy, including ^{29}Si , ^{27}Al , ^{27}Al MQMAS, $^{27}\text{Al}\{^{29}\text{Si}\}$ J-HMQC, and ^{23}Na at 9.4 T and 17.6 T. The “ideal” and “real” structures coincide only in the perfectly long-range ordered, stoichiometric end-members: C-1 albite ($\text{NaAlSi}_3\text{O}_8$) and P-1 anorthite ($\text{CaAl}_2\text{Si}_2\text{O}_8$), where crystallographically distinct sites correspond directly to spectroscopically distinct sites. Intermediate compositions instead consist of site distributions with positional disorder arising from locally ordered X–Si–Al–O configurations. NMR reveals a continuous structural evolution along the plagioclase series, allowing three regimes to be distinguished. Peristerites ($\text{An}_0\text{--An}_{30}$) show fully ordered local structures, with Al exclusively in the T₁₀ tetrahedral site. Labradorites ($\text{An}_{30}\text{--An}_{65}$) display highly complex atomic arrangements yet remain fully ordered at the local scale. Bytownites ($\text{An}_{65}\text{--An}_{100}$) exhibit Si and Al distributed across two distinct four-site configurations corresponding to Na-rich and Ca-rich domains. These results demonstrate that low plagioclase solid solution series are locally ordered even when their average structures, and the conventional lattice model, fail to reflect this order. Their non-stoichiometric, incommensurable and aperiodic architectures illustrate how NMR supports a more realistic understanding of mineral structures, beyond idealized crystallographic descriptions.

Mineral features of labradorite from Nain, Labrador (Canada)

Luis Sánchez-Muñoz¹, Javier Zúñiga², Pierre Florian³, Marta Furio¹, Carlos Pecharromán⁴, Gema Marcelo Alejandre⁵, Antonio Castro¹, Alana Hinchey⁶

¹Museo Nacional de Ciencias Naturales, ²Universidad del País Vasco, ³Université d'Orléans, ⁴Instituto de Ciencia de Materiales de Madrid,

⁵Universidad de Alcalá de Henares, ⁶Geological Survey of Newfoundland and Labrador.

E-mail: lsm@mmcn.csic.es

Labradorite is an exceptional mineral due to the unusual coexistence of multiscale structural organization, non-stoichiometry, local chemical order-disorder, incommensurate atomic structure with aperiodic configurations and remarkable optical iridescence produced by exsolution and local atomic ordering. Together, these features provide a unique and powerful framework for understanding the behaviour and complexity of crystalline matter. This study presents an integrated dataset combining electron microprobe analyses (EMPA), single-crystal X-ray diffraction with CuK α 1 and MoK α 1 radiation (SC-XRD), field-emission scanning electron microscopy (FESEM), scanning transmission electron microscopy (STEM), optical and luminescence spectroscopy (OLS), confocal microscopy (CM) and multinuclear magnetic resonance (NMR) spectroscopy, including ²⁹Si, ²⁷Al, ²⁷Al{²⁷Al} DQ/SQ, ²⁷Al{²⁹Si} J-HMQC, and ²³Na spectra at 17.6 T. These techniques were applied to labradorite samples from the Nain region of Labrador, Canada displaying violet to red or infrared iridescence. Samples with compositions An₅₀₋₅₅ exhibit resolved e₁-, e₂-, and e₃-satellites with similar *q*-vectors, along with weak *c*- and *d*-reflections suggesting P-1-like distortions. Microscopy reveals microtextures defined by a double system of chemical waves forming a cross-hatched lamellar pattern on the (001) plane. Optical spectra show that labradorite behaves as a natural photonic crystal composed of domains with refractive index contrasts of approximately 0.05, responsible for the vivid colors and for a differential luminescence phenomenon arising from optical modulation of the photonic structure. At the atomic scale, site distributions are chemically ordered, with ordering increasing slightly as lamellae coarsen from violet to infrared iridescence. Altogether, these results demonstrate that non-stoichiometry, incommensurability, mesoscale pseudo-periodic microtexture and aperiodicity in labradorite do not imply local disorder. Their persistence reinforces the notion that mineral structures cannot be reduced to a stoichiometric formula and a periodic lattice alone, supporting the view that labradorite should be regarded as a mineral species with its own natural identity.

Aeromagnetic, stratigraphic, structural, geochronological and lithogeochemical data question the veracity of the defining characteristics of the Dog Bay Line in northeast Newfoundland

Hamish A. I. Sandeman¹, Ian W. Honsberger², Cameron Peddle³

¹Geological Survey of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada, ³NewFound Gold Corp.

E-mail: hamishsandeman@gov.nl.ca

Previous mapping in northeastern Newfoundland led to the definition of the Dog Bay Line (DBL), the proposed terminal Silurian Iapetan suture zone. Key points supporting the DBL were 1) The Duder Mélange, strongly deformed black shale enveloping sparse, large blocks of mafic volcanic and gabbroic rocks, traces the fault zone; 2) distinct Silurian rock types and depositional facies on either side of the fault (Botwood vs. Indian Islands Group); 3) Ordovician to Silurian rocks are unconformably overlain by red micaceous sandstone; 4) The Mount Peyton Suite (MPS) cuts the DBL. In that context, the DBL was described as a tectonized olistostromal mélange representing the suture along which the Tetagouche–Exploits back-arc seaway closed in the Silurian. Based on new aeromagnetic, geological and stratigraphic, geochronological, lithogeochemical and structural data we present six points that contradict previous proposals. 1) The Reach Fault, the neighbouring fault of the DBL, deforms the MPS as opposed to being cut by it. 2) The Indian Islands Group spans from Homerian to Lochkovian (ca. 435–416 Ma), younger than originally interpreted and overlapping in age with the Botwood Group. 3) Deformed, latest Silurian (ca. 420 Ma) bimodal volcanic rocks occur with the Indian Islands Group to the southeast of the proposed trace of the DBL. 4) Gabbro units that exhibit boudinage, described as knockers or blocks in Duder Mélange, locally preserve chills and cut Ordovician and Silurian rocks. Such gabbros range in age from ca. 454 Ma to 382 Ma. 5) Southeast-dipping cleavage or faults are associated with Early Devonian transpression. Earlier, major northwest-dipping Salinian structures are absent. 6) The Ten Mile Lake Formation is also tight to isoclinally folded by the oldest deformation. Our observations indicate that the DBL in northeast Newfoundland is not a Salinian suture, but instead is a polyphase, within-plate fault zone that accommodated both extension and compression.

Advances in understanding REE-bearing pegmatites across the Wollaston Domain, northern Saskatchewan

Ana Cláudia Santos¹, Alan Cardenas-Vera¹, Joseph A. Bravo¹, Irvine R. Annesley^{1,2}, Tania Martins^{1,3}, Camille A. Partin¹

¹University of Saskatchewan, ²Université de Lorraine, ³Manitoba Geological Survey.

E-mail: claudia.santos@usask.ca

The Wollaston Domain in northern Saskatchewan hosts granitic pegmatites that remain under-evaluated regarding their rare earth elements (REE) potential. Despite their shared origin via crustal anatexis during the ca. 1.8 Ga Trans-Hudson Orogen, some aspects of their petrogenesis remain poorly understood, such as the mechanisms controlling the mineralization. Under our NSERC–industry collaborative project, we conducted an extensive regional field program in 2025 covering the Fraser Lakes, Kulyk Lake, Key Lake Road, Highrock Lake and Karin Lake areas. Pegmatites are usually found as dykes and sills intruding the Wollaston Group and present variable mineralogy. Compositionally, they vary from U-rich to Th–REE-rich to barren. At least three generations of pegmatites were identified in the field, with cross-cutting relations supporting a syn- to late-tectonic timing of intrusion, consistent with the established regional framework. The REE mineralization (Ce-monazite) is generally associated with biotite-rich zones within the pegmatites and/or wall zone. Whole rock geochemistry of the pegmatites is quite variable with a strongly peraluminous signature supporting

an anatectic origin derived from crustal sources. Decoupling in space and time from any nearby granitic plutons implies independent crustal melts. By integrating whole rock and in situ mineral geochemistry with U–Pb geochronology of monazite and zircon; this research is assessing the petrogenesis of REE mineralization and defining geochemical vectors for exploration. Our findings will help refine the regional metallogenic framework and provide a foundation for distinguishing prospective targets from non-mineralized occurrences in the Wollaston Domain. This talk presents the research conducted on pegmatites from Fraser Lakes and Kulyk Lake areas. In both cases, monazite exhibits textural and chemical features indicative of initial crystallization from a melt, subsequently modified by dissolution-reprecipitation and/or other processes. The U–Pb ages obtained from monazite are consistent with the formation of pegmatites during peak metamorphism of the Trans-Hudson Orogen (ca. 1.81 Ga).

Dunitization of depleted mantle peridotite during subduction initiation in the Penobscot back-arc basin: Evidence from the Great Bend Complex, central Newfoundland

Gabriel Santos, Ivan Yip, Hamish Sandeman
Geological Survey of Newfoundland and Labrador.
E-mail: gabrielsantos@gov.nl.ca

The ca. 510–494 Ma Great Bend Complex (GBC) is one of three commonly correlated ophiolitic complexes at the base of the Exploits Subzone, a major tectonic division in central Newfoundland. This presentation focuses on a ~200 m wide, previously unsampled dunite within the GBC. The GBC dunite and associated chromitite layers record a multi-stage petrogenetic history constrained by integrated olivine, chromite and clinopyroxene mineral chemistry, whole rock major and trace element geochemistry, and platinum-group element (PGE) systematics. Primitive mantle-normalized trace element patterns reveal extreme depletion and an overall negative slope, with superimposed negative high-field-strength element (Nb, Ta, Hf, Ti) anomalies, positive large-ion lithophile element anomalies, general light rare earth element enrichment ($L_{AN}/Sm_N = 2.02\text{--}5.39$) and middle rare earth element enrichment ($Sm_N/Yb_N = 2.22\text{--}4.63$). These features are diagnostic of a mantle wedge metasomatized by slab-derived fluids following extensive melt extraction. Ti–Yb systematics constrain partial melting to > 25% within the spinel stability field, while V–Yb systematics indicate oxygen fugacity of ~QFM +1. Dunite formation occurred through reactive melt percolation, with orthopyroxene dissolution driving olivine ($Fe_{0.90-0.92}$, NiO 0.11–0.34 wt.%) crystallization in melt channels. Clinopyroxene (Mg# 95–96, TiO_2 0.01–0.05 wt.%) inclusions in chromite, physically shielded from post-crystallization re-equilibration, yield the most reliable parental melt estimates (Mg# 80–85, TiO_2 0.01–0.16 wt.%), identifying the melt as a primitive boninite. Chromitite layers subsequently crystallized within the same conduit system from two compositionally distinct, more primitive melt pulses, distinguished by chromite (Crr# 74–76 vs. 82–87) and Al_2O_3 (6.5–9.2 wt.% vs. 10.3–13.0 wt.%) content. PGE systematics preserve the record of initial base metal exhaustion during high-degree mantle melting, followed by spatially heterogeneous refertilization during boninite percolation. The GBC dunite provides the first documented record of subduction initiation in the Penobscot back-arc basin in Newfoundland.

Quaternary reorganization of the Indonesian Throughflow and its influence on regional sea level and monsoon dynamics

Muhammad Sarim
Northwest University.
E-mail: msarim92@yahoo.com

Understanding how low latitude ocean circulation and hydroclimate respond to glacial–interglacial forcing is essential for improving future sea-level projections, particularly in regions where ocean–atmosphere coupling and land–ocean sediment fluxes influence regional sea-level variability. The Indonesian Throughflow (ITF), the only low latitude gateway between the Pacific and Indian Oceans, plays a key role in regulating heat transport, regional sea level and the Australian summer monsoon (ASM), yet its long term sensitivity to climate forcing remains poorly constrained. Here we reconstruct Mid–Late Quaternary (ca. 800 ka) variability of the ITF and ASM using high-resolution clay mineral assemblages, Sr–Nd–Pb isotopes and grain-size records from IODP Site U1483 along the northwest Australian margin. Clay minerals are dominated by smectite, with moderate kaolinite and illite and minor chlorite. Combined clay mineral and radiogenic isotope ($^{87}Sr/^{86}Sr = 0.730\text{--}0.720$; $\epsilon Nd = -8.22$ to -10.73 ; $^{206}Pb/^{204}Pb = 19.25\text{--}18.95$) indicate that sediments were primarily derived from the Victoria and Ord Rivers of the Kimberley region, with some contributions from the Timor region via the ITF. Time-series records show pronounced glacial–interglacial cyclicity, with finer grain size, higher smectite and low kaolinite and illite during glacials, and coarser sediments with increased kaolinite and illite during interglacials. Ratios of kaolinite/smectite and clay/silt track variations in river discharge, monsoon intensity and ITF strength, indicating a stronger ASM and intensified ITF during interglacials, and weakened conditions during glacials. A distinct shift at ca. 450 ka coincides with the Mid-Brunhes Event, marking the onset of extreme glacial–interglacial variability and an enhanced imprint of high latitude forcing ($65^\circ S$). Orbital scale variability shows power in the 100 ka, 41 ka, and 23 ka bands, reflecting that ice sheet-driven climate cycles and low latitude insolation forcing jointly regulated ITF–ASM dynamics. These results provide long term process-based constraints relevant for improving representations of low latitude circulation and regional sea-level variability in future projection frameworks.

An aqueous geochemical exploration strategy tested on streams draining Li–Cs–Ta (LCT) pegmatites in southern Newfoundland

Shramana Sarkar¹, Michael G. Babechuk¹, James Conliffe², Duc Huy Dang³, Gabrielle Ledesma¹

¹Memorial University of Newfoundland, ²Geological Survey of Newfoundland and Labrador, ³Trent University.

E-mail: shramanas@mum.ca

Increasing interest in Li–Cs–Ta (LCT) pegmatites as a potential critical mineral source has motivated innovations in geochemical exploration to discover more deposits, but aqueous geochemical approaches amongst these strategies remain undeveloped. To test the exploration utility of aqueous trace element geochemistry, the dissolved load of streamwaters draining outside and within areas of known LCT pegmatites in southern Newfoundland were collected with ultra-clean field protocols and measured by ICP–MS at academic and commercial laboratories. As anticipated from the weathering-limited boreal environment of the study site, streamwater trace element abundances were in the ng/g to pg/g range, including elements hypothesized to be the most useful pathfinders (Li, Cs, Rb, W). The academic laboratories were able to better resolve pathfinder element signatures with enhanced precision down to lower levels of detection compared to the commercial laboratory, but the primary variation of Li, Cs and Rb abundances was resolved in all datasets. Calcium- or Na-normalized or inter-element (e.g. Cs/Rb) ratios (to minimize influence from variable hydrologic flux) of these pathfinder elements reveal subtle but discernible elevations (above regional background levels) downstream of known pegmatites, as well as other streams with no currently documented upstream mineralization. However, inter- and intra-catchment variations also revealed the effects of downstream dilution by waters draining unmineralized catchment areas and the probability of mineral-specific controls on the release and transport of some pathfinder elements. The multi-element analytical approach was key to constraining region-specific, boreal catchment characteristics such as marine aerosol input (most prominent for Na), background bedrock control on element signatures (REE patterns) and the importance of organic complexation in some element transport (e.g. Co, Ni). Overall, the tested strategy was established as useful to LCT pegmatite exploration in catchments prospective to host currently undocumented upstream mineralization, with evidence for portability between different laboratories when sampling cleanliness is tightly controlled.

Preliminary mineralogy and trace element systematics of ore lenses at the Lalor volcanogenic massive sulphide (VMS) deposit, Manitoba, Canada: Implications for ore-forming processes

Manju Sati¹, Tania Martins^{1,2}, Christopher R. M McFarlane¹, David R. Lentz¹, Pura Alfonso³

¹University of New Brunswick, ²Manitoba Geological Survey, ³Universitat Politècnica de Catalunya Barcelona Tech.

E-mail: manju.sati@unb.ca

The Lalor base metal deposit in Manitoba, is characterized by its significant ore textures, wall rock hydrothermal alteration, and Zn–Cu ± Au ± Ag endowment. Mineralization occurs in 12 discrete lenses or ore zones and the rocks experienced amphibolite-facies metamorphism. The Lalor deposit, hosted in the lower Chisel sequence of the Snow Lake arc assemblage, was affected by at least four deformation episodes linked to the Trans-Hudson orogeny. The mineral assemblage in massive sulphide zones includes sphalerite–pyrite–chalcopyrite–galena and biotite–muscovite–chlorite–kyanite–quartz, reflecting evolving physicochemical conditions of hydrothermal fluids with a regional metamorphic overprint. The footwall rocks adjacent to the ore lenses are intensely pyritized and rich in biotite and kyanite, with kyanite forming up to 15 vol.% as porphyroblasts (≤ 2 cm) confined to pyrite-rich zones. The sulphide mineralogy of the lenses is dominated by pyrite and sphalerite (10–70 vol.%), with minor chalcopyrite, pyrrhotite and galena. Small, multi-phase polymetallic blebs indicate localized sulphide melting. Pyrite occurs as anhedral to euhedral grains (10–80 μ m) and mostly exhibits brittle deformation. Trace element concentrations of pyrite from massive sulphide are enriched in Co (75–434 ppm), Ni (50–228 ppm), As (984–1990 ppm) and Au (0.1–0.2 ppm), with Co/Ni ratios mostly > 1 (~ 4), reflecting precipitation from evolving metalliferous exhalative hydrothermal fluids. Furthermore, localized remobilization during regional deformation and metamorphism likely contributed to the redistribution of trace metals under changing temperature, pressure and sulphur fugacity. Detailed textural and trace element studies reveal successive sulphide formation stages: primary deposition, secondary deformation-driven recrystallization and re-equilibration, and localized remobilization, including differential liberation of precious metals. Cryptic trace element signatures from deformed and folded ore lenses can help to reconstruct the original deposit geometry. These results provide new insights into ore genesis, structural controls, metal redistribution and critical metal enrichment in Paleoproterozoic VMS systems, with broader implications for exploration strategies.

Deconvoluting the Neoproterozoic and Paleoproterozoic tectonometamorphic evolution of the Angikuni Lake region, Nunavut: Implications for the tectonic framework of the western Churchill Province

Matthew Sayles¹, Dan Gibson¹, Joshua Laughton², Jamie Cutts²

¹Simon Fraser University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: msayles@sfu.ca

The Snowbird Tectonic Zone (STZ) is a major crustal scale feature which separates the Archean Rae and Hearne cratons within the western Churchill Province. Along the STZ, metamorphism and deformation spanning from the Neoproterozoic to Paleoproterozoic is preserved and has led to persistent uncertainty about the timing, geometry and nature of the boundary. This holds especially true in the Angikuni Lake area, which is located alongside the geophysical trace of the STZ and comprises several shear zone and fault-bounded high- and low-grade domains with complex tectonometamorphic histories. This study uses new field observations, petrography, structural analyses, metamorphic phase modelling and U–Pb and Rb–Sr geochronology to investigate the timing and nature of tectonometamorphism in the southern Angikuni Lake region. Results demonstrate that hanging wall panels are

separated from a high-grade footwall complex by an east–west trending curvilinear shear zone and preserve distinct tectonometamorphic events: a western greenschist-facies panel metamorphosed at ca. 1.9 Ga, a central upper amphibolite- to granulite-facies panel metamorphosed at ca. 2.5 and 1.9 Ga, and an eastern amphibolite-facies panel metamorphosed at ca. 2.5 Ga with a younger greenschist-facies overprint. Footwall rocks preserve upper amphibolite-facies to migmatite-grade metamorphism, characterized by garnet amphibolite, migmatitic paragneiss and variably foliated granitic orthogneisses preserving metamorphism at ca. 2.5, 1.9, and 1.85–1.82 Ga. These results provide new constraints on the timing and nature of the STZ at the latitude of Angikuni Lake, contributing to models of Paleoproterozoic evolution of the Rae craton and assembly of Laurentia.

Re-evaluating the age and longevity of seafloor hydrothermal systems

Johannes Scheffler¹, John Jamieson²

¹Memorial University of Newfoundland, ²University of Ottawa.

E-mail: jmscheffler@mun.ca

Hydrothermal systems occur where seawater circulates through oceanic crust, driven by shallow magmatic heat sources. Hydrothermal venting represents an important ore-forming process, and has a major influence on oceanic chemical budgets, as well as crustal cooling. Uranium series geochronology has been applied to rock samples collected from hydrothermal vents to determine the age and longevity of hydrothermal systems. This approach has assumed that the rock samples represent a closed system with respect to the radioisotopes used for dating, and calculated ages have been interpreted to represent a single age of formation for each dated sample. However, hydrothermal venting and associated mineral precipitation are continuous processes of finite duration. Thus, a singular age calculated from a chronometer applied to a sample may not accurately reflect the formation history of that sample or the respective vent field. In light of this, we have developed new age models to evaluate the effects of discrete versus continuous on U-series isotope evolution. By introducing some simplifying assumptions, age constraints can be derived from radioisotope measurements even for mixed age samples. Reinterpreting published age data under these assumptions, we find that, assuming continuous fluid discharge over the lifespan of a hydrothermal vent, vent ages are about twice as old compared to the conventional approach, which evaluates measurements to a single, instantaneous age. These results imply that hydrothermal venting is a longer lasting phenomenon than currently assumed, vent-associated ecosystems are older than previously thought and hydrothermal circulation is a more temporally stable mechanism of crustal cooling. These results suggest that previously calculated rates of ore-forming processes at the seafloor may be lower than previously thought.

The role of interior ocean Wilson cycles in Pangea assembly: Implications for supercontinent formation

Karel Schulmann¹, José Ramón Martínez Catalán², Brendan Murphy³, Urs Schaltegger⁴, R. Damian Nance⁵, Yvette D. Kuiper⁶, Stephen Collett¹, Jean-Marc Lardeaux^{1,7}

¹Czech Geological Survey, ²Universidad de Salamanca, ³St. Francis Xavier University, ⁴University of Geneva, ⁵Ohio University, ⁶Colorado School of Mines, ⁷Université Côte d'Azur.

E-mail: schulmann.karel@gmail.com

Complexly deformed rocks crop out across Europe and northwestern Africa; some record high pressure metamorphism, others partial melting and intrusion by granitoid plutons. They formed during the Variscan orogeny, when Laurussia and Gondwana collided in the Late Paleozoic to assemble Pangea. The study of the Variscan basement shaped many of the emerging ideas about geodynamics among European scientists. The Variscan orogeny was not a single collision but a ca. 200 Myr evolution involving the opening and closure of three oceans: the Rheic, the Rheohercynian and the Paleotethys. Rheic subduction began in the late Silurian along Laurussia and in the mid-Devonian along Gondwana. Devonian rollback along Laurussia opened the Rheohercynian Ocean, while multiple peri-Gondwanan subduction systems developed. Farther east, mid-Devonian subduction beneath Gondwana triggered opening of the wedge-shaped Paleotethys and rifting of a major Galatian terrane. In the Carboniferous, continued Paleotethys spreading drove final Rheic closure and the accretion of Gondwanan terranes to Laurussia producing a linear Variscan collage. Subsequent subduction along the northern Paleotethys margin induced widespread extension and melting within the Variscan belt. During the Carboniferous, continued Paleotethys spreading drove final Rheic closure and accretion of Gondwanan terranes to Laurussia, forming a largely linear Variscan collage. Subsequent mid-late Carboniferous subduction along the northern Paleotethys margin induced widespread extension and melting within the orogen. In the Early Permian, collision of Laurussian and Gondwanan megablocks produced (ultra) high pressure metamorphism along the Gondwanan margin, strongly curved deformation belts (oroclines) and dextral shear zones transecting the entire Variscan collage. Paleogeographic reconstructions indicate persistent oceanic domains between Laurussia and Gondwana throughout the Paleozoic, implying semi-continuous Wilson cycles and a long-lived spreading centre within the Pangean realm. This evolution is consistent with large-scale mantle convection processes governing supercontinent assembly.

Making a geological map for the Cabox Aspiring Geopark, Newfoundland: Merging disjointed source maps

Martin Schwangler¹, Jordan M. Koop¹, John W.F. Waldron^{1,2}

¹University of Alberta, ²Acadia University.

E-mail: schwangler@ualberta.ca

Public outreach initiatives such as the Cabox Geopark are essential in sharing geological information with interested members of the public, and the Bay of Islands area of western Newfoundland contains exceptional rocks which have aided in the development of geologic thought. Early reconnaissance and biostratigraphic studies noted the complexity in the area and initially described ophiolitic rocks as intrusive complexes. After the theory of plate tectonics was developed, researchers recognized the allochthonous nature of the ophiolite and many of the sedimentary rocks.

Subsequent stratigraphic, sedimentological and structural studies yielded a modern understanding of the formation of the Appalachian Orogen. Multiple projects created a patchwork of geologic maps using different stratigraphic schemes, producing challenges for public outreach. In addition, new mapping supported by the Cabot Aspiring Geopark led to the separation of structures generated by three distinct orogenic episodes and the recognition of a tectonic window through sedimentary strata of the Laurentian shelf. To address these challenges, a compilation shapefile containing the geology of the region was updated using GIS (Geographic Information System) software. Boundary issues between different map sources were resolved using geological knowledge, GIS principles and project-specific GIS techniques. The resulting map presents a unified picture of the geology, suitable for use in outreach projects.

Perspectives on the magmatic framework of the Mackenzie Large Igneous Province

James S. Scoates¹, R.F. Jon Scoates²

¹University of British Columbia, ²Great Outcrop in the Sky.

E-mail: scoates@mail.ubc.ca

The magmatic products of the 1.27 Ga Mackenzie large igneous province (LIP), one of the largest igneous events preserved on Earth, are distributed across a broad swath of northern Canada. The different components of the Mackenzie LIP include (1) flood basalts of the > 4.2 km-thick Coppermine River Group, (2) ultramafic–mafic cumulates of the sub-volcanic, 1.8 km-thick, Muskox layered intrusion, (3) the giant, > 2400 km-long, radiating Mackenzie dyke swarm, (4) mid-crustal ultramafic–mafic intrusions (6–20 km thick) at depth below an inferred apical graben structure, and (5) a deep magma underplate at the base of the crust. The Coppermine River basalts (> 150 flows, 10–25 m thick) erupted from vents or fissures to the north, flowed hundreds of km as inflated pahoehoe sheet flows, and represent the differentiated products of the mid-crustal intrusions. The Muskox intrusion is the high level, open system projection of a much larger magma reservoir, also to the north, from which 25 separate magma batches flowed laterally and crystallized. Geochemically correlative lavas to the Muskox intrusion are recognized as a distinctive suite of contaminated basaltic andesite (~400 m thick) that forms the base of the flood basalt sequence. The Mackenzie dykes, cutting both the Muskox intrusion and the lower members of the Coppermine River basalts, were driven by magma buoyancy from the deep magma underplate, ascending vertically within 500 km of the focal point of an underlying mantle plume and propagating outward horizontally at greater distances. The dykes, predominantly fractionated Ti-rich basalt, mostly did not reach the surface to feed volcanic eruptions but were vertically arrested in the subsurface. The Mackenzie LIP continues to offer exceptional opportunities to investigate the crustal scale magmatic architecture of continental large igneous provinces, with implications for the origin of associated Ni–Cu–PGE sulphide mineralization and potential impacts on Earth's global biogeochemical cycles during the Mesoproterozoic.

Characterizing mineralization and critical metal remobilization at the McLymont deposit in northern British Columbia

Victoria Scoging, Renelle Dubosq

University of British Columbia Okanagan.

E-mail: victoriascoging14@gmail.com

The McLymont project in northern British Columbia is a significant Au–Ag–Cu mineral occurrence spatially associated with the McLymont fault. Despite extensive drilling, the deposit type and mineralization style remain poorly defined. This study characterizes mineralization and alteration assemblages within the McLymont deposit using correlative microscopy and geochemical analysis to determine deposit type and assess the structural control of the McLymont fault on the current deposit geometry. Core logging, optical microscopy and micro-X-ray fluorescence mapping reveal three distinct assemblages: (1) hematite-bearing (specular hematite, garnet, pyrite, chalcopyrite, chlorite and carbonates); (2) garnet-dominant (garnet, pyrite, chalcopyrite, quartz, sericite and carbonates); and (3) pyrite-dominant (pyrite, chalcopyrite, quartz and carbonates). Three mineralized vein types are broadly consistent with these assemblages, with pyrite-bearing veins hosting trace native gold in ~200 µm fractures. Across these assemblages, three texturally distinct pyrite populations have been identified: (1) nearly euhedral, cubic-octahedral, ~500 µm grains; (2) subhedral, cubic-octahedral, inclusion-rich grains (~500 µm); and (3) fine-grained (< 50 µm), anhedral, polycrystalline aggregates. Electron microprobe analysis shows strong oscillatory zonation of Ni and As. High contrast backscattered electron imaging and electron backscatter diffraction mapping reveal that deformation across all three pyrite types is dominantly brittle, with localized plastic strain at microfracture tips and fragment margins. Laser ablation–inductively coupled plasma–time-of-flight–mass spectrometry mapping will be used to quantify trace metal distributions within deformed and undeformed pyrite across all alteration and vein types. By integrating microstructural and geochemical datasets, this study will evaluate the primary modes of metal enrichment and secondary modes of remobilization. Ultimately, this work will identify mineralization at the McLymont deposit and provide a transferable framework for exploration and geometallurgical processing of ore deposits.

From deposition to mantle depths: Neoproterozoic sedimentation and UHP metamorphism in the Baie Verte Margin, Newfoundland, and links to the Grampian terrane

Ludovico G. Scorsolini¹, Cees van Staal², Alana M. Hinchey¹, John M. Hanchar³, Chris Yakymchuk², Matthew Steele-MacInnis⁴

¹Geological Survey of Newfoundland and Labrador, ²University of Waterloo, ³Memorial University of Newfoundland, ⁴University of Alberta.

E-mail: LudovicoScorsolini@gov.nl.ca

The Baie Verte Peninsula exposes a key segment of the Laurentian margin that formed part of the Taconian–Grampian tract, yet its tectonostratigraphic architecture and pre-subduction history appear more complex than previously recognized, with implications for Appalachian–Caledonian correlations. We integrate new field observations, Raman spectroscopy and geochronology to refine a three-unit tectonostratigraphic framework for the Baie Verte Margin. The structurally lowest unit, the Middle Arm Brook Complex (MABC), includes Mesoproterozoic to Early

Neoproterozoic rocks previously grouped within the structurally overlying East Pond Metamorphic Suite (EPMS). The EPMS instead contains metasedimentary and volcanoclastic rocks with detrital zircon populations dominated by Tonian–Mesoproterozoic ages and possible Ediacaran maximum depositional ages, consistent with a volcano-sedimentary cover distinct from the MABC. Mafic bodies intruding the MABC-EPMS sequence preserve high pressure assemblages. Raman spectroscopy reveals coesite micro-inclusions within quartz inclusions hosted by garnet, consistent with burial to ultra-high pressure conditions (> 2.8 GPa) during Ordovician subduction. These assemblages occur within eclogitic boudins hosted by EPMS metasedimentary rocks, suggesting that Laurentian margin sediments reached mantle depths prior to exhumation along a major shear zone separating the EPMS from the overlying Fleur-de-Lys Supergroup (Bear Cove Road Shear Zone). The refinement of the margin architecture supports correlations between the Baie Verte Margin and segments of the Grampian terrane of Ireland and Scotland, where comparable Neoproterozoic successions were involved in collision-related deformation and metamorphism, providing a framework for cross-Atlantic correlation and mineral system targeting in peri-Laurentian terranes.

Lycopod tombs in the Pennsylvanian Clifton Formation of New Brunswick, Canada: Ichnofaunal diversity within hollowed stumps

Margaret Scott¹, Matt Stimson^{2,3}, Bailey Malay³, Brian Hebert⁴, Lynn Dafoc⁵, Robert Gastaldo^{6,7}, Mike Rygel⁸, Page Quinton⁸, Lucy Smith³, Kayla Gerard⁹, Luke Allen⁹, Steven Hinds^{3,10}, Keenan Richard¹¹, Olivia King¹², Spencer Lucas¹³, Hillary Maddin¹²

¹Memorial University of Newfoundland, ²Saint Mary's University, ³New Brunswick Museum, ⁴Fundy Treasures, ⁵Natural Resources Canada, Geological Survey of Canada, ⁶Colby College, ⁷Smithsonian Institution, ⁸State University of New York at Potsdam, ⁹University of New Brunswick, ¹⁰New Brunswick Department of Natural Resources, ¹¹Moncton, NB, ¹²Carleton University, ¹³New Mexico Museum of Natural History and Science.
E-mail: mlscott@mun.ca

The Moscovian-aged Clifton Formation in northern New Brunswick is well known for its palaeobotanical record including in situ lycopod trees. The lycopods are hollowed-out stumps, that are rooted in mineral paleosols and were episodically infilled with layers of fine-grained sediments. Mud cracks, raindrop impressions and trace fossils are preserved on a bedding plane between strata that contain vertebrate and invertebrate body fossils. Preservation of traces within stumps are rare within the Paleozoic, with this report representing the first invertebrate assemblage and second record of vertebrate ichnofossils preserved inside a Pennsylvanian lycopod tree. The ichnoassemblage within the tree is diverse and dominated by an invertebrate assemblage that includes the ichnogenera *Gordia*, *Helminthoidichnites*, *Helminthopsis*, *Circulicbnius*, *Planolites*, *Diplichnites*, *Striatichnium* and *Diplopodichnus* and a single vertebrate ichnotaxon cf. *Characichnus*. The Clifton Formation also preserves a sparse ichnofaunal assemblage from the flanks of channel bodies or floodplain deposits and within abandoned channel deposits. Invertebrate ichnoassemblages (outside of lycopods) include *Diplichnites*, *Stiaria*, *Hexapodichnus*, *Cochlichnus*, *Planolites*, *Gordia* and *Helminthoidichnites*. The tetrapod track assemblage includes large *Characichnus* (swimming stem tetrapods), *Batrachichnus*, *Matthevichnus*, *Limnopus* (temnospondyl/microsaur) and *Hylopus* (anthracosaurs/reptiliomorphs), in addition to tetrapod coprolites which contain skeletal remains. Trace fossils can be compared with body fossils of vertebrates and invertebrates that are also found preserved in lycopod hollows from the Clifton Formation, a unique preservational occurrence. Trace fossils inside a lycopod have implications for microhabitats in tree hollows within the Carboniferous and potentially expand the known paleobiodiversity of this time. Vermiform invertebrates tend to leave traces in environments with high nutrients that may have been provided by organic matter from the decaying tetrapods, and the interior of the lycopod stump. The Clifton Fossil Forest provides ichnofossils that represent the first direct evidence of invertebrate and vertebrate activity inside their lycopod tombs.

Mineral-scale trace element evolution of the Kiglapait Intrusion, Labrador: Implications for fractional crystallization and crustal interaction

Isabelle Seguin-Gravelle^{1,2,3}, Alana Hinchey³, Chris Spencer¹, Roger Paulen²

¹Queen's University, ²Natural Resources Canada, Geological Survey of Canada, ³Geological Survey of Newfoundland and Labrador.
E-mail: isabellegravelle109@gmail.com

The Mesoproterozoic Kiglapait intrusion of the Nain Plutonic Suite, Labrador, preserves an ~8 km thick stratigraphic sequence of troctolitic to iron-rich syenitic cumulates that record near-complete differentiation of a mantle-derived magma. Previous isotopic work demonstrated derivation from predominantly depleted mantle with minor crustal input and progressive radiogenic Sr enrichment in the upper stratigraphy. However, the evolution of trace elements within major cumulus minerals has not been systematically evaluated. This study investigates in situ LA-ICP-MS trace element concentrations in plagioclase, olivine, apatite and clinopyroxene from stratigraphically constrained samples spanning the Lower and Upper Zones. The objective is to determine how compatible and incompatible trace elements evolved during crystallization and whether mineral-scale systematics preserve evidence of fractional crystallization, magma recharge or subtle crustal assimilation. Particular emphasis is placed on Ni and Cr in olivine and clinopyroxene as monitors of early mafic fractionation, Sr and Ba in plagioclase as indicators of melt evolution, and rare earth element distributions, including Eu anomalies, to track evolving melt composition and plagioclase accumulation. We test whether mineral compositions define smooth, stratigraphically coherent trends consistent with closed system differentiation, or whether departures from expected partitioning behaviour occur in the upper levels where isotopic evidence suggests increasing crustal influence. Zoning profiles within individual crystals will further assess whether late-stage melt–rock interaction or diffusive re-equilibration modified primary magmatic signatures. By integrating mineral-scale trace element data with established whole rock and isotopic frameworks, this project refines models of differentiation in large, layered intrusions and evaluates the scale at which crustal contamination is recorded. The results provide new constraints on magma chamber processes in Proterozoic anorthosite–mangerite–charnockite–granite systems and demonstrate the value of mineral chemistry in resolving the dynamics of long-lived mafic magmatic reservoirs.

Was the third interval of Huronian glaciation global in scale? Insights from the sedimentological record of the Gowganda Formation

Nabil A. Shawwa¹, Darrel G.F. Long¹, Thomas R. McLoughlin-Coleman², Robert H. Rainbird³

¹Laurentian University, ²University of Ottawa, ³Natural Resources Canada, Geological Survey of Canada.

E-mail: nsbawwa@laurentian.ca

The early Paleoproterozoic Huronian Supergroup is exposed from Sault Ste. Marie, along the north shore of Lake Huron, to Sudbury, Ontario (southern Huron basin), and northeastward to Rouyn-Noranda, Quebec (Cobalt Basin). This intracontinental succession contains three glaciogenic intervals (Huronian glaciations). The youngest is represented by the lower Gowganda Formation, which has been proposed to be a component of a continental, and possibly global, glaciation. It includes diamictite, sandstone and mudstone, with limestones and till pellets, interpreted to represent glaciomarine deposition from either a grounded or floating icesheet. Local subglacial deposits are also present. In the northern Cobalt Basin, Gowganda strata infill major paleofjords, with deposits reflecting progradational sequences linked to glacio-isostatic uplift. In the northeast Cobalt Basin, moraine deposits are restricted to proximal settings near the basin's margin, east of regional orthogonal fault systems. In contrast, the southern Huron basin contains thicker successions dominated by resedimented glaciomarine facies, including stratified diamictite, cobble- to boulder-supported conglomerate and graded sandstone-rich gravity flow deposits. These indicate sediment discharge into an open marine environment beneath a floating icesheet and record repeated phases of icesheet growth and decay. In the Elliot Lake area, glaciogenic strata were not extensively redeposited and instead record ice shelf uplift and jökulhlaup activity, as indicated by inverse graded bedding and imbricated sandstone rafts. The contrast between dynamic ice margin fluctuations in the south and more persistent grounded ice in the Cobalt Basin indicates strong spatial variability in ice sheet behaviour when retreat occurred to the north. This pronounced environmental heterogeneity, in combination with basin asymmetry typical of dynamic continental glaciations, complicates interpretations that invoke a globally extensive "hard snowball" during the early Paleoproterozoic. These observations highlight the need for caution when correlating Paleoproterozoic glaciations at the global scale, particularly given the lack of precise geochronological constraints.

Zircon geochronology and Hf isotopes of the silicic Panjal Traps: A window into the Himalayan basement rocks of the Pangea megasequence

J. Gregory Shellnutt¹, Sam Uthup¹, Robert B.-J. Hsieh¹, Hao-Yang Lee²

¹National Taiwan Normal University, ²Institute of Earth Sciences, Academia Sinica.

E-mail: jgsbshelln@ntnu.edu.tw

Zircon U–Pb dating of rhyolites from the Panjal Traps yielded Early Permian crystallization ages (287.2 ± 2.5 Ma; 287.1 ± 2.8 Ma; 290.5 ± 3.3 Ma; 287.5 ± 3.3 Ma; 287.0 ± 3.7 Ma). Minor amounts of Carboniferous inherited zircons (330–300 Ma) were identified and are likely derived from the earliest rift-related volcanoclastic rocks of the Panjal Traps (i.e. agglomeratic slate). The zircons from all rhyolites have enriched $\epsilon\text{Hf}(t)$ isotopic values ($\epsilon\text{Hf}(t) = -10.4$ to -4.2) indicating a crustal source for the parental magmas. The lone dacite of the study did not yield a definitive crystallization age but contains abundant inherited zircons with Neoproterozoic (2.6–2.5 Ga), Paleoproterozoic (2.4–1.8 Ga), Mesoproterozoic (1.4–1.0 Ga), Neoproterozoic (0.9–0.6 Ga) and Early Paleozoic (0.58–0.43 Ga) ages. The inherited zircon groupings match the detrital zircon age populations from the Indus River system, Indus Group sedimentary rocks, and major tectonomagmatic periods within the Archean–Paleoproterozoic Aravalli-Bundelkhand Craton. Furthermore, the inherited zircons show secularly variable Hf isotopes ($\epsilon\text{Hf}(t) = -18.9$ to $+10.2$) that match inputs of isotopically juvenile magmas into Aravalli-Bundelkhand Craton during the Paleoproterozoic (1900–1700 Ma) indicative of craton-wide isotopic re-fertilization.

Trace element geochemistry of ca. 2.3 Ga weathered clasts in basal breccia of the Lorrain Formation, Huronian Supergroup: New insights into chemical weathering during the Great Oxidation/Oxygenation Event

Arianna F. Sheppard¹, Michael G. Babechuk¹, Ian N.A. Coxon¹, Nabil A. Shawwa², Robert H. Rainbird³, Sarah P. Slotznick⁴

¹Memorial University of Newfoundland, ²Laurentian University, ³Natural Resources Canada, Geological Survey of Canada, ⁴Dartmouth College.

E-mail: arianna1sheppard@gmail.com

Earth's Great Oxidation Event (GOE) at ca. 2.3 Ga, marking the first sustained oxygenation of the atmosphere, is geologically evident in terrestrial deposits through the appearance of hematite (signalling terrestrial Fe oxidation) in both red beds and oxidized paleosols; however, how other redox-sensitive elements responded to accumulating O_2 levels during the GOE, and to what extent rock type and mineralogy-controlled element mobility remains unclear. To further address these knowledge gaps, weathered clasts eroded from a range of rock types (local basement granite and mafic to intermediate volcanic rocks) were isolated from the hematitic matrix of colluvial breccia of the Lorrain Formation. A geochemical comparison of the breccia's hematitic matrix to its clasts offers a unique opportunity to investigate weathering processes across a wide range of rock types developed at approximately the same time at the paleosurface prior to breccia emplacement. Comprehensive ultra-trace element analysis provides an assessment of immobile elements that retain igneous petrologic information for the different clast types (Nb–Ta–Zr–Hf–Th) vs. elements that were seemingly mobilized during paleoweathering (e.g. Li, Sr, U, REE) vs. elements that had their signatures replaced during regional metasomatic alteration of the clasts and matrix (Cs, Rb, Ba, Tl). Of the elements seemingly mobilized during paleoweathering, the REE were significantly mobilized with large inter-clast REE variations and enrichments often coupled with phosphorus. Despite the extensive REE mobility, only a small number of clasts show evidence for minor Ce anomaly development. Uranium is significantly fractionated from Th, with preferential enrichment in most of the weathered volcanic rock clasts, and minor mobility of Cr and Mo is apparent in some clasts. Other than U, several of the redox-sensitive trace elements show

evidence for either mineralogically controlled immobility or that conditions were still not optimal for a valence state change at the Earth's surface during the GOE.

Deposition of the Paleoproterozoic Loaf Formation, Belcher Group, Canada: Implications for time in the rock record and the Trans-Hudson orogen

Anthony Shillito, Camille Partin

University of Saskatchewan.

E-mail: anthony.shillito@usask.ca

The Belcher Group, a ~7–10 km thick succession of sedimentary and volcanic rocks, crops out over almost 13 000 km² on the Belcher Islands in southeastern Hudson Bay, Nunavut. Here we address the sedimentary facies, depositional setting and tectonic implications of the youngest constituent of the group, the Loaf Formation. The Loaf Formation occurs only on small islands in the northeastern archipelago with extensive coastal exposure, abundant sedimentary structures and minimal tectonic deformation. Despite high outcrop quality, little previous work exists because it is remote and difficult to access. Five lithofacies have been recognized, relating to deposition by fluvial and shallow marine processes. The maximum depositional age of the Loaf Formation is ca. 1835 Ma, but the duration of deposition is unknown. We discuss how structures related to different sedimentation states (deposition, stasis and erosion) provide insights into the completeness or incompleteness of the exposed strata, and how this varies between different facies. Diverse microbially induced sedimentary structures in the lower formation reveal that some substrates experienced prolonged sedimentary stasis, increasing the apparent time-completeness. Conversely, amalgamated trough cross-bedded sandstones from the upper formation reveal high rates of erosion and low time-completeness. The fluvial systems of the Trans-Hudson orogen are understudied yet are essential to understanding the transition of ocean closure in the Trans-Hudson orogen. Fluvial sedimentary rocks from the Loaf Formation, deposited on the Superior craton margin, can provide important constraints on the dynamics of the terminal collision of the Trans-Hudson orogen. Previous provenance analysis shows far-reaching sources forming a connected, transcontinental river system on the margin of the Superior craton. Details of how the distal reaches of this system functioned can be understood from the Loaf Formation.

Building spectral capacity: Workforce and regional development implications of hyperspectral imaging in mineral exploration

Janelle Skeard

College of the North Atlantic.

E-mail: janelle.skeard@cna.nl.ca

Hyperspectral imaging (HSI) is increasingly integrated into mineral exploration workflows as a rapid, non-destructive method for mineral identification and high-resolution mapping of alteration assemblages. Advances in spectral calibration, mineral classification algorithms and integration with complementary datasets (e.g. XRF and gamma-ray spectroscopy) are strengthening vectoring toward mineralization and supporting increasingly data-rich geological models. However, the effectiveness of HSI depends not only on analytical performance, but also on workforce capacity and regional innovation systems. This paper examines the workforce and socioeconomic dimensions of hyperspectral adoption within Canadian mineral exploration contexts. Drawing on applied research and institutional case evidence, we analyze how spectral data transitions from acquisition to geological interpretation and identify the competencies required to translate high dimensional spectral outputs into exploration decisions. Particular attention is given to spectral literacy among geologists, integration of HSI outputs into established logging and modeling workflows, data management capacity and collaboration between geoscientists and data specialists. Findings indicate that while acquisition technologies are advancing rapidly, bottlenecks frequently emerge at the interpretation and integration stages. Smaller firms and emerging mineral regions may face disproportionate challenges due to limited in-house expertise and infrastructure. Targeted investments in technical training, applied research partnerships and shared scanning facilities can mitigate uneven adoption and strengthen regional mineral innovation ecosystems. By situating hyperspectral imaging within a broader workforce and regional development framework, this contribution complements ongoing technical advances and highlights enabling conditions necessary to maximize the geological and economic impact of spectral technologies in Canada's evolving mineral sector.

Cretaceous evolution of the Selwyn fold belt in central Yukon: Insights from structural mapping, in situ white mica ⁴⁰Ar/³⁹Ar dating and Raman thermometry

Diane Skipton^{1,2}, Alfredo Camacho³, Dawn Kellett⁴, Matthew Steele-MacInnis⁵

¹Geological Survey of Newfoundland and Labrador, ²Yukon Geological Survey, ³University of Manitoba, ⁴Natural Resources Canada, Geological Survey of Canada, ⁵University of Alberta.

E-mail: DianeSkipton@gov.nl.ca

The Selwyn fold belt formed along the northern margin of the Selwyn basin in response to Jurassic–Cretaceous shortening during the Cordilleran orogeny. In the McQuesten Lake area of the NW–SE trending fold belt, Neoproterozoic–Cambrian Selwyn Basin strata are juxtaposed against Paleozoic rocks of the Ogilvie Platform across the Dawson fault. The McQuesten Lake area consists of at least five thrust sheets and includes parts of three regional-scale faults: the Robert Service thrust, Tombstone thrust and Dawson fault. Northeast-vergent thrusting produced folds and axial planar foliation at greenschist-facies conditions. The poor constraints on timing of deformation are a source of uncertainty regarding the evolution of the Selwyn fold belt and its role in Cordilleran orogenesis. New in situ ⁴⁰Ar/³⁹Ar dating of foliation-defining white mica in nine samples across the thrust stack yielded dates of ca. 108–101 Ma from the immediate hanging wall and footwall of the Robert Service thrust, whereas footwall rocks of the

underlying Tombstone thrust and approaching the Dawson fault yielded younger dates of ca. 70–67 Ma. Average temperatures estimated from Raman spectroscopy on carbonaceous material mostly range from ~375 to 450°C, regardless of structural level. These temperatures are generally lower than or overlap with estimates of closure temperatures of ^{40}Ar in white mica in these samples. The $^{40}\text{Ar}/^{39}\text{Ar}$ dates may thus reflect the timing of white mica growth/recrystallization during metamorphism and foliation development, although thermal diffusion of ^{40}Ar during cooling is not ruled out. The data constrain the timing of thrust and fold belt development to the mid-Cretaceous and suggest a younger episode of deformation in lower levels of the thrust stack during the Late Cretaceous. The younger episode occurred coevally with orogen-parallel strike-slip faulting in the surrounding region in the Yukon Cordillera.

Geology and geochronology of the southern Long Range Inlier, western Newfoundland (parts of NTS 12H/11 & 12H/14)

Diane Skipton¹, Alana Hinchey¹, Nicole Rayner², Zachary Adam¹

¹Geological Survey of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: DianeSkipton@gov.nl.ca

The Long Range Inlier of western Newfoundland is a massif of Proterozoic crystalline rocks with Grenvillian affinity that forms the basement to Late Neoproterozoic to Ordovician cover sequences, which were structurally overlain by parautochthonous to allochthonous rocks during the Appalachian orogen. The inlier hosts gold mineralization along its eastern margin bordering the Doucours Valley Fault system. As significant portions of the inlier have only been mapped at reconnaissance scale, and the ages of the rocks were largely unknown, its geological evolution and mineral potential remain uncertain. Recent detailed (1:50 000 scale) bedrock mapping and U–Pb zircon geochronology in the Silver Mountain (12H/11) and Main River (12H/14) areas demonstrate the lithological complexity of the inlier and shed light on its tectonic evolution. The mapped area largely consists of gneissic basement rocks that are interpreted to form part of the Late Paleoproterozoic to Early Mesoproterozoic Long Range Gneiss Complex. The area also includes felsic metaplutonic rocks that were emplaced during two pulses at ca. 1044–1037 and ca. 999–993 Ma, comparable with Grenvillian plutons in the surrounding region. The inlier hosts the Silurian (ca. 431 Ma) Taylors Brook Gabbro Suite (TBGS), a heterogeneous mafic intrusive suite related to Appalachian post-collisional extension. The TBGS is flanked by metasedimentary rocks with maximum depositional ages of ca. 996, 906 and 554 Ma, which are interpreted to represent Late Neoproterozoic to (?)Ordovician cover sequences. Collectively, the bedrock mapping and geochronological results help to refine tectonic links with Grenvillian rocks elsewhere and contribute to understanding the evolution of the Laurentian margin during Appalachian orogenesis.

Investigating Appalachian tectonic reworking of Proterozoic basement in the Long Range Inlier, western Newfoundland

Diane Skipton¹, Alana Hinchey¹, Nicole Rayner², Hamish Sandeman¹, Daniela Mendoza Marin¹

¹Geological Survey of Newfoundland and Labrador, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: DianeSkipton@gov.nl.ca

Along the Laurentian margin of western Newfoundland, Grenvillian basement rocks of the Long Range Inlier were variably reworked during the Appalachian orogeny. The inlier mainly consists of the Late Paleoproterozoic–Early Mesoproterozoic Long Range Gneiss Complex (LRGC) and Late Mesoproterozoic–Early Neoproterozoic Grenvillian-aged metaplutonic rocks. The inlier's western margin is marked by the Long Range Frontal Thrust, which transported the inlier over autochthonous Cambro-Ordovician platformal sequences and Taconic allochthonous rocks. Along its eastern margin, the inlier is bounded by the Doucours Valley Fault system, which was episodically reactivated during Appalachian orogenesis and is spatially associated with Devonian gold mineralization. The eastern part of the inlier hosts Silurian intrusions, including the Taylors Brook Gabbro Suite (TBGS), which is flanked by Late Neoproterozoic to (?)Ordovician metasedimentary rocks that likely represent Laurentian cover sequences. Previous studies have shown that the LRG records Mesoproterozoic regional tectonometamorphism at amphibolite- to granulite-facies conditions, with a southwestward increase in peak temperature from ~600–700°C to ~700–800°C. Subsequent regional amphibolite-facies tectonometamorphism has historically been dated at ca. 1 Ga. Recent work in the southern part of the inlier shows that Appalachian reworking may be more significant than previously understood. This contribution uses new field and petrological data from metasedimentary samples to investigate the tectonometamorphic evolution of the inlier. High-grade assemblages define the foliation in Late Neoproterozoic to (?)Ordovician metasedimentary rocks, suggesting that, rather than resulting solely from contact metamorphism in the thermal aureole of the TBGS, metamorphism was coeval with deformation and may represent Appalachian (Taconian?) tectonism. The inlier also records lower temperature thermal activity and deformation that likely reflect later stages of Appalachian tectonism, possibly associated with transpression along the inlier's bounding fault systems. Investigating post-Grenvillian reworking of the inlier is important for understanding the tectonometamorphic evolution of the Laurentian margin and the potential for orogenic-style mineralization.

Cementing the diagenetic history of the Ben Nevis Formation, Hibernia Oil Field

Noah Slaney, David Lowe, Jaimee Hodgson, Brette Harris, Eric Hutton, Hilary Corlett

Memorial University of Newfoundland.

E-mail: Naslaney@munn.ca

Challenges surround the extraction of hydrocarbons and the injection of carbon dioxide in siliciclastic reservoirs due to the filling of intergranular pore space with carbonate cements. Carbonate cements are challenging to distinguish using petrophysical logs, seismic data and drill core; furthermore, it is nearly impossible to differentiate between multiple generations of cementation without rigorous and time-consuming petrographic and geochemical sampling/analyses of the cored intervals. This results in uncertainty in subsurface reservoir heterogeneity, cement distribution and ultimately permeability pathways. Hyperspectral imagery provides a quick, in situ, continuous and non-destructive method that, alongside sedimentological

analyses and other spectroscopy techniques, can isolate multiple generations of carbonate cements using characteristic absorption features in the short-wave (2325–2345 nm), mid-wave (3920–3960 nm), and long-wave (11 140–11 300 nm) infrared ranges. A case study of the hydrocarbon-bearing Aptian–Albian Ben Nevis Formation of the Jeanne d'Arc Basin was conducted on drill core located in the Hibernia oil field offshore Newfoundland. Hyperspectral imaging is combined with detailed analyses of sedimentary facies, optical petrography, X-ray fluorescence (XRF) and energy dispersive X-ray spectroscopy (EDS) to generate a subsurface model to determine the depositional and structural controls of carbonate cementation found pervasively throughout sandstones of the Ben Nevis Formation. Preliminary results of this study have identified multiple stages of diagenesis that variably cause the retention or loss of reservoir-quality sandstones. This includes five main types of carbonate cementation: siderite, poikilotopic non-ferroan calcite cement, intraclast calcite cement, selective allochem replacement calcite cement and intergranular ferroan calcite cement. Analyses of conventional drill core reveal a shallow marine depositional environment with early generations of calcite cementation associated with the initial depositional conditions, and late phases of cement demonstrating a structural control on reservoir cementation.

Differentiating microbial biogeochemical cycling of modern versus petroleum carbon sources during oil sands tailings reclamation

Greg Slater, Chenlu Wang

McMaster University.

E-mail: gslater@mcmaster.ca

Microbial biogeochemical cycling of petroleum hydrocarbons and methane is an important aspect of remediation and reclamation of sites impacted by residual petroleum hydrocarbons. Base Mine Lake (BML) is the first full scale pit lake in the Alberta Oil Sands Region and is an important component of site closure plans for Syncrude and for many other sites. Compound Specific Radiocarbon Analysis of microbial phospholipid fatty acids (PLFA) from BML demonstrated that initially the microbial community was primarily utilizing carbon derived from the recalcitrant petroleum within the underlying tailings ($\Delta^{14}\text{C} = -800$ to -900‰). Subsequently greater metabolism of recently fixed organic carbon in the epilimnion ($\Delta^{14}\text{C} = -700\text{‰}$, comparable to $\Delta^{14}\text{C}_{\text{DIC}}$) implied photosynthetic fixation. Notably, this signature is not observed in the hypolimnion, implying that while the sinking of recent photosynthetically produced organic carbon is hypothesized to be driving the development of anoxic bottom waters, no geochemical signature is preserved. The hypolimnetic microbial community is primarily supported by aerobic methanotrophy evidenced by depleted biomarker PLFA $\delta^{13}\text{C} = -50\text{‰}$. Most of the methane is produced from petroleum sources ($\Delta^{14}\text{C} = -951 \pm 10\text{‰}$) via syntrophic fermentation of residual hydrocarbons coupled to methanogenesis within the underlying tailings. However, observation of isotopically depleted aerobic methanotrophy biomarkers in the underlying tailings at depths of 0.5 to 1 m at several sites raises questions as to how such biosignatures could occur in anoxic sediments. In addition, the location with the highest methane ebullition flux is composed entirely of modern carbon ($\Delta^{14}\text{C} = 10\text{‰}$), demonstrating a distinct, modern carbon source the origin of which is unknown. Microbial carbon biogeochemical cycling in BML is more complex than expected and the metabolism of recalcitrant versus recently fixed carbon sources has significant implications to reclamation outcomes.

The Shaakichiwaanaan lithium-cesium-tantalum pegmatite deposit – A geological overview

Darren L. Smith, Patrik Schmidt

PMET Resources Inc.

E-mail: dsmith@pmet.ca

PMET Resources' Shaakichiwaanaan Project, situated in the James Bay Region, Quebec, hosts the largest lithium pegmatite mineral resource in the Americas and is one of the top 10 largest globally. Additionally, the same pegmatites host one of the world's largest tantalum resources as well as the largest in situ pollucite-hosted cesium resource. The pegmatites at Shaakichiwaanaan are of the highly fractionated Li–Cs–Ta (LCT) type and form multiple distinct clusters along an approximate 1 km wide by 25+ km long corridor, whereby the CV5 and CV13 clusters in the core of the corridor host the currently estimated mineral resources. The pegmatites are non-concordant with the regional fabric, relatively undeformed, and vary in dip from shallow to near vertical. The level of fractionation varies between clusters based on K/Rb ratios (4 to 17). At CV5, the pegmatite has been traced for ~5 km and remains open along strike and to depth. The vast majority of CV5 is hosted within a single, steeply dipping dyke, which is flanked on both sides by multiple, subordinate, sub-parallel trending dykes. Widths of the principal dyke range from < 10 m to 125+ m, and may pinch and swell aggressively along strike, up dip, and down dip. The most fractionated part is the Nova Zone (K/Rb ratio of ~7), hosting some of the highest grade (2 to 5+% Li_2O) zones in the deposit. At CV13, the pegmatite has been traced for ~3.2 km and remains open along strike and to depth. The pegmatite forms a series of flat lying to moderately dipping, sub-parallel trending bodies that range in thickness from < 5 to 40+ m. This cluster is the most fractionated (K/Rb ratio of 4) at Shaakichiwaanaan, whereby sections in the main dyke with lowest K/Rb ratios host several extensive zones of pollucite mineralization at widths of 2 to 10+ m thickness.

From upper to mid slope: Hydraulic controls on channel levee evolution in the Neoproterozoic Isaac Formation, Windermere Supergroup, western Canada

Richard Smith, Bill Arnott

University of Ottawa.

E-mail: warnott@uottawa.ca

In east-central British Columbia mudstone-rich continental slope strata of the Neoproterozoic Isaac Formation (Windermere Supergroup) conformably overlie sandstone-rich basin floor strata of the Kaza Group and are superbly exposed at the Castle Creek study area – a recently deglaciated exposure with vertically dipping strata that is > 4 km thick and up to 8 km wide. Slope strata consist of sandstone-rich channel fills and genetically related mudstone-rich levee deposits that build up multiple channel levee complexes ranging up to > 250 m in thickness. Previous work has focused on base of slope to mid-slope strata that are compared with upper slope strata described here. Upper slope channels are significantly thinner, coarser, more deeply scoured and exhibit characteristics suggesting more extensive cannibalization, including pervasive mud clast breccia and preferential preservation of coarse-grained channel axis deposits. Such attributes reflect flows that had surplus turbulent kinetic energy relative to suspended sediment load and thus operated in an under capacity, erosion-dominated regime – conditions consistent with flow acceleration on the steep upper slope. Additionally, channels on the upper slope were over-steepened relative to the equilibrium channel profile, thereby reducing accommodation space with transport bypass and thinning of the channelized part of the depositional record (farther downslope accommodation becomes positive with much higher net deposition). Levee deposits, on the other hand, are thicker but generally finer grained than those lower on the slope. This difference is attributed to early and prolonged entrenchment by scour and deepening of the channel, which then sustained deposition of the fine-grained, upper part of channelized turbidity currents over the adjacent levees. Despite these differences, detrital zircon assemblages, reflecting sediment provenance and the evolution of channel architecture (mass transport deposits overlain by aggradationally filled channels, overlain by laterally accreting channel deposits) remain similar, suggesting that stratal differences are related only to flow hydraulics controlled by position along the continental slope.

Small carbonaceous fossils from the Ordovician carbonate platforms in northern Manitoba

Urgon J.T. Snider^{1,2}, Ricardo L. Silva¹, Joseph Moysiuk^{2,3,4}

¹University of Manitoba, ²Manitoba Museum, ³Royal Ontario Museum, ⁴University of Saskatchewan.

E-mail: snideru@myumanitoba.ca

Small carbonaceous fossils (SCF) encompass a range of microfossils, including whole microorganisms, meiofauna and macrofossil fragments. These preserved elements of organisms that seldom leave a macroscopic record are vital to ecosystem structure and under-represented in the fossil record; therefore, SCF are fundamental for determining trophic structure and diversity in past and modern day environments. SCF have illuminated diversity within Cambrian paleoenvironments, but very few studies have examined SCF in well-constrained Ordovician environments. Northern Manitoba yields carbonate rock outcrops representing a short time interval in the Late Ordovician (Katian–Hirnantian, 453.0–443.8 Ma) within two distinct basins. These outcrops are well known for their exceptional preservation of soft-bodied macrofossils. For the first time, SCF assemblages were extracted from carbonate samples collected from Cat Head and Lake Winnipeg (Katian) and Airport Cove (Hirnantian). For this, a low concentration acetic acid dissolution method was developed and successfully used. After dissolution, SCF were mounted onto glass slides with specialized mounts, designed to protect their 3D components. Other SCF samples were mounted for scanning electron microscopy. These collections will be the basis for statistical analyses examining changes in SCF diversity across stratigraphic successions at each locality. Samples from known stratigraphic intervals were also analyzed using standard microfacies analysis to correlate sedimentological changes and fossil assemblages. Determination of total organic carbon throughout each succession will illustrate ecosystem function, potentially correlatable with water salinity, depth and nutrient abundance. X-ray diffraction analysis will reveal the mineralogical characteristics of both localities. Using the data collected from each locality, we aim to reconstruct Ordovician ecosystems in each study site and showcase changes in diversity and environment over a relatively short geological interval. Future applications of these methods will establish a more accurate representation of life during the Great Ordovician Biodiversification Event, while emphasizing the significance of SCFs in the carbonate system.

Temporal constraints on auriferous fluid activity along the Destor-Porcupine Fault Zone, southern Abitibi Greenstone Belt, Canada

Safak Utku Sönmez¹, Shane Webb¹, Crystal LaFlamme¹, Robert Creaser², Georges Beaudoin¹

¹Université Laval, ²University of Alberta.

E-mail: suson1@ulaval.ca

The Abitibi Greenstone Belt in the southern Superior Province is one of the most globally prolific Archean orogenic gold provinces. In its southern part, gold mineralization is spatially associated with two major crustal-scale fault systems: the Larder Lake-Cadillac Fault Zone (LLCFZ) to the south and the Destor-Porcupine Fault Zone (DPFZ) to the north. These mineral systems developed during successive shortening events (i.e. D1–D5). While the timing of gold mineralization along the easternmost segment of the LLCFZ is relatively well constrained, the temporal evolution of auriferous events along the DPFZ remains poorly resolved. This study provides new geochronologic constraints on gold mineralization along the DPFZ based on in situ U–Pb dating of hydrothermal xenotime and monazite from gold-bearing shear and crustiform quartz veins and alteration assemblages, and

Re–Os molybdenite model ages from crustiform-banded quartz veins. U–Pb monazite ages from shear quartz veins at the Whiskey Jack deposit of 2686 Ma overlap with pre-D3 events. Coeval U–Pb xenotime ages of 2685 Ma at the Duparquet deposit together with a Re–Os molybdenite model age of 2670 Ma from the Gibson deposit (from crustiform-banded veins) indicate that mineralization occurred during a transition from late D1–D2 shortening to extension. Younger xenotime and monazite ages from major deposits (McIntyre, Hollinger, Bell Creek, Pamour, Stock, Black Fox and Holloway) cluster between ca. 2660 and 2620 Ma. These ages also overlap with previously reported U–Pb monazite ages from the Dome mine and U–Pb hydrothermal zircon rims from the Hoyle Pond mine. Collectively, the datasets suggest that the main gold mineralization event was associated mainly with D3 shortening and subsequent transpressional deformation, with possible Au remobilization. Within this framework, although the geochronological data presented here are under interpretation, gold mineralization along the DPFZ appears temporally distributed, with D3 shortening representing the dominant mineralization interval.

Structural and tectonic controls on lithium mineralization in the Hermitage Flexure, southern Newfoundland

Alessandro Spinaci¹, Eric Thiessen¹, Donnelly Archibald²

¹Memorial University of Newfoundland, ²St. Francis Xavier University.

E-mail: aspinaci@mun.ca

Lithium–cesium–tantalum (LCT) pegmatites are a major source of lithium, and a recent discovery in southwestern Newfoundland (Killick Lithium Project), located 30 km north of Burgeo, provides the present motivation to characterize the structure, emplacement processes and regional significance of the deposit. The pegmatite dykes are located north of the Bay d'Est Fault Zone (BDFZ) and hosted by amphibolite-facies metavolcanoclastic and metasedimentary rocks of the Dolman Cove Formation, a distinct lithotectonic belt of the Bay du Nord group. The mineralized dykes strike NE–SW and dip steeply to the SE and are asymmetrically folded in an S-fold train plunging steeply to the SW. These folds are characterized by forelimb and hinge thickening, with a boudinaged back-limb. Fold analysis shows that the folding of the dykes is sub-cylindrical to cylindrical, indicating some degree of lateral continuity in the hinge zones. The cusped-lobate folding of the dykes, the foliation divergent fan patterns and flanking folds in the host rock indicate the high competency contrast of these rocks during deformation. However, the pegmatites display undeformed primary magmatic textures and characteristic zoning with only minimal plastic deformation in hinge zone quartz. The aims of this study are to characterize the kinematics and timing of reactivations along the BDFZ and test a model of syn-deformation emplacement of the dykes. As hypothesized for apparently similar dykes in Scotland, the LCT pegmatites herein may have partly solidified on their margins and acted as semi-competent bodies enveloping a molten core that allowed macroscopic folding without abundant solid state strain internally. Hinges of the folds show perpendicular offshoots into the host rock, possibly as a result of solid rinds that could not withstand the hydrostatic pressure of the residual quartz-rich melt in the core during folding.

Evolution of the Atrypida (Brachiopoda): A case of paleobiogeographical and ecological paradoxes

Colin D. Sproat¹, Bing Huang², Li Qiao², B. Gudveig Baarli³

¹University of Saskatchewan, ²Nanjing Institute of Geology and Palaeontology, ³Williams College.

E-mail: c.sproat@usask.ca

The Atrypida, one of the shorter-lived brachiopod orders, originated during the Great Ordovician Biodiversification Event in the late Mid Ordovician. These spire-bearing brachiopods initially evolved and survived the first mass extinction of the Phanerozoic in the Late Ordovician only to meet their ultimate demise in the next mass extinction in the Late Devonian. This makes them a good candidate to test evolutionary theory and examine some of the dynamics behind these major events in the history of life, but this requires an understanding of the evolution, phylogeny, and the biogeographic origin and dispersal of atrypide lineages around the globe. To truly delve into the paleobiogeographic drivers of the evolution of this lineage will require a better understanding of evolution at the level of plates and terranes. Here we see the atrypides split into endemic provinces early in their evolution during the Late Ordovician before becoming more cosmopolitan during the Late Ordovician Mass Extinction and more diverse during the Silurian. By the Pridoli (late Silurian), diversity collapsed and the lissatrypids became the most dominant lineage. In the early Devonian, diversity again rebounded but by the Frasnian, only the Atrypinae, Spinatrypinae and Variatrypinae remained. Some patterns are consistent throughout the range of atrypides, with diversity always being highest in equatorial landmasses and lowest closer to the polar regions indicating a preference for stable, warm water settings. This also explains their collapse and relatively low diversity during mass extinction events and intervals of paleoenvironmental change. This niche conservatism contributed to their ultimate demise during the Frasnian biotic crisis that disproportionately affected the shallow tropical marine ecosystems.

Zircon U–Pb geochronology of the Charlevoix impact crater

Livia Standjofski-Figols¹, Jean-Michel Gastonguay², Morgann G. Perrot³, Jesse R. Reimink⁴, Erik Schoonover⁴, Antoine Godet⁵, Nicolas Pinet⁵, Pierre Verpaclst², Natasha Frost³, Joshua H.F.L. Davies¹

¹Université du Québec à Montréal, ²Centre d'études collégiales en Charlevoix, Observatoire de l'Astrophysique de Charlevoix, ³McGill University, ⁴Penn State College of Earth and Mineral Sciences, ⁵Natural Resources Canada, Geological Survey of Canada.

E-mail: liviaj@outlook.com

The Charlevoix impact crater is one of the largest impact structures in eastern North America, yet its timing remains poorly constrained. Several previous studies have suggested a possible link between the Charlevoix impact and an enhanced meteorite flux during the Ordovician about 450 to 500 million years ago, when Earth may have had a ring. This event has also been tentatively associated with global cooling that drove the Hirnantian

glaciation and the end-Ordovician mass extinction. Constraining the age of the Charlevoix impact is therefore critical for reconstructing geological events. Rock sampling within and adjacent to the crater was conducted in 2025 with the aim of extracting zircon for U–Pb geochronology. Samples include clastic sedimentary rocks stratigraphically above and below the inferred impact horizon, a tectonic breccia (mylonite), and an impact melt rock (impactite). Zircon U–Pb analyses were performed by LA-ICP-MS at Université du Québec à Montréal. The results point towards a Late Ordovician age. The carbonate matrix sandstone sample produced a robust maximum depositional age for this sample based on a cluster of young concordant zircons. Zircons from the mylonite show a Pb-loss trajectory with an Ordovician lower intercept age albeit with a large uncertainty. In contrast, zircons from the impact melt do not show any signs of Pb loss or recrystallization during the Ordovician; all the grains preserve Grenvillian ages. An Ordovician age has also been calculated using the U–Pb system in a shocked carbonate sample from within the impact, although the analytical error is large. Ongoing analyses of zircons from the mylonite and other clastic sediments from below the impact horizon will further refine these age constraints. Together, these new data provide improved temporal limits on the formation of the Charlevoix impact crater and support its potential association with enhanced asteroid flux during the Ordovician.

“structr” – a statistical toolset for modern structural geology

Tobias Stephan, Moses Angombe

Lakehead University.

E-mail: tstephan@lakeheadu.ca

Geological interpretation often involves claims such as “foliation and lineation become parallel with the shear zone core” and “multiple stages of fabric development occurred”. Testing such hypotheses requires statistical analysis, which, depending on the question, requires extensive and complex tools that may not be readily available. Our most used data analysis technique, visualization, can be time-consuming when working with increasingly large complex datasets. We present structr, a free and open source software package developed in R that streamlines analytical and visualization tasks in structural geology. The package integrates tools for structural data visualization (projections, contouring, fabric plots) and implements modern statistical methods such as dispersion and distribution analysis, inference methods for confidence regions, hypothesis testing, cluster analysis and geodesic regression. These tools allow users to refute or support their geological hypotheses through statistical argumentation and modern visualization. Implementation within the R universe provides users automated repetitive workflows, flexible and advanced data visualization and access to R’s vast statistical capabilities. Additional functionality includes reconstruction of fabric orientations in oriented drill cores (using α , β and γ angles) and simulation of progressive fabric deformation. The package further provides tools for paleostress analysis, including stress inversion from fault slip data, determination of maximum horizontal stress orientations and visualization of stress magnitudes using Mohr circles. structr also includes routines for strain analysis (e.g. Rf/phi methods, Fry and Hsu plots) and vorticity analysis (e.g. Rigid Grain Net method). The software supports straightforward import of structural field datasets, including simple integration from StraboSpot© projects. Structr is an actively evolving, community-driven project designed to expand access to quantitative structural geology tools, while promoting reproducible and transparent research. Future developments will include tools for crystallographic orientation datasets. A beta version is freely available at <https://github.com/tobiste/structr>. Enjoy structr – we welcome your feedback and contributions.

Filling in “Romer’s Gap”. A stroll through geological time from 350 million years ago in the Stonehammer UNESCO Global Geopark: The role New Brunswick fossil footprints play in our understanding of the evolution of vertebrate life on land

Matthew Stimson¹, Olivia King², Luke Allen³, Eleanor Spence², Margaret Scott⁴, R. Andrew MacRae⁵, Steven Hinds⁶, Spencer Lucas⁷, Brian Hebert¹, Adrian Park⁶, Trystan Warnock-Juteau², Bailey Malay¹, Caleb Bohus⁸, Tetsuto Miyashita⁹, Daniel Fraser⁹, Robert Gastaldo¹⁰, Ian Glasspool¹⁰, Patricia Gensel¹¹, Hillary Maddin², Jennifer Dingman¹²

¹New Brunswick Museum, ²Carleton University, ³University of New Brunswick, ⁴Memorial University of Newfoundland, ⁵Saint Mary's University,

⁶New Brunswick Geological Survey, ⁷New Mexico Museum of Natural History and Science, ⁸Uppsala University, ⁹Canadian Museum of Nature,

¹⁰Colby College, ¹¹University of North Carolina, ¹²Stonehammer UNESCO Global Geopark.

E-mail: matt.stimson@nbm-mnb.ca

The geology within the Stonehammer UNESCO Global Geopark, located in southern New Brunswick is diverse and spans more than 1 billion years of Earth’s history. New fossil discoveries made within the geopark near the village of Norton are now helping to fill a ‘gap’ in the fossil record when vertebrate life made the permanent transition into continental environments. Tetrapods (vertebrates with four limbs) made their first steps on land during the Devonian Period about 385 million years ago. It would take these large amphibians another 60 million years to establish themselves as fully terrestrial colonists during the Pennsylvanian Period (325 million years ago). These early reptiles and amphibians would set the stage for the radiation of all terrestrial vertebrate life to follow, but the exact timing and evolutionary diversification of early vertebrates into continental environments during the Mississippian Period (359–323 Ma) are still poorly understood. This is due to a paucity of rocks exposed at the Earth’s surface that were deposited in ancient continental environments, and results in a lack of fossils available for study. We call this hiatus in the fossil record “Romer’s Gap”. Atlantic Canada has long been known to contain one of the most complete fossil footprints records from the Carboniferous (359–299 Ma). Footprints can offer new insights into the presence of ancient animal life, even if the bones are not fossilized. New fossil discoveries (footprints, plants, invertebrates, bones of amphibians and fish) are populating ancient lake and forested wetland environments and represent one of the few fossil sites globally that offer a glimpse into this cryptic and pivotal interval of Earth’s history. This talk will explore these new discoveries and interpret what they tell us about the change in paleobiodiversity, the evolution of early terrestrial life through time and changing paleoclimates within the Stonehammer UNESCO Global Geopark.

Tonian magmatism in the Grenville Province: Exploring links to the opening of the Asgard Sea

Susan Strowbridge, Aphrodite Indares, Greg Dunning

Memorial University of Newfoundland.

E-mail: susans@mum.ca

In eastern Laurentia the Grenville Orogen is associated with the assembly of Rodinia at ca. 1000 Ma and Laurentia remained nestled within the supercontinent until breaking apart with the opening of the Iapetus Ocean at ca. 615 Ma. Recent work on the Appalachian basement in the Humber Zone of Newfoundland has identified Tonian rift successions (ca. 980–950 Ma) which overlie Mesoproterozoic (ca. 1491 Ma) basement. The ages of the basement and rift magmatism have been used to correlate these units in Newfoundland to Mesoproterozoic continental arc and Tonian pluton ages in the Pinware terrane of the Grenville Province. Furthermore, it has been interpreted that the Tonian magmatism is related to tectonic processes driven by the opening of the Asgard Sea. These findings call for a reassessment of enigmatic Tonian igneous, metamorphic and hydrothermal ages that have been reported throughout the eastern margin of the Grenville Province from the Melville Lake terrane in the north to the Adirondacks in the southeast and Grenvillian inliers in the Appalachians.

Chromitite petrogenesis in the Muskox Layered Intrusion, Canada

Cesar Tarazona¹, Brian O'Driscoll¹, Hadrien Henry²

¹University of Ottawa, ²Université Toulouse III.

E-mail: ctara019@uottawa.ca

Chromitite layers and seams in layered mafic intrusions represent the key processes of magmatic differentiation and metal enrichment, but the mechanisms controlling chromite crystallization and accumulation remain debated. Here, we investigate chromite crystallization and textural evolution in Megacycle 4 (cyclic unit 22) of the Muskox Intrusion from the Geological Survey of Canada North Drill Hole. Our integrated microstructural approach combines petrography, crystal size distribution (CSD), apparent dihedral angles (chromite–chromite–clinopyroxene and chromite–chromite–chromite), chromite chemistry and electron backscatter diffraction (EBSD). Chromite on either side of the studied chromitite seam occurs as disseminated, fine-grained (12–400 μm) equant chadacrysts forming chains and clusters enclosed within poikilitic pyroxene. The chromitite seam is texturally heterogeneous, comprising irregular, bifurcating patches of coarse-grained, polygonal chromite aggregates (10–1000 μm ; CGC), together with abundant fine-grained chadacrystic chromite (FGC) enclosed in poikilitic clinopyroxene, similar to the footwall and hanging wall assemblages. EBSD data show that clinopyroxene and orthopyroxene [001] axes are oriented oblique to layering, consistent with comb-layering and also suggesting epitaxial clinopyroxene crystallization on orthopyroxene. Misorientations at chromite–chromite grain boundaries cluster preferentially around $\langle 111 \rangle$, particularly in the FGC; a weaker but persistent $\langle 111 \rangle$ clustering is preserved in the CGC. The CSD and dihedral angle datasets indicate that the CGC reflects protracted crystallization and equilibration in the presence of a fluid or melt; from the presence of hydrous minerals we infer a volatile-rich melt. In contrast, the fine-grained population records relatively high nucleation densities with limited textural equilibration and was likely fully solidified before the CGC. Together, these results point to multiple, temporally distinct crystallization regimes at sub-millimetre length scales. FGC records an early stage of chromite nucleation and growth, characterized by preferential aggregation of crystals on [111] faces. In contrast, the CGC reflects partial overprinting of the primary microstructure during post-aggregation textural modification, driven by melt percolation reaction and supra- to sub-solidus textural coarsening.

A new plate reconstruction for the Neoproterozoic Arabian Nubian Shield

Dene Tarkyth^{1,2}, Bruce Eglington¹, Hoang Anh Tu (Lavie) Nguyen-Ridgway¹

¹University of Saskatchewan, ²BHP Co.

E-mail: djt983@mail.usask.ca

The Arabian Nubian Shield (ANS) is involved in the assembly of northern Gondwana and the details of its amalgamation are not well understood. A new plate reconstruction for the ANS in the Neoproterozoic is presented, which builds upon the unpublished Eglington and Evans PalaeoPlates model and includes closed plate boundaries. Existing published global models lack sufficient detail within the ANS to link metallogenic processes to geodynamic triggers, which is a key objective of this model. Advances in geochronology and the abundance of new published data on the area provide improved temporal resolution on units that provide constraints on the timing of plume-related, supra-subduction and post-collisional magmatism. The geology and mineral occurrences help to constrain the geologic environments and whether the transient environments of formation were compressional or extensional. The new model presents a plausible integration of available geology, geochronology and mineral occurrence data and offers insights into the possible geodynamic history of the ANS.

Characterizing the bimodal mafic host rocks of (semi-)massive sulphide mineralization at the Neo-Archean Homer Lake prospect, Northwest Territories

Dolvan Tchomugna Kamleu¹, Stefanie M. Brueckner¹, Merilie A. Reynolds², Ryan Bachynski³

¹Laurentian University, ²Northwest Territories Geological Survey, ³Gold Terra Resources Corp.

E-mail: sbrueckner@laurentian.ca

The Homer Lake prospect is located within the Yellowknife greenstone belt, approximately 25 km north of Yellowknife and close to past orogenic gold producers of the Giant and Con mines. In the mid 2010s, (semi-)massive Zn–Pb sulphide mineralized intervals of up to 50 cm were intersected and are hosted in basaltic flows, which are locally strongly deformed, and in minor felsic units. Samples were selected for whole rock lithogeochemistry from both mafic and felsic units to constrain if the bimodal mafic host sequence 1) shares favourable composition for massive sulphide mineralization formed on or near the seafloor by hydrothermal fluids and 2) is unrelated to orogenic events responsible for gold mineralization documented in the area. These bimodal mafic rocks supposedly belong to the 2.73–2.70 Ga Kam Group that is characterized by pillowed and massive tholeiitic basalts and minor rhyolitic units that intercalate with the basalts. The most dominant rock type is basalt which is divided into low Ti–P, tholeiitic to calc-alkaline basalts and high Ti–P, tholeiitic to transitional basalts. Both units have similar REE patterns with greater enrichment relative to primitive mantle for the high Ti–P basalts. Both units also show chlorite–carbonate alteration. Rhyolitic units are sericitized, calc-alkaline rhyolites with Zr < 115 ppm and a steep REE pattern with a pronounced negative Eu anomaly. Based on trace element data, the tectonic setting for basalts is constrained to be of N-MORB origin with different degrees of crustal assimilation. Rhyolites also show a volcanic arc signature. Based on the geochemical composition of bimodal mafic host rocks, their formation in an arc environment and the pervasive chlorite–carbonate (basalts) and sericite (rhyolite) alteration, the host rocks formed in an environment common for Zn–Pb rich volcanogenic massive sulphide deposits. However, more research on these host units and the ore mineralization is needed to further characterize the origin and genesis of the sulfide mineralization.

Evidence for a regional 1.75 Ga thermal-tectonic event recorded in the Ungava orogen, Nunavik, northern Québec

Isabelle Theriault¹, Kyle P. Larson¹, Mehdi Jouhari², Carl Guilmette²

¹University of British Columbia Okanagan, ²Université Laval.

E-mail: isabelle.theriault@ubc.ca

The Paleoproterozoic Trans-Hudson Orogen (THO) formed through a series of accretionary and collisional events involving multiple Archean cratonic blocks, microcontinents and arc terranes. While the main collisional orogenic activity is generally interpreted to have occurred between ca. 1.92–1.79 Ga, the post-collisional evolution of the THO remains comparatively poorly understood. Recently, an increasing number of multidisciplinary datasets from across the THO have reported recurrent ca. 1.75 Ga tectonometamorphic dates, variably interpreted as reflecting cooling, retrogression and/or thermal resetting. These observations raise fundamental questions regarding the duration, spatial extent and geodynamic significance of post-collisional deformation, exhumation and thermal evolution within the THO. Comparable ca. 1.75 Ga signatures are observed in the Ungava orogen (UO) of Nunavik, Québec, which occupies the northeastern segment of the THO and formed during terminal collision between the Archean Churchill province and the Superior craton. Recent work in the UO documents ca. 1.75 Ga dates associated both with the interpreted basal detachment zone in the foreland and within multiple structural domains of the hinterland, indicating that this signal is regionally significant within the UO. This contribution integrates new structural observations with modern, spatially resolved petrochronological data, derived predominantly from U–Pb and Rb–Sr in situ analyses, to investigate the extent of ca. 1.75 Ga geochronometers within the UO. These data are evaluated alongside previously reported results from across the Arctic region to assess whether the observed signatures are compatible with previously proposed large scale lithospheric delamination models or whether alternative tectonothermal mechanisms better account for the timing and spatial patterns observed. These results provide new insights into the late stage evolution of the Ungava orogen and contribute to a broader reassessment of post-collisional processes within the Trans-Hudson Orogen.

Tectonostratigraphy of southeastern New England, USA: Affinities within and beyond West Avalonia

Margaret D. Thompson¹, James L. Crowley², Jahandar Ramezani³

¹Wellesley College, ²Boise State University, ³Massachusetts Institute of Technology.

E-mail: mtompson@wellesley.edu

Recently published CA-ID-TIMS U–Pb zircon dates from Ediacaran granitoid rocks in the southeastern New England Avalon zone reinforce previously recognized affinities with igneous assemblages in Atlantic Canada. Several of these samples – 627.68 ± 0.22 Ma diorite at Rowley, MA and associated < 629.44 ± 0.57 Ma tonalite near Topsfield, MA, along with a 618.60 ± 0.66 Ma subsurface sill in a tunnel transecting the faulted western boundary of the Boston Basin – overlap ages of early Ediacaran intrusives in the Caledonia terrane of New Brunswick and in Nova Scotia's Cobequid and Antigonish Highlands. Stratified units respectively within the Jeffers and Georgeville groups of the latter areas, provide possible counterparts to argillite and conglomerate intruded by the sill. These significantly pre-date the < 595 Ma Roxbury Conglomerate and overlying Cambridge Formation farther east in the basin. Available Nd and Hf isotopic data also favour links between southeastern New England, New Brunswick and mainland Nova Scotia. Detrital zircon assemblages from two Boston area quartzite samples assigned to the Westboro Formation resemble those from the Gamble Brook Formation in the Cobequid Highlands. All three probability density distributions feature Mesoproterozoic peaks at ca. 1000, ca. 1200 and ca. 1500 Ma, as well as subsidiary Paleoproterozoic and sparser Archean components. While these age distributions have variously been attributed to sources in West Africa, Amazonia and Baltica, εHf values from these samples are most consistent with Paleoproterozoic crustal sources in Baltica. By contrast, West African sources show more widespread Archean contributions, and the absence of 0.9–0.6 Ga zircons in the Westboro-Gamble Brook

zircon suites argues against proximity with Goiás arcs bordering the Amazonian craton. Unresolved are sources for ca. 680–640 Ma inheritance in < 630 Ma Jeffers block tuffs and the Topsfield intrusion in Massachusetts. Baltica's Timanide margin includes rocks of suitable age, but by ca. 650 Ma, West Avalonia was drifting towards collision with Ganderia.

Construction of a new biostratigraphic framework for megaherbivorous dinosaurs for the Dinosaur Park Formation using bentonite correlation and detailed fluvial stratigraphy

Mira Thompson¹, Kirstin Brink¹, Caleb Brown², Paul Durkin¹

¹University of Manitoba, ²Royal Tyrrell Museum of Palaeontology.

E-mail: mira.g.w.thompson@gmail.com

Biostratigraphic research in the Campanian Dinosaur Park Formation (DPF) in Dinosaur Provincial Park (DPP), Alberta has focused on megaherbivore dinosaur fossil assemblages, which appear to differ between lower and higher strata. This biostratigraphic shift indicates a faunal turnover in megaherbivore communities in the DPF environment through time. However, the exact timing and cause of this faunal turnover remains unclear. This uncertainty stems from the complex nature of DPF strata, which are composed of highly variable fluvial sandstones and floodplain mudstones, lateral accretion and localized deposition. Thus, a stratigraphic framework based on dated marker beds and detailed fluvial stratigraphic observations is necessary to resolve dinosaur biostratigraphy issues in the DPF. Recent research on DPF bentonites has allowed for aging and initial correlation of the Plateau Tuff bentonite (PT; 75.639 ± 0.025 Ma) in DPP. Using field observations, geochemical fingerprinting, aerial photography, elevation data and structure-from-motion drone photogrammetry, we further correlate the PT. To test the utility of the PT as a marker bed, we focus on several megaherbivorous dinosaur fossil sites preserved in channel belt sandstone deposits located near PT outcrops. We employed detailed stratigraphic sections to determine boundaries of individual channel belt deposits and stratigraphic position of fossils. These observations suggest that many dinosaur fossil sites are considerably different in age than than previously suggested by traditional use of strict elevation-based measurements, producing a significantly different biostratigraphic succession compared to previous DPF biostratigraphic studies. Our results demonstrate that several species of megaherbivorous dinosaur that were previously thought to live at different times coexisted for part of their evolutionary history. Additionally, we observe a decline in megaherbivore species in strata younger than the PT compared to strata older than the PT. Our work ultimately demonstrates that age constraints and careful, detailed analysis and understanding of fluvial stratigraphy are necessary to accurately place fossils into a stratigraphic context.

Stepwise metamorphism and accretion of ultra-high pressure rocks in the northern Canadian Cordillera?

Kyle Tollefson^{1,2}, Kyle Larson², Brendan Dyck², Nathan Clevens³, James Ryan³, Jeff Vervoort⁴

¹Geological Survey of Newfoundland and Labrador, ²University of British Columbia Okanagan, ³Natural Resources Canada, Geological Survey of Canada, ⁴Washington State University.

E-mail: kyletollefsen@gov.nl.ca

The Yukon-Tanana terrane (YTT) of the northern Canadian Cordillera has a complex history, including rifting from the ancestral Laurentian cratonic margin, multiple arc-building events and accretion back onto the margin. The protracted, overprinting deformational history of the terrane has made deciphering specifics about the YTT's tectonic evolution difficult. Located on the eastern margin of the YTT, the St. Cyr area comprises primarily quartzofeldspathic rocks, some of which host eclogites that record Permian subduction. The eclogites have been viewed as part of a single tectonic slice; however, this interpretation is based on limited data, leading to ambiguity in characterizing the tectonic evolution of the region. To develop a more comprehensive understanding of the eastern YTT, this study integrates phase equilibrium modelling and conventional geobarometry (Si-in-phengite) with targeted, multi-chronometer geochronology (ID Lu–Hf garnet, in situ U–Pb apatite and rutile and in situ Rb–Sr biotite and phengite) on specimens collected at different structural levels in the St. Cyr area. Pressure-temperature estimates indicate that rocks in the St. Cyr area were subducted to depths of ~100 km before exhumation and accretion to the lower crust of the YTT. Lu–Hf garnet dates from these UHP rocks exhibit a younging trend from southwest to northeast across the St. Cyr area, indicating that the entire St. Cyr area may not have subducted and exhumed as a single unit, but rather assembled through stepwise metamorphism and accretion of multiple tectonic slices. These new data, however, must be reconciled with previous legacy zircon U–Pb and white mica Ar/Ar dates.

Petrographic, chemical and isotopic characterization of sulphides from abyssal peridotites of the Gakkel Ridge

Diego I. Toro Vivanco¹, Jörg Hermann¹, Andreas Stracke², Sarah Woodland³, D. Graham Pearson³, Eric Hellebrand⁴, Suzette Timmerman¹

¹University of Bern, ²University of Münster, ³University of Alberta, ⁴Utrecht University.

E-mail: diego.toro@unibe.ch

Gakkel Ridge, located at the boundary of the North America and Eurasian plate in the Arctic, is the slowest spreading ridge globally (< 15 mm/yr). The ultra-slow spreading rate and efficient conductive cooling causes a low degree (or complete absence) of melt produced by adiabatic decompression melting. Therefore, only thin oceanic crust overlies the oceanic lithospheric mantle, allowing direct sampling of abyssal peridotites and, therefore, assessment of the chemical heterogeneity of Earth's peridotitic mantle. Re–Os geochronology of peridotites can constrain the timing and evolution of the mantle, with sulphides hosting most of the Os in the peridotites. Previous studies have characterized the petrography and determined the major and trace element concentrations and Re–Os and Pb isotope ratios on sulphides from abyssal peridotites of the Gakkel Ridge, but these data were rarely collected together on individual samples. Here, we integrate petrographic information, in situ LA-ICP-MS trace element concentrations of chalcophile, platinum group [PGE] and highly siderophile elements [HSE], and in the near future, Pb and Re–Os isotopes on sulphides from Gakkel

Ridge peridotites. This comprehensive characterization can offer insights on the time of formation and preservation of ancient and depleted components in the mantle. Patterns of HSE show coexisting primary and secondary sulphides from peridotites along the Gakkel Ridge, even at the scale of individual samples. The origin of the sulphides is not systematically related to morphology, mineral host and location of the grains. Most of the measured Pb concentrations (< 5 ppm) are within previously reported values for unaltered sulphides from abyssal peridotites. Lead and Re–Os isotope analyses of extracted sulphides in abyssal peridotites of the Gakkel Ridge are in progress and will help constrain the evolution of Pb isotope ratios of the oceanic lithospheric mantle and may provide critical data to solve the long-lasting paradox of the bulk silicate Earth's Pb isotopic evolution.

The suturing problem of far-travelled ophiolites – examples from the Albanian Dinarides and Canadian Appalachians

Alain Tremblay

Université du Québec à Montréal.

E-mail: tremblay.a@uqam.ca

Far-travelled ophiolites are upper plate oceanic segments of subduction systems. Defining the roots and the amount of transport over continents of such ophiolites is often a difficult task. The Albanian Dinarides consist of a western zone of nappes derived from Adria, a central belt of the Jurassic Mirdita ophiolite (ca. 165 Ma), and an east zone of Hercynian basement and Permian to Jurassic rocks, collectively known as the Korabi zone. The latter is interpreted as a micro-continent separating two oceanic basins, the Mirdita and Vardar basins, or a structural window below a Mirdita-Vardar ophiolitic nappe. Structural analysis supports the latter hypothesis, implying a minimal transport distance of ~120 km for the ca. 170–162 Ma obduction of the Mirdita ophiolite. This is favoured by top-to-west structures and west-directed obduction, and the presence of normal faults at the Mirdita-Korabi contact. In Canada, the Québec Appalachians consist of Neoproterozoic to Ordovician rocks of Laurentia, oceanic rocks mostly made up of ca. 480 Ma supra-subduction-zone (SSZ) ophiolites and ca. 470 Ma arc rocks overlain by mélanges, sandstones and black shales. Ophiolite obduction occurred at ca. 475–470 Ma, creating an almost flat-lying continent–ocean suture that roots eastward at ~100 km. The ophiolite(s) and underlying rocks were then exhumed, eroded and recycled into syn-collisional basins. The obduction of both the Québec and Albanian ophiolites lasted for 10–20 Myr. At a conservative thrusting rate of 1 cm/yr, this implies a tectonic transport of 100–200 km. Raising this rate to values like those of the archetypical Samail ophiolite (Oman) would imply 170 to 340 km of thrusting, which can be easily accounted by current distances between both ophiolites and their inferred roots. In the Appalachians, such values are minimal since an undefined amount of flattening has been superposed on accreted ophiolites during the Acadian orogeny.

Automated zirconology using scanning electron microscopy (BSE, CL, and EDS) for high throughput grain selection

Jonathan Tremblay, Réjean Girard

IOS Geosciences.

E-mail: jtremblay@iosgeo.com

Advances in zirconology rely on rapid, automated characterization methods capable of handling large grain populations with minimal manual intervention. Traditional zircon sorting from heavy-mineral concentrates is labour-intensive, subjective and prone to the loss of rare or atypical grains. Selecting and analyzing grains that are not zircons will undoubtedly increase the costs associated with isotopic studies. An integrated, fully automated workflow combines scanning electron microscopy (SEM), backscattered electron (BSE) imaging, cathodoluminescence (CL) and energy-dispersive spectroscopy (EDS) mapping to efficiently locate, classify and document zircon grains directly on grain mounts, eliminating the need for manual sorting. High-resolution BSE and CL mosaics enable automated grain detection, segmentation and textural classification, while EDS maps ensure precise mineral identification and discrimination from other dense phases. The data are embedded within a dedicated software where physical parameters can be compiled, including size, shape, elongation, inclusions and growth zoning patterns. The approach provides an objective, reproducible dataset suitable for geochronology. Once characterized, grains of interest (e.g. euhedral or rounded, inclusion-bearing, well zoned) can be relocated with high precision using an automated triangulation procedure for correlative LA-ICP-MS or SIMS analyses. This eliminates the common difficulty of re-identifying specific grains on the mount during subsequent manipulations. This automated zircon-imaging workflow enhances analytical efficiency and is less user dependent. The presented technique might help universities, research centres, government agencies and exploration companies to ease their research or fieldwork.

Tracing plant, fungal and bacterial inputs to inform boreal forest soil climate feedbacks

Samantha Turtle¹, Michael Philben², Susan Ziegler¹

¹Memorial University of Newfoundland, ²Hope College.

E-mail: sturtle@mun.ca

Boreal forests store vast amounts of soil organic C and play a critical role in global C storage and climate feedbacks. However, how the sources of organic matter input to these soils, including plants, fungi, bacteria and mosses, will shift under future climate conditions remains poorly understood. Prior studies suggest that warming and increased precipitation can enhance primary productivity by increasing N cycling and its availability, thereby offsetting soil respiration and maintaining boreal C stores, while the constraints on enhanced N cycling and soil C stores in these systems remain unclear. Climate-driven changes in vegetation composition (e.g. reductions in moss) and nutrient regime shifts are likely to have cascading effects on bacterial and fungal communities (e.g. relative roles of saprotrophic and ectomycorrhizal fungi). Given differences in the chemical composition among vascular plants, mosses, bacteria and fungi, relevant to the stabilization of soil organic matter, these changes have the potential to alter soil organic matter cycling and fate, emphasizing the need for tools that can trace the origin of soil organic matter. Compound-specific stable isotope

analysis of $\delta^{13}\text{C}$ in amino acids offers a promising approach to distinguish organic matter contributions from broad taxonomic groups across soil horizons. Preliminary results indicate this technique is applicable for tracing inputs from fungi, bacteria and plants to boreal soil organic matter, and may present a new biomarker tool for understanding the relative contributions of soil organic matter inputs. Exploring these signatures over a boreal forest climate transect should resolve differences in the organic horizon inputs associated with decadal scale climate change. If detected, such a change would have potential implications for the large stores of mineral-associated C in the underlying mineral soils of these boreal forests.

The northern Caribbean arc, Hispaniola: An analogue for the Taconic evolution of the Dunnage Zone oceanic island arc complexes?

P. Valverde-Vaquero, J. Escuder-Viruete

Instituto Geológico y Minero de España.

E-mail: p.valverde@igme.es

A great contribution of Cees van Staal has been the study of the Taconic orogeny in the Northern Appalachians and the complexities of arc-continent collision, involving the intra-oceanic island arcs of the Dunnage Zone. These juvenile arcs have analogies with the evolution of the intra-oceanic Caribbean island arc recorded in the island of Hispaniola. The oldest rocks in the upper plate are an Early Cretaceous oceanic plateau built on Late Jurassic, Pacific-derived, oceanic crust upon which the arc grew in two main stages. Boninitic and tholeiitic primitive island arc magmatism marks the initiation of subduction in the Early Cretaceous (126–110 Ma). Contemporaneously, fragments of volcanic arc, high-P mélanges and subducted proto-Caribbean oceanic lithosphere formed a subduction accretionary complex. Island arc extension, oceanic plateau accretion and subsequent deposition of upper Lower Albian reef limestones signal a halt and change in the subduction regime. Magmatism was renewed in the Late Cretaceous (90–74 Ma), forming a mature arc with gabbro-tonalitic plutonism and calc-alkaline volcanism. These events were contemporaneous with the peak (ca. 90 Ma) mantle plume related magmatism of the Caribbean Large Igneous Province in the back-arc domain. The subduction of the Bahamas continental margin of North America under the Caribbean plate in the Mid-Eocene led to the arc-continent collision and ophiolite emplacement and transformed the pre-collisional forearc into a syn-collisional basin. The blocked suture zone in northern Hispaniola transferred deformation to the southern back-arc region, inducing a subduction polarity reversal and mid Eocene-late Oligocene shortening. From the early Miocene onwards, thrust and strike-slip transpression produced eastward lateral escape and tectonic disruption of the arc along the Caribbean–North American plate boundary.

Elucidating tourmaline trace element systematics to understand Li-pegmatite systems

Vincent van Hinsberg, Kim Berlo, Stan Roozen, Catherine Crotty, Dominic d'Amato, Josephine Livak

McGill University.

E-mail: Vincent.vanHinsberg@mcgill.ca

Tourmaline is a common accessory phase in crustal rocks, especially in evolved magmatic rocks. This presence of tourmaline is advantageous as it is a powerful indicator mineral. Its composition has been used with great success to determine pressure-temperature conditions, fluid composition, age and provenance. Tourmaline is particularly promising in understanding Li-rich pegmatites where melt source, magmatic evolution, fluid involvement and emplacement conditions are all debated. However, a mineral's composition is controlled by multiple processes, which moreover rarely act independently. In addition to P-T conditions, the bulk composition of the host environment and the element-exchanging mineral assemblage, these controls include the mineral's crystal structure and that of its growth surfaces. To use tourmaline composition as an indicator of its environment thus requires a thorough understanding of how its composition reflects external physical and chemical conditions and internal crystallo-chemical controls. Unfortunately, this has yet to be fully explored for tourmaline. This contribution will review element systematics and partitioning data for tourmaline, and present new data from well equilibrated natural samples as well as from experiments involving granitic melts and aqueous fluids. Results show that tourmaline Mg-Fe and Ca-Na exchanges are temperature-sensitive, whereas K correlates with pressure, but all are affected by bulk composition and tourmaline crystal structure. In terms of trace elements, tourmaline preferentially incorporates Cr, V, the base metals and Sn, but little Rb, Cs and Ba. The REE are compatible in tourmaline in melt and fluid experiments, and tourmaline prefers the LREE compared to coexisting minerals. Partition coefficients range from highly incompatible to compatible with a similar pattern for melt and fluid, showing that tourmaline has a distinct element incorporation fingerprint. As a result, tourmaline does not passively record its environment, but its crystal structure actively fractionates the elements. This must be accounted for in its application as an indicator mineral.

Transpressional and transtensional cryptic sutures and terrane boundaries in the Nova Scotia segment of the Appalachian orogen

Deanne van Rooyen¹, Sandra M. Barr¹, Chris E. White¹, Cees R. van Staal², Dylan McKeen¹

¹Acadia University, ²Natural Resources Canada, Geological Survey of Canada.

E-mail: deanne.vanrooyen@acadiau.ca

Identification of ocean closures and sutures is an ongoing issue in tectonic analysis of orogenic systems. The Iapetus and Rheic oceans as well as their subsidiary oceanic seaways closed during Paleozoic formation of the Appalachian orogen. However, identification of the related sutures is complicated by irregularities in the original Laurentian margin, collisional diachroneity, and syn- and post-collisional deformation and associated structural excision. Terrane boundaries in Nova Scotia that may have formed after ocean closures do not show typical assemblages associated with subduction-related accretion and hence remain contentious. Three such terrane boundaries in Nova Scotia are between (i) the Ganderian Aspy and Bras d'Or terranes, (ii) between the Ganderian Bras d'Or terrane and Avalonian Mira terrane, and (iii) between Avalonia and the peri-Gondwanan Meguma terrane. The Aspy

and Bras d'Or terranes were juxtaposed between ca. 420–390 Ma along the Eastern Highlands shear zone following a long history of arc magmatism and metamorphism recorded mainly in the Aspy terrane. Localized magmatism at ca. 402 Ma likely occurred in a syn-collisional pull-apart setting that formed in an overall transpressional environment. On the trailing edge of the Bras d'Or terrane, no evidence of a magmatic or metamorphic event associated with accretion of the Avalonian Mira terrane is preserved, and the suture is an inferred discrete fault not exposed at the surface. Geophysical data constrain the location of the boundary, and clasts in a conglomerate overlying the suture constrain its age, but its nature is not well understood. Transpressional docking of the Meguma terrane to West Avalonia led to Famennian indentation and underthrusting of Avalonia near a promontory at the junction between southeastern Cape Breton Island and mainland Nova Scotia, as evidenced by dextral and sinistral faults near the promontory. Indentation overlapped and followed upper plate A- and S-type magmatism in Avalonia and the Meguma terrane.

Musings concerning defining orogenies and the use of Wilson cycles

Cees van Staal^{1,2}

¹Natural Resources Canada, Geological Survey of Canada, ²University of Waterloo.

E-mail: cees.vanstaal@NRCan-RNCan.gc.ca

Although mountains can be produced by several processes, most geologists associate orogenesis with accretion/collision of terranes to continents or other buoyant tectonic elements. Historically, orogenic events are generally defined and classified solely on basis of time by most earth scientists, although plate tectonic theory predicts this practice is potentially flawed. Since convergence is rarely head-on and continental margins commonly have complicated and irregular outlines, collisions are expected to be diachronous along the length of the converging and colliding terrane. Hence, contrasting tectonic regimes and settings can be expected to be present coevally along the length of a collision or convergent zone (e.g. Taiwan), which complicates tectonic analyses of old orogens. In addition, unrelated terranes with a different provenance and/or setting can converge and collide approximately at the same time with the same collider along strike. In addition to time, we should therefore also try to incorporate the dynamic and kinematic processes in describing and naming the orogenic events in complex mountain belts. Rather than just using orogeny for events in a specific time slot, one approach is the use of tectonic or orogenic cycle, which relates to one dynamic process but can encompass several different kinematic events and assembly of terranes during ocean closure. Wilson cycles historically refer to the opening and closing of simple oceans bounded by two continental masses. However, when the ocean opening is tectonically complex and as a result comprises numerous buoyant, unobductable terranes, defining which collisional event defines ocean closure is not so simple and becomes arbitrary. This problem is especially pertinent in long-lived and progressively growing accretionary orogens.

Mineral composition is all you need — thermobarometric inversion using Gibbs free energy minimization

Jonas Vanandois, Philip Hartmeier, Pierre Lanari

University of Lausanne.

E-mail: jonas.vanandois@unil.ch

Phase diagram modeling has been for two decades the powerful tool allowing us to constrain the pressure-temperature (P-T) conditions of metamorphic mineral assemblages. This method requires the use of a 'reactive bulk composition' representing the composition of the reactive part of a rock at equilibrium. The definition of this reactive bulk composition is not straightforward due to the metastable perseverance of minerals or parts of minerals, for example during prograde metamorphism. In addition, the reactive bulk composition can evolve if considering open systems with fluids and/or melt migration. An important aspect is that at any given P-T condition, the Gibbs free energy of a phase within a stable mineral assemblage is independent of the modal proportion of that phase. This has led to the development of several inversion methods over the past few years, which minimize the difference between the observed and predicted compositions using Gibbs free energy minimization. In this presentation we will describe a new approach for thermobarometry and the Julia package named 'miniPT'. Optimal P-T conditions are determined by inversion from the observed stable mineral compositions without the need to explicitly define a reactive bulk composition. Thermodynamic calculations are performed using the MAGEMin Gibbs free energy minimizer. A Monte Carlo simulation is used to propagate the uncertainties of mineral compositions to the inversion results. Our method can be used (i) to estimate the minimum uncertainties of phase equilibrium modeling assuming perfect equilibrium and thermodynamic data, (ii) to identify phases that are part (or not) of a given equilibrium assemblage and (iii) to derive P-T conditions from successive mineral assemblages in partially re-equilibrated rocks.

A pyrochlore factory generated by carbonatitic magma–gneiss interaction and alkaline silicate melt production

Olga Vasyukova¹, Anthony Williams-Jones¹, Anastasia Kostyuk², Alena Serdyuk²

¹McGill University, ²D.S. Korzhinsky Institute of Experimental Mineralogy RAS.

E-mail: olga.vasyukova@mcgill.ca

It is widely accepted that ijolites and nepheline syenites fractionate from olivine-(melilite) nephelinitic magmas, which are the products of low degrees of partial melting of metasomatized mantle. Our experiments show, however, that these rocks can also crystallize from magmas generated by the interaction of carbonatitic magmas with quartz-feldspathic gneisses in a manner similar to the armouring of conduits in the mantle by wehrlitization. We reacted silicate glass (quartz-feldspathic gneiss) with Na-bearing dolomitic liquid at 800–1100°C and 2–4 kbar and produced a rind on the glass which has up to four zones: 1) phonolitic silicate melt, 2) ijolite, 3) pyroxenite and biotite (this zone is absent at > 900°C), and 4) calcite carbonatite containing biotite and olivine. Zones 1 and 2 formed through melting of the glass induced by the carbonate liquid, Zone 3 records the metasomatic interaction of the glass with the carbonate liquid, and Zone 4 crystallized from carbonate liquid that assimilated silicate components from the glass. If

Nb was added to the carbonate liquid, and Zone 3 was absent, pyrochlore crystallized either in Zone 4 or at the contact between Zones 2 and 4. We propose that the alkaline silicate rocks in carbonatite complexes originate from the interaction of carbonatitic magmas with their host gneisses. This interaction is a factory for pyrochlore production controlled by the carbonatitic magma. The reason for this is: 1) the solubility of Nb is much lower in silicate magmas than in carbonatitic magmas, and thus niobium transferred to the silicate magma during its generation is crystallized as pyrochlore; and 2) consumption of Ca, Mg and Na to generate the silicate magma, saturate the carbonatitic magma in pyrochlore. This hypothesis is exemplified by the Lackner Lake alkaline silicate/carbonatite complex (Ontario), where pyrochlore is observed along the contacts between calcite carbonatite and ijolite.

Relationships between the Pan-African belts sitting on both sides of the West African craton (northwestern Gondwana)

Michel Villeneuve

Aix-Marseille Université.

E-mail: michel.villeneuve65@gmail.com

At least 9 different Pan-African belts surround the West African cratons (CWA). Four on the western side (Rokelides, Bassarides, Mauritanides and Souttoufides), one to the North (Anti-Atlas), three on the eastern side (Pharusides, Iforas, Dahomeyides) and another one at the southern end of the West African cratons (Gurupi). The connection between the eastern and western Pan-African belt has been located by their Brazilian extension, between the Amazonian and Sao Francisco cratons. In this southern connection, the Paraguay belt linked to the Rokelide belt overlaps the Brazilian belt linked to the Dahomeyide belt, but the northern connections between the western and eastern belts have not been evidenced. Recent studies on the western side (Mauritanides and Souttoufides) and northern side (Anti-Atlas belt) indicate that the Anti-Atlas belt corresponds to the northern extension of the Souttoufides belt and overlaps the Pharosides. This contact between the two sets of belts outcrops in the Bou-Azzer inlier which belong to the Pharosides; meanwhile the other Anti-Atlas inliers belong to the western belts. In a similar way to the southern Brazilian connection, the northern anti-Atlas connection indicates that the western belts are younger than the eastern one. The linkage between the Pan-African and Cadomian orogens is questioned.

Mid-plate anorogenic magmatism: Weakspots or hotspots?

Peter R. Vogt¹, Gillian R. Foulger²

¹University of California Santa Barbara, ²Durham University.

E-mail: g.r.foulger@durham.ac.uk

Episodic, short-lived intraplate tension or compressive stress relaxation can explain mid-plate magma ascent at structural or compositional lithospheric “weakspots”. Stress reduction episodes may happen during plate motion adjustments. We propose that this model provides a better explanation than hotspots/mantle plumes for: (A) Cretaceous magmatism (ca. 130–120 Ma) in the New England–Monteregian Hills (Quebec), and (B) Eocene magmatism (49–47 Ma) in the Shenandoah Province (Virginia) areas of the mid-Atlantic Appalachians. Both Shenandoah Province and New England–Monteregian Hills are associated with negative seismic wave speed anomalies in the mantle lithosphere and more loosely with ongoing seismicity. The hotspot/plume model does not explain why both provinces experienced previous anorogenic magmatism (ca. 190–160 Ma at New England–Monteregian Hills and 148 Ma, possibly also 720 Ma, at Shenandoah Province). The New England–Monteregian Hills dates peak at 124–123 Ma with less well-defined clusters around 118–117 Ma and 134–132 Ma. These three time periods may correspond to coeval distant LIP magmatism (Ontong Java, Kerguelen and Etendeka-Parana). Shenandoah Province (49–47 Ma) and possibly Bermuda magmatism (≥ 47 –40 Ma) coincided with the Hawaiian–Emperor bend. These correlations, if supported by additional data, suggest that large readjustments in major plate motions reduce intraplate stresses, and facilitate magma ascent through the crust. Geomagnetic reversal frequency changed around A) the ca. 121 Ma onset and B) a ca. 83 Ma termination of the C34n normal polarity superchron. A) coincided with peak New England–Quebec magmatism, other intraplate magmatism and speed-up of African–North American plate motion. B) coincided with the eastern New England seamounts emplacement and change in central North Atlantic plate rotation pole (transform fracture zone bends). Future research should include 1) collection of more paleostress data around the times and sites of magmatic events, and 2) radiometric dating of western seamounts in the eastern New England seamounts and the Corner Seamounts.

Heavy metal storytelling: What U, Mo and Tl isotopes reveal about U ore-forming processes

Alexandre Voinot, Steve Beyer

¹Natural Resources Canada, Geological Survey of Canada.

E-mail: alexandre.voinot@nrcan-mcan.gc.ca

Understanding how redox-sensitive metals behave during the formation and alteration of uranium ore systems is essential for reconstructing fluid histories, improving exploration strategies and interpreting major geobiological transitions. This presentation integrates two complementary studies of U, Mo and Tl isotope systematics: (1) a detailed investigation of $< 2 \mu\text{m}$ clay fractions from the McArthur River unconformity-related uranium deposit (Athabasca Basin, Canada), and (2) a global comparison across intrusive, granite-related, metamorphic and unconformity-related U deposits. At McArthur River, clay minerals – especially illite-rich assemblages – preserve high-resolution records of hydrothermal fluid pathways and post-depositional modification. Uranium and Mo isotopes in clays are readily overprinted by secondary processes, reflected in wide $\delta^{234}\text{U}$ variability and preferential adsorption of light Mo isotopes. In contrast, Tl isotopes remain strikingly robust: $\epsilon^{205}\text{Tl}$ values in silicified sandstone clays faithfully retain the signature of the original ore-forming fluids despite subsequent fluid flow, mineralogical alteration and redox fluctuations. These results position Tl isotopes as powerful vectoring tools capable of identifying mineralizing fluid footprints where U and Mo isotopic systems have been reset. Globally, the integrated dataset shows that coupled Tl–U isotopic fractionation is a consistent response to redox gradients during uraninite

precipitation. Across diverse geological settings and ages, decreasing $\epsilon^{205}\text{Tl}$ correlates with decreasing $\delta^{208}\text{U}$, indicating synchronous changes in Tl and U oxidation states during fluid reduction. Molybdenum isotopes, however, exhibit strong secondary fractionation tied to remobilization, adsorption processes and sulfide interaction. Together, these studies demonstrate that Tl isotopes reliably record primary redox conditions and remain largely unaffected by later alteration, whereas U – and particularly Mo – can be substantially modified by post-ore processes. Integrating deposit-scale clay signatures with global isotopic systematics highlights the potential of multi-isotope approaches for tracking redox evolution from ore-forming microenvironments to planetary-scale oxygenation events, offering new opportunities for exploration and deep-time environmental reconstruction.

Petrology of the lithospheric mantle beneath northern New England: Insights from xenoliths in the North Hartland dyke, Vermont

Abby Voisard, Brian O'Driscoll

University of Ottawa.

E-mail: abbyvoisard@gmail.com

Mantle xenoliths provide insights into the thermal and rheological history of the continental lithospheric mantle (CLM) by revealing snapshots of the mineralogical composition and chemical signature(s) of the region at the time of their eruption. In eastern North America, the Grenville Province represents the footprint of the orogenesis that produced the Canadian Shield, with its most southern exposures found in the east-central United States of America. Minimal work has been done to understand the geochemistry and petrology of the CLM in this tectonically reworked, post-Grenville setting. The extent to which the Mesozoic magmatism of the New England–Québec Igneous Province modified this mantle also remains poorly understood. Here we investigate mantle xenoliths from a 133 (± 6) Ma lamprophyric dyke in North Hartland, Vermont. We use petrographic observations and mineral chemistry together with geothermobarometry to constrain the structure, thermal state and modification of the CLM. The samples analyzed to date are harzburgitic, with olivine Fo contents of 88 to 92 mol.%, high Mg# [$\text{Mg}/(\text{Mg}/\text{Fe}^{2+})$] in orthopyroxene (90 to 94) and variable spinel Cr# [$\text{Cr}/(\text{Cr}+\text{Al})$], ranging from 23 to 48. Clinopyroxene is present in low modal abundances ($< 5\%$). Calculated degrees of partial melting are relatively moderate, at 12–16% using Cr# in spinel and 13–19% based on olivine Fo content. For two xenoliths studied in detail, equilibration temperatures using the Al-in-olivine thermometer average $886 \pm 19^\circ\text{C}$ and $910 \pm 53^\circ\text{C}$, with calculated pressures using the Ca-in-olivine-clinopyroxene barometer of 13 to 29 kbar. These results are interpreted to indicate derivation of the xenoliths from relatively cold shallow lithospheric mantle. Analyses are currently ongoing to further evaluate the composition, oxidation state, pressure-temperature conditions and melt–rock interaction history of the CLM as represented by the North Hartland xenolith suite.

The impact of wall rock alteration on lithium grades in lithium-cesium-tantalum (LCT) pegmatites

Anna Volynets¹, Anthony Williams-Jones¹, Olga Vasyukova¹, James Clark¹, Hubert Mvondo², James Moorehead²

¹McGill University, ²Ministère des Ressources naturelles et des Forêts.

E-mail: anna.volynets@mcgill.ca

Although wall rock alteration can provide an important vector for lithium–cesium–tantalum (LCT) pegmatite exploration, it can also have a negative impact on the lithium grade of these pegmatites. Here we present the results of a study of the mineralogy and geochemistry of metapelitic rocks intruded by the Trieste pegmatitic dyke swarm (James Bay area, Québec), for which initial drilling indicates Li_2O grades of up to 2.2 wt.% over 31.8 m. In most cases, the margins of the spodumene-bearing dykes comprise unmineralized muscovite pegmatite with variably low Li and Cs concentrations. The host metapelites, however, are characterized by extremely high Li (up to 6490 ppm) and Cs (up to 6700 ppm) concentrations adjacent to the dykes (1–2 m). Away from the dykes, Li concentrations gradually decrease but remain well above background values (> 100 ppm versus 20 ppm) for at least 60 m from the dykes; Cs decreases sharply to 200 ppm at 20 m and to background values (~ 10 ppm) > 30 m from the dykes. We propose that this exceptionally strong alteration of the host rocks, and the absence of spodumene or another lithium mineral in the pegmatites within several metres of the endocontacts, resulted from early saturation of the magma with an aqueous fluid, the absence of a border zone, and the strong preference of Li and Cs for the fluid over the melt. Because of these factors, the exsolved fluids escaped into the host rocks, enriching them in these metals and delaying spodumene saturation in the magma until the outer parts of the dykes were crystallized. Thus, although the mobile Li ions provide an important exploration vector for dyke fertility, their loss to the wall rocks can significantly reduce the Li grade of the adjacent pegmatites and, in the extreme, lead to the formation of barren pegmatites.

Playing with “Practitioner’s Wisdom”: An update aimed towards removing barriers to geoscience participation and persistence

B.D. Voss

University of British Columbia Vancouver.

E-mail: bdvoss@geos.ubc.ca

Field-based instruction is considered a fundamental component of geological education, with many practicing geologists and geology departments promoting its persistence in curricula despite challenges to field course efficacy and barriers to participation. In a 2012 publication, David Mogk and Charles Goodwin introduced the concept of “practitioner’s wisdom” to explain the support for field-based teaching methods. This “practitioner’s wisdom” includes a combination of evidence-based findings that support field course teaching methods, and the lived experience of geologists. These authors expand on the evidence-based findings through literature review, resulting in categories that supported field course efficacy in both geological knowledge and social science domains. This presentation aims to expand on developments to this “practitioner’s wisdom” theory, based on reviewing

publications that have explicitly cited the theory since its initial publication, as well as other pieces of literature within the geoscience education research discipline. Of particular note is how little the totality of “practitioner’s wisdom” is interacted with in the existing literature, as well as how few publications focus on the lived experience of instructors of these courses. The end results of this exercise are: 1) suggested updates to “practitioner’s wisdom” as a theory, and 2) recommendations to flesh out information on geologist and instructor lived experiences. This work aims to move toward a vision of “practitioner’s wisdom” that informs practices to address barriers to participation and persistence in the geosciences past the undergraduate degree.

Characterization of sediment transport systems in the Jeanne d'Arc Basin

Kate Waghorn¹, Iain K. Sinclair², J. Kim Welford¹

¹Memorial University of Newfoundland, ²Independent Researcher.

E-mail: kawaghorn@mun.ca

Two large canyon channel complexes in the Jeanne d'Arc Basin are mapped and characterized using high-resolution 3D seismic data. There are two large, complex sediment transport systems in the Jeanne d'Arc Basin that preserve multiple generations of channel erosion and infill, along with complex overbank depositional features, submarine slides and fan complexes. Sands infilling these channels have been proposed as CO₂ storage targets in the Jeanne d'Arc Basin, so understanding the evolution and internal geometry of these features is important in assessing their potential to act as reservoirs and (importantly) their ability to trap fluids. Our data indicate distinct seismic character of sediment packages laterally across channels as well as vertically through the various cut and fill sequences. This presentation focuses on our interpretation of the sedimentary packages through the channels and our understanding of the potential lateral and vertical fluid flow pathways through these canyon channel complexes.

Formational and emplacement environments of ophiolites and their importance in relating ophiolites to orogenic processes

John Wakabayashi

¹California State University, Fresno.

E-mail: jwakabayashi@csufresno.edu

The character and context of ophiolitic rocks in orogenic belts reflects their formational and their emplacement environments. Geochemical and petrologic characteristics give insight into the formational environment of ophiolites, whereas field relationships inform emplacement environments and mechanisms. Upper plate ophiolites exhibiting supra-subduction zone (SSZ) geochemical affinity formed over a subduction zone and were emplaced above it, whereas lower plate ophiolites, derived from the subducting plate by subduction-accretion, show mid-ocean ridge basalt (MORB) or ocean island basalt (OIB) affinity for coherent rocks. Upper plate ophiolitic pseudostratigraphy commonly reflects spreading centre characteristics such as spreading rate and magma supply, with little subsequent deformation or burial metamorphism. In contrast, lower plate ophiolitic pseudostratigraphy records subduction processes which removed (subducted) all but the uppermost oceanic crust. Lower plate rocks commonly exhibit deformation and burial metamorphism, some of which may be high-pressure (HP)–low-temperature (LT) metamorphism. The grade of sea-floor metamorphism increases downward in upper plate pseudostratigraphy, with high-temperature fabrics confined to the gabbroic and lower levels. Low-grade metamorphism of upper plate ophiolites may resemble low-grade burial metamorphism; the best measure of burial metamorphism of such ophiolites is from the basal sedimentary rocks that overlie them. Metamorphic soles, thin sheets of HT-HP metamorphic rocks found beneath some upper plate ophiolites, are the structurally highest part of the subjacent subduction complex. The fault separating upper plate and lower plate rocks exhumed the latter relative to the former. Such a fault reactivated a subduction initiation horizon. Mélange horizons in lower plate and upper plate settings introduce complications. Upper plate ophiolites commonly have coherent character but may be depositionally overlain by serpentinite matrix olistostromes with blocks derived from both upper and lower plates. Lower plate ophiolitic rocks include serpentinite matrix and siliciclastic mélanges with ophiolitic blocks commonly exhibiting SSZ character, in addition to some of MORB and OIB affinity.

Paleomagnetic rotation and non-Laurentian detrital zircon record of the Early Devonian Knoryd Formation, Antigonish Highlands terrane, Nova Scotia: Protracted collision of Avalonian terranes with Laurentia

John W.F. Waldron^{1,2}, Brynn A. Quist², Phil J.A. McCausland³, J. Brendan Murphy⁴

¹Acadia University, ²University of Alberta, ³Western University, ⁴St. Francis Xavier University.

E-mail: waldronjwf@gmail.com

The Silurian through Devonian arrival of Avalonian terranes at the composite Laurentian margin during closure of the Iapetus Ocean is complicated by margin-parallel motion during accretion and by Laurentian margin promontories and embayments. We report and discuss new detrital zircon U–Pb age and paleomagnetic results from the Early Devonian Knoryd Formation in the Avalonian Antigonish Highlands terrane (AHT), Nova Scotia. Two detrital zircon geochronology sites and twelve paleomagnetic sites were sampled from the lower stratigraphic part of the Knoryd Formation along McAras Brook. Sampled rock types are gently southwest-dipping red, grey and green siltstone, mudstone and sandstone beds, likely representing a marine-influenced deltaic setting. The Knoryd Formation bears bony fish fossils including *Pteraspis crinchi*, which constrain the section age to Lochkovian (419.0–412.4 Ma). Both detrital zircon samples contain abundant grains with concordant U–Pb ages that have dominant Pridoli (ca. 420 Ma) peaks and a range of older grains consistent with derivation from Avalonian or Ganderian sources, but not Laurentia. Avalonian terranes have no known source of ca. 420 Ma zircon, but the Ganderian St. Croix, Kingston, Aspy and La Poile terranes host late Silurian Coastal Igneous Belt magmatic rocks that may have been a source for the Knoryd detrital zircon. Paleomagnetic directions in the Knoryd Formation have moderate

inclinations and a polarity reversal in the section. The paleomagnetic directions place AHT at $\sim 27^\circ\text{S}$, at the composite Laurentian margin by ca. 415 Ma, but indicate $\sim 80^\circ$ clockwise post-magnetization rotation compared with Laurentia. Taken together, these provenance and paleomagnetic results suggest that in Lochkovian time, the AHT lay astride the margin of the Laurentian plate but was separated from Laurentia by a basin possibly correlative with the Mascarene back-arc. The AHT subsequently may have rotated clockwise into the embayment during continued Devonian oblique motion of Avalonian terranes relative to Laurentia.

Cabox Aspiring Geopark, western Newfoundland: An unparalleled opportunity to bring tectonics to a general audience

John W.F. Waldron^{1,2}, Paul Wylezol³, Martin Schwangler¹

¹University of Alberta, ²Acadia University, ³Cabox Aspiring Geopark.

E-mail: waldronjw@uofa.ca

Elmstukwek, the Bay of Islands, in western Newfoundland, Canada, is unrivalled for its landscapes, coastal scenery and scientific significance. Major fjords lead into the bay; the largest, Humber Arm, hosts the administrative centre of the Qalipu First Nation and Corner Brook, Newfoundland's second largest city. The area boasts a rich fauna and flora, and a human history involving both Indigenous peoples and European settler populations. The massifs of the Bay of Islands Ophiolite Complex were among the first to be identified as ancient oceanic lithosphere following the development of plate tectonics. The southernmost massif, the Lewis Hills, contains the highest point (Cabox) on Ktaqmkuk, the Island of Newfoundland. Blow Me Down Mountain contains a historically mined VMS deposit and the Tablelands massif, in the adjacent Gros Morne National Park, contains much-visited mantle rocks and preserves the Moho. To the west, the Coastal Complex records an older arc, the earliest evidence for subduction in the Iapetus Ocean. Beneath these igneous units, deepwater sedimentary units of the Humber Arm Allochthon record the Paleozoic evolution of the continental margin of Laurentia. Beneath the allochthon, cliff-forming carbonates record contemporary carbonates. The ocean floor, slope and shelf were juxtaposed during a mid-Ordovician arc-continent collision during the closing of the Iapetus Ocean at the start of Appalachian orogenesis. Silurian subduction beneath Laurentia produced spectacular folds, refolding the Ordovician structures. In the Devonian Acadian orogeny the rocks were thrust westward again. Glacial erosion has exposed the rocks in accessible sections. Geomorphological features include raised beaches produced by post-glacial isostatic rebound, and numerous karstic features. The International Appalachian Trail takes more adventurous visitors to the highest peaks. Cabox Aspiring Geopark occupies an accessible central position that has been pivotal for the understanding of plate tectonics and one of the world's best studied orogens.

Reducing analytical time and increasing precision by using 10^{13} ohm resistors for high-precision CA-ID-TIMS U-Pb geochronology on Nu TIMS.

Corey Wall¹, Dominique Weis¹, Daniel Roberts²

¹University of British Columbia, ²Nu Instruments Ltd.

E-mail: coreyw@mail.ubc.ca

Uranium-lead geochronology by chemical abrasion-isotope dilution-thermal ionization mass spectrometry (CA-ID-TIMS) is the gold standard for determining precise and accurate dates and rates of geological events throughout Earth's history. The abundance of high-U minerals in most rock types and their resistance to chemical and physical weathering contribute significantly to the popularity and prolificacy of the U-Pb system in geochronology. The small sample size, especially for radiogenic Pb, requires highly sensitive ion detection systems. Most studies, therefore, employ either secondary electron multipliers (SEM) or Daly photomultipliers, which provide low noise and high sensitivity but have a limited linear range and require dynamic peak-hopping, which consumes precious analytical time. We evaluate the application of new 10^{13} ohm resistors in the Faraday cup amplifier feedback loop for the static collection of all Pb isotopes (sample and tracer) with $^{205,206,207,208}\text{Pb}$ measured on Faraday cups and ^{204}Pb measured on a SEM of a Nu Instruments TIMS instrument. The Nu TIMS instrument at PCIGR, equipped with 16 Faraday collectors and Zoom Optics, enables perfect peak alignment of Pb and U isotopes at each magnet position. We demonstrate long-term stability of the amplifier gain calibration and test short and long-term stability and reproducibility of amplifier baselines. Measured ionization efficiency for Pb isotopes averages 10 mV/pg, and ionization efficiency for U isotopes averages 20 mV/ng. Results for all reference zircons (Plesovice, FC-1, 91500, AN2) and synthetic solutions (ET100Ma, ET500Ma, ET2000Ma) yield ages within error of the published reference values. Additionally, the static Faraday measurements reduce the uncertainty of measured U/Pb ratios by up to 50% compared to peak-hopping equivalent measurements while taking only 30% of the analytical time. This new technique allows us to push the frontiers of high precision U-Pb geochronology and may represent a crucial advancement in the quest towards inter- and intra-laboratory reproducibility at the 0.01% level.

A multi-mineral detrital U-Pb and trace element provenance investigation of the Taconic, Salinic and Acadian foredeeps in the northern Appalachians of Newfoundland

Lijun Wang¹, Shoufa Lin², Cees Van Staal³, David Chew⁴, Veronica Peverelli⁴

¹Zhejiang University, ²University of Waterloo, ³Natural Resources Canada, Geological Survey of Canada, ⁴Trinity College Dublin.

E-mail: lijun.wang@uwaterloo.ca

Applying U-Pb geochronology and trace-element geochemistry of multiple detrital minerals (rutile, apatite, monazite, titanite, zircon) across several foredeeps in the Newfoundland Appalachians provides a more complete view of sediment provenance and tectonic evolution than zircon spectra alone. Three unconformity-bounded Middle Ordovician to Devonian foreland-basin successions occur in western Newfoundland. The Middle Ordovician Goose Tickle Group shows pronounced ca. 480 Ma apatite and monazite peaks, with mafic and S-type igneous and high-grade

metamorphic apatite trace-element signatures, indicating input from an early Taconic arc. The Upper Ordovician Long Point Group yields dominant 475–465 Ma peaks in monazite, apatite and titanite with primarily metamorphic apatite signatures, consistent with unroofing of the Taconic hinterland. The appearance of ca. 455 and ca. 425 Ma monazite peaks in the Upper Silurian–Lower Devonian Clam Bank Formation records progressive exhumation of a polyorogenic hinterland influenced by both Taconic and Salinic events. Salinic foredeep deposits are represented by marine turbidites preserved in eastern Newfoundland in units such as the Outflow Formation. These turbidites overlie the Middle–Upper Ordovician Davidsville and Baie d'Espoir groups and are locally overlain by shallow marine to terrestrial strata of the Indian Island Group. An Outflow Formation turbidite sample yielded a dominant ca. 429 Ma zircon peak, indicating derivation from a western Salinic orogenic source. Acadian foredeep deposits are preserved in the Devonian(?) Fortune belt of Avalonia adjacent to Ganderia. A turbidite sequence is overlain by three unconformity-bounded formations of sandstone and conglomerate, which are intruded by ca. 376 Ma granite dykes in their lower part. Detrital zircon age dates yield major peaks at ca. 427, 482, 526 and 604 Ma. Approximate ages for detrital apatite and titanite show prominent 435, 450 and 500 Ma peaks, whereas detrital rutile displays major peaks estimated at 460, 600, 665 and 715 Ma. Together, these data indicate derivation from an Acadian hinterland in eastern Ganderia with input from Avalonia.

Hyperacidic oxidizing brines as a key control on the formation of world class, high-grade unconformity-related uranium deposits in the Athabasca Basin (Canada)

Yumeng Wang^{1,2}, Guoxiang Chi¹, Sean Bosman³

¹University of Regina, ²IFN-2, Forschungszentrum Jülich, ³Saskatchewan Geological Survey.

E-mail: geomeng@foxmail.com

The Athabasca Basin hosts the world's largest and highest grade uranium (U) deposits and represents one of the top U producers globally. Despite decades of studies dedicated to understanding the formation mechanisms of these deposits, the fundamental reason for the exceptional U endowment of the Athabasca Basin remains incompletely understood. Currently, the most widely accepted diagenetic–hydrothermal metallogenic model invokes the interaction between oxidizing basinal brines carrying U and reducing basement-derived fluids or basement rock types near the basin–basement unconformity as the main mechanism of U mineralization. The mineralizing fluid is believed to have originated from seawater evaporation beyond halite saturation up to epsomite saturation, which is rich in potassium (K). Geochemical analysis of fluid inclusions from the U deposits reveal extraordinarily high U concentrations (up to 3700 ppm) in the mineralizing fluid, indicating extreme leaching from source rocks and metal enrichment. However, the key processes by which the evaporated brines evolved into the metal-rich fluids remain unclear. In particular, the mechanism of the low pH required for the basinal brines to dissolve large amounts of U is unknown. We propose a water–rock interaction model, in which K-rich evaporated seawater interacts with kaolinite-bearing quartzose sandstones and results in the basin-scale development of hyperacidic brines through illitization: $3 \text{ kaolinite } [\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4] + 2 \text{ K}^+ \leftrightarrow 2 \text{ illite } [\text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2] + 3 \text{ H}_2\text{O} + 2 \text{ H}^+$. This mechanism is supported by basin-wide petrographic and infrared hyperspectral logging data demonstrating the coexistence of kaolinite and illite in quartz-dominated fluvial or alluvial sandstones. Recognition of this mechanism provides a new geochemical indicator for further evaluating U resource potential in the Athabasca Basin and other sedimentary basins.

Gold mineralization along the Larder Lake-Cadillac Break (Abitibi Greenstone Belt): Constraints on the timing of emplacement and fluid sources

Shane Webb, Safak Sonmez, Georges Beaudoin, Crystal Laflamme

Université Laval.

E-mail: shane.webb.1@ulaval.ca

The Larder Lake-Cadillac Break (LLCdZ), an E–W structure traversing > 250 km of the Canadian Shield, represents an important gold-producing region. Whereas the ages and fluid sources of the mineralization are relatively well constrained around Val-d'Or, there is considerable uncertainty regarding the metallogenic processes to the west from Rouyn-Noranda to Kirkland Lake. In the area, we recognize two styles of gold mineralization: 1) syenite-hosted gold deposits (e.g. South Mine Complex of Macassa), and 2) orogenic gold deposits hosted in ultramafic or metasedimentary rocks (e.g. Kerr Addison, Anoki-McBean). Unlike the syenite-hosted mineralization, the temporally later orogenic gold deposits are foliation-parallel and hosted in shear zones. LA-ICP-MS mapping indicates that auriferous pyrite from orogenic gold deposits is composed of “cores” with elevated Co and Ni concentrations overgrown by Bi–Te–Pb–Sb–Ag “rims.” In the syenite-hosted mineralization, gold remobilization has concentrated trace elements (Co, Ni, As, Bi, Te, Pb, Sb) into fractures and domains within the cores/rims. Pyrite $\delta^{34}\text{S}$ values are typical of Archean gold mineralization ($0 \pm 6\text{‰}$), whereas syenite-hosted Kirkland Lake displays low values (-7 to -15‰); this may be indicative of highly oxidizing conditions during the mineralization process. Similarly, the $\delta^{18}\text{O}_{(\text{H}_2\text{O})}$ values recorded from the South Mine Complex are relatively low (5‰ ; typical of magmatic water) compared to fluids associated with the orogenic gold deposits (7 – 13‰). In situ U–Pb geochronology on monazite from the syenite-hosted gold deposits indicate ages of ca. 2670 (Young Davidson and South Mine Complex; $n = 31$), while xenotime from the orogenic prospects yielded ages of ca. 2643 Ma ($n = 29$; Cheminis). These ages are consistent with the structural characteristics of both mineralization styles, and with monazite/xenotime U–Pb and molybdenite Re–Os ages elsewhere along the LLCdZ, including Val-d'Or, Malaric and Kirkland Lake. The syenite-hosted deposits are linked to magmatic–hydrothermal fluid circulation and the orogenic gold deposits formed from metamorphic fluid release.

New official geological borehole nomenclature and management system for Greenland

Sylvia Weging, Christian Rode Juhl, Romain Meyer

Government of Greenland.

E-mail: sywe@nanoq.gl

Greenland's official Greenland Mineral Resources Portal (greenmin.gl) serves as a comprehensive, searchable and open access downloadable repository of all available geological and mineral-related data including 4817 geological boreholes. This large number of boreholes in combination with the management tasks related to the opening of the new national core archive (Qillikkanut Toqqorsivik) in Nuuk for around 200 km of core showed the need for a new nomenclature system for Greenlandic boreholes and related drill cores. We present a systematic summary of the first unique national nomenclature. Combined with this nomenclature we will also present our new data exchange strategy for drill core data with companies. Mining companies in Greenland use different tools to store drill core data ranging from expensive software solutions to simplistic log reports in text editors. However, reports of core descriptions and related data to the Government of Greenland is generally done by submitting simple PDF documents of these log text files. This approach is insufficient for our governmental data management tasks, as it makes fast digital processing of the data impossible and comparison among boreholes difficult. As a result, we developed a fast and cheap national platform to facilitate drill core data exchange with industry and academia. In our next step, we are implementing a national database that integrates all these data. After companies release their data, they can be digitally shared within the geological community for educational and/or new exploration purposes. Prior to its implementation in Greenland, the user-friendliness of the exchange platform is presented and discussed. We would like to get feedback from administration and industry regarding their expectations and experiences on the integration and exchange of borehole data.

Characterizing continental ribbons, their origins, and their impact on rifting within the southern North Atlantic realm

J. Kim Welford

Memorial University of Newfoundland.

E-mail: kwelford@mun.ca

The role of inherited tectonic structures on the evolution of continental rifts and passive rifted margins appears significant. In the Atlantic Ocean, intact continental fragments that remain tethered to their parent plates within rift systems, known as continental ribbons, are most pervasive in the southern North Atlantic, along the margins of Newfoundland, Iberia, and Ireland. These added rift complexities likely resulted from lithospheric heterogeneity inherited during the previous Paleozoic Appalachian–Caledonian and Variscan orogens, which ultimately influenced strain partitioning and the formation of sedimentary basins during subsequent rifting. To properly understand and reconstruct the evolution of these margins for resource prospecting and for improving our fundamental understanding of rift processes, a comprehensive knowledge of these continental ribbons and their origins is essential. Meanwhile, characterization of the geometries, inferred properties and distributions of continental ribbons relies heavily on seismic reflection profiling, with coverage becoming sparser distally towards continent–ocean transition zones. Consequently, complementary geophysical methods, such as potential field methods, are needed to infill sparse seismic constraints and capture the 3D nature of these features as well as their 4D evolution. This presentation focusses on how these goals are being achieved for the continental ribbons of the southern North Atlantic Ocean and on how this information is improving regional plate reconstructions.

Passive array for critical minerals on the island of Newfoundland (PACMIN)

J. Kim Welford¹, Fiona Darbyshire², Maureen Long³

¹Memorial University of Newfoundland, ²Université du Québec à Montréal, ³Yale University.

E-mail: kwelford@mun.ca

In the summer of 2025, the passive array for critical minerals on the island of Newfoundland (PACMIN) project was launched. The deployed array comprises 22 broadband seismograph stations, which will record local, regional and global earthquakes as well as ambient ground vibrations for a period of two years. This experiment will yield the first ever detailed 3D lithospheric structure models of the entire island of Newfoundland from multiple types of seismic analysis. From these models, we will be able to investigate how the region was shaped by Appalachian mountain-building processes, while also exploring tectonic controls on the distribution of key mineral deposits such as gold and critical minerals. The onshore seismicity of Newfoundland, while low, will also be investigated to better understand and mitigate mining exploration/exploitation hazards. Improved detection and locating of small local earthquakes will also allow fault networks in the shallow crust to be mapped and assessed in terms of their potential as fluid pathways that may carry critical minerals.

Sphalerite as an indicator mineral of Pb–Zn deposits in the Mackenzie Mountains, Northwest Territories: Trace elements, fluvio-glacial dispersion and provenance

Jacob A. White¹, Erin Adlakha¹, I. Rod Smith², Micheal G. Gadd³, Mo Snyder³, Merilie Reynolds⁴

¹Saint Mary's University, ²Natural Resources Canada, Geological Survey of Canada, ³Acadia University, ⁴Northwest Territories Geological Survey.

E-mail: Jacobawhite2@gmail.com

This research will evaluate the use of sphalerite mineral chemistry from stream sediment samples in the Mackenzie Mountains, NWT, as an indicator for Pb–Zn exploration. The results of this work will be used to bolster mineral exploration efforts for Pb–Zn deposits in both the Mackenzie

Mountains and elsewhere in Canada and better understand fluvial and glacial dispersion patterns throughout orogenic belts. The Mackenzie Mountains host hundreds of Pb–Zn occurrences of various deposit types that include carbonate-hosted, skarn and sediment-hosted massive sulphide deposits. Each deposit type is distinct in its geochemistry, mineralogy and host rock as they are formed by different geological processes. Even different deposits of the same type may have differences in these characteristics. These differences may be recorded in trace element composition of sphalerite. Using an extensive historical archive of stream sediment heavy mineral concentrates and picked grains, a bench-top micro-X-ray Fluorescence spectrometer (μ XRF) will be used to produce elemental maps of polished sphalerite grains mounted in epoxy pucks. The maps will be used to confirm whether each grain is sphalerite ((Zn, Fe) S), and to visualize intragrain compositional variation. After μ XRF analysis, scanning electron microscopy will be used to select targets for sphalerite trace element analysis. Features such as fractures, zoning and inclusions will be noted to avoid trace element contamination and quantify the major element composition and variation of sphalerite. Selected targets will then be analyzed using a laser ablation-inductively coupled plasma-mass spectrometer to measure the trace element abundances of each sphalerite grain. This process will be repeated using hand specimens and polished thick sections of known Pb–Zn deposits in the Mackenzie Mountains, proximal to assumed dispersal trains. Multivariate statistical analyses will be conducted using the trace element data to characterize different populations of sphalerite and determine their provenance by correlating grains to a source deposit.

Helium production and exploration in Alberta – potential for expansion and secure supply of a Canadian critical mineral

Henry Williams, Brent Jonah

Thor Resources Inc.

E-mail: henry.williams@thorres.com

Helium is one of the 34 substances designated on Canada's Critical Minerals list. While the United States, Qatar, Algeria and Russia remain the dominant global producers, Canada is an emerging and strategically important supplier, with active production in southeastern Alberta (Thor Resources) and southwestern Saskatchewan (North American Helium). Currently, refined gaseous helium produced in Canada is transported to the United States for final purification, liquefaction and distribution. Thor Resources is developing its helium resources with a strong commitment to minimizing environmental impact, including extensive wildlife and archaeological surveys, regulatory engagement and mitigation measures to preserve ecological and cultural integrity. In partnership with the Alberta Conservation Association, Thor has also permanently protected a 160-acre foot access only nature preservation area. Helium is a non-renewable resource with critical applications in aerospace, medical imaging (MRI cooling), semiconductor manufacturing and emerging technologies such as quantum computing. Helium-4 is typically generated through radioactive decay of uranium and thorium in granitic crust over hundreds of millions of years, while Helium-3 is primordial and mantle-derived. Reserves in Canada are found in reservoirs dominated by nitrogen or carbon dioxide, rather than methane. Helium systems resemble hydrocarbon systems (source, migration, trap, reservoir, seal) but also rely on igneous activity for gas release and migration. In western Canada, accumulations are commonly associated with Precambrian basement structures or Eocene laccolith intrusions, both of which have been imaged by 3D seismic and penetrated in exploration wells. Although designated a critical mineral, helium receives limited financial incentives in Canada and is inconsistently regulated across jurisdictions. Despite Canada's growing production, the country lacks a domestic helium liquefaction facility, requiring all liquid helium to be imported from the United States. Thor Resources is supporting industry–government collaboration to establish a Canadian-based liquefier and strengthen domestic supply security.

Revisiting the origin, mode of emplacement and economic potential of the Coppermine River Group, Mackenzie Large Igneous Province (Nunavut, Canada)

Marie-Claude Williamson, Rob Rainbird

¹Natural Resources Canada, Geological Survey of Canada.

E-mail: Marie-Claude.Williamson@nrcan-mcan.gc.ca

The 1.27 Ga Mackenzie Large Igneous Province (LIP), located in northern Canada, is a well established target for nickel, copper and platinum group elements. Despite several decades of mapping, sampling and mineral exploration in this region, no significant economic discoveries have yet been made. The Mackenzie LIP includes flood basalts and feeder dykes of the Coppermine River Group (CRG), the Muskox layered intrusion (MLI) and the Mackenzie dyke swarm (MDS). Previous studies of the Mackenzie LIP focused on each of these components of the LIP, but knowledge gaps remain, limiting our ability to understand its origin. In this presentation, we highlight the results of a new project on the CRG flood basalts and associated feeder dykes with a focus on Ni–Cu–PGE prospectivity. Our objectives are to: (1) fill knowledge gaps on the CRG feeder dykes, (2) evaluate the prospectivity of contact zones between intrusions and their mainly sedimentary host rocks, and (3) identify channelized lava flows, sills and dykes. We applied remote predictive mapping (RPM) techniques to unravel the dense network of dykes feeding the oldest lava flows, allowing us to identify multiple cross-cutting relationships and assess the influence of faulting on dyke emplacement. Complementing the RPM work, we conducted detailed mineralogical and geochemical analyses of lava flows in the lower September Creek Member to evaluate the roles of magma recharge and crustal contamination at the transition to the overlying Stony Creek Member. For the first time, accessory minerals including zircon, baddeleyite and apatite have been identified and targeted for U–Pb geochronology of the CRG lava flows. Ultimately, our goal is to reconstruct the timing and duration of CRG volcanism within the broader framework of MLI and MDS magmatism, while also exploring the intriguing possibility that a meteor impact triggered emplacement of the Mackenzie LIP at ca. 1.27 Ga.

Metamorphic evolution of non-eclogitic assemblages in the lower plate of a collisional wedge at the Baie Verte Line, West Newfoundland, Canada

Arne P. Willner¹, Johannes Glodny², Masafumi Sudo³, Ludovico G. Scorsolini⁴, Cees R. van Staal⁵

¹Ruhr-University Bochum, ²Geoforschungszentrum Potsdam, ³University of Potsdam, ⁴Geological Survey of Newfoundland and Labrador, ⁵Natural Resources Canada, Geological Survey of Canada.

E-mail: *arne.willner@rub.de*

The Baie Verte Line is the Taconic suture of an arc-continent collision, where the lowermost part of the collisional wedge (East Pond Metamorphic Suite, or EPMS) contains eclogite bodies that preserve peak Taconic high-pressure and ultra-high-pressure conditions and exhumation stages (483–452 Ma). However, non-eclogitic assemblages in (garnet-) mica schist and (garnet) amphibolite in the structurally overlying Fleur de Lys Supergroup (FDLS) behave differently during burial, exhumation and reburial. We studied these events using pseudosection techniques, Rb–Sr isochron and limited Ar–Ar spot age dating. In garnet-mica schist and garnet amphibolite of the FDLS close to the border of the EPMS a prograde stage in the range of 455–500°C/15–19.2 kbar is proved by relict garnet core and phengite compositions, whereas in garnet-mica schist in the upper wedge only phengite relicts evidence a prograde stage > 10 kbar. However, in all studied garnet-mica schist and garnet amphibolite a mid-crustal stage in the range of 485–555°C/3.0–8.8 kbar is recorded by garnet cores followed by burial to conditions in the range of 530–600°C, 6.0–11.8 kbar recorded by the garnet rims. Compositions of recrystallized white mica and plagioclase are compatible. In all units local layers of mica schist and amphibolite are intercalated, where garnet is entirely dissolved at retrograde conditions < 450–500°C, < 4–5 kbar likely by late fluid influx from deeper parts of the wedge. Rb–Sr isochrons of white mica-bearing assemblages date a Salinic mid-crustal reburial throughout the FDLS at 438 ± 4 – 440 ± 9 Ma, similar to a white mica Ar–Ar spot age of 436 ± 3 Ma from an EPMS orthogneiss. A relict Ar–Ar spot age of 462 ± 2 Ma only occurs in the uppermost FDLS, where overlying lower grade rocks of the Birchy Complex record abundant Taconic relict ages. The FDLS was less deeply buried than the EPMS. The two units were juxtaposed along a shear zone during early exhumation. The Salinic mid-crustal reburial is well developed throughout the FDLS.

Hyperspectral scanning of drill core from the Strange Lake deposit, Labrador: The Nd absorption band as a proxy for REE mineralization

Derek Wilton¹, Michel Rosener¹, K  le Migeul¹, Stewart Sharpe¹, Elizabeth Baird²

¹College of North Atlantic, ²Vale Base Metals Ltd.

E-mail: derek.wilton@cna.nl.ca

The College of North Atlantic's hyperspectral scanning unit (HSU) can analyze through visible, near infrared, short-wave infrared, mid-wave infrared and long-wave infrared spectral regions and has laser profiling and ultra-high definition RGB photographic capabilities. We scanned core from over 140 drill holes, with a cumulative length of over 6000 m, drilled at the Strange Lake (SL) REE deposit in Labrador; as stored at the Newfoundland and Labrador government core storage facility in Goose Bay. The deposit occurs within a small (~6 km in diameter), shallow, peralkaline granite–aplite–pegmatite complex. In 1983 the Iron Ore Company previously calculated a resource of ~52 million tonnes grading 2.93% ZrO₂, 0.31% Y₂O₃, 0.38% Nb₂O₅, 0.54% REE and 0.08% BeO for the SL deposit. The narrow Nd absorption band at ~810 nm in the visible and near-infrared (VINR) range was readily apparent in the scanned SL core and, using the observed Nd spectra as a proxy, REE mineral contents could be calculated for the holes. We conducted MLA-SEM analyses of both select core pieces and crushed coarse rejects from core over intervals that had exhibited the Nd absorption and found that the absorption was indeed related to REE minerals, principally gadolinite. The HSU analyses of crushed core rejects and down-ice surficial sediment from SL also exhibited the Nd absorption, but in the latter (sediment) calculated mineral values were low.

Long range (~145 km) indicator mineral quantification in till-covered regions: The case of gittinsite down-ice from the Strange Lake REE deposit, Labrador–Québec

Derek Wilton^{1,2}, Carol Seymour³, Victoria Currie⁴

¹College of North Atlantic, ²Memorial University of Newfoundland, ³Altius Minerals Corp., ⁴Foran Mining Corp. E-mail: derek.wilton@cna.nl.ca

The Strange Lake (SL) REE deposit occurs on the Labrador border within a small, shallow, peralkaline granite intrusion. SL mineralization contains substantial incompatible element-enriched (Zr, Y, Nb, Be and REE) minerals within the pegmatite–granite–aplite phases of the granite roof. Previous calculations in 1983 showed a resource for the Main Zone in Labrador of ~57 million tonnes grading 2.93% ZrO₂, 0.38% Y₂O₃, 0.31% Nb₂O₅, 0.54% Total REE oxides and 0.08% BeO. A key indicator mineral associated with the SL REE mineralization is the very rare phase gittinsite (CaZrSi₂O₇) known only in Labrador from SL. Stream sediment samples down-ice from SL contained anomalous Be, La, Pb, Nb and Y for up to 55 km. GSC researchers identified gittinsite in tills collected up to 10 km down-ice from the deposit and defined the glacial outflow from SL as a fast-moving ENE ice stream. Till samples collected from a regional survey near Nain, ~145 km ENE from SL, on the Labrador coast, were analyzed by automated SEM techniques (MLA-SEM) and were found to contain grains of feather-like gittinsite intergrown with quartz. Similar gittinsite–quartz (GQ) grains were detected in a single 100 km long by 10 km wide corridor, presumably corresponding to the ice-stream. GQ with the same textures were observed by MLA-SEM in samples of coarse rejects from stored SL drill core. LAM-ICP-MS analyses of these GQ grains from till near Nain and the core rejects defined similar REE contents with the same normalized enriched HREE patterns, suggesting a common source. A series of follow-up surface till samples collected for over 30 km directly down-ice from SL contained similar GQ grains with contents matching the regional survey. This study suggests that MLA-SEM techniques can be trained to home in on and map specific exotic minerals uniquely associated with different mineralization styles in surficial sediment surveys.

Using automated SEM (SEM-MLA) techniques to quantify indicator minerals in tills aiding in the discovery of hidden ore deposits in glaciated terrains

Derek Wilton^{1,2}, Carol Seymour³, Rod Smith³

¹College of North Atlantic, ²Memorial University of Newfoundland, ³Altius Minerals Corp.

E-mail: derek.wilton@cna.nl.ca

This presentation summarizes a project to determine 'indicator mineral' fingerprints for three significant mineral deposit types in Newfoundland and Labrador using the examples of base metal volcanogenic massive sulphides (VMS) at Buchans, lode gold at the Moosehead lode prospect and komatiitic Ni–Cu–PGE mineralization at Florence Lake. Using crushed samples from each prospect (n = 30 for Buchans, n = 50 for Moosehead and n = 25 for Florence Lake), potential indicator minerals were identified using scanning electron microscope - mineral liberation analyzer (SEM-MLA) analytical techniques. No unique or rare phases were identified as definitive indicator minerals. Till samples were collected down-ice from the prospect centres and analyzed by SEM-MLA to characterize any indicator mineral fingerprints outwards from each prospect (n = 213 for Buchans, n = 102 for Moosehead and n = 94 for Florence Lake). The till samples were collected at a nominal 250 m spacing with the 125–180 µm size fraction used as the optimal grain size for analysis. At Buchans, sulphide minerals proved reliable indicator minerals in till, along with some others, as their mineral abundances correspond to areas of known mineralization. General dispersion in the down-ice direction indicates that VMS deposits, as well as some other documented occurrences, are detectable in the till profile. At Moosehead, the arsenian pyrite and oxidized pyrite, in addition to other phases, form a well-defined northeast-trending anomaly along the area of known mineralization. At Florence Lake, till samples contained sulphide grains with mineral associations and textures possibly indicative of a nickel sulphide-bearing system. The SEM-MLA analyses produced a huge quantity of data and provided final results as originally planned. The main advantage of the SEM-MLA technique is that a mineral library can be customized to filter the dataset and essentially remove minerals that are not of interest and which might dilute the indicator minerals of interest. Another significant advantage of the SEM-MLA over other techniques is the ability to quantify relationships between key indicator minerals at a fine scale (e.g. at Florence Lake, single grains of pyrrhotite and chalcopyrite with exsolved pentlandite can be identified).

Synchronous vertical and horizontal tectonism shaping the Neoarchean crustal architecture: Insights from 3D numerical modeling of the Superior Craton

Qihang Wu¹, Shoufa Lin², Guochun Zhao², André Unger², Chris Yakymchuk², Chenying Yu¹, Chuan Huang¹, Xin He¹, Jian Zhang¹

¹The University of Hong Kong, ²University of Waterloo.

E-mail: wu.qihang@hku.hk

As the largest Neoarchean craton on Earth, the Superior Craton is characterized by the progressive horizontal accretion (plate tectonic regime) of multiple terranes, which led to its final cratonization. However, within each terrane, the crustal framework is predominantly characterized by dome-and-keel structures that developed under a vertical tectonism (non-plate tectonic regime). How these two distinct regimes collectively controlled the crustal evolution offers critical insights into Neoarchean geodynamics but remains poorly understood. Existing studies highlight a major obstacle: the absence of a true 3D numerical model that reproduces the entire geodynamic process. Here, we report a methodological and technological breakthrough that addresses this gap. For the first time, we conducted 3D crustal-scale numerical models that simulate the transition from the non-plate to plate tectonic regimes and their synchronous role in shaping the Neoarchean crustal architecture of the Superior Craton. Our models successfully reproduce the iconic dome and keel geometry, strain accumulation and distribution, and shearing kinematics within the granitoid–greenstone terranes under a non-plate tectonic regime. Subsequently, horizontal shortening driven by the plate tectonic regime induces superposition on pre-existing dome and keel structures, generating variable structural patterns. Our models further reveal that under the high Archean Moho temperature conditions, synchronous vertical and horizontal movements synergistically facilitate strain localization and propagation, leading to the development of crustal-scale shear zones that are widely preserved in granite–greenstone terranes. By integrating geological and geophysical data from global Neoarchean cratons with our numerical modeling results, we propose that the Neoarchean represents a critical transitional interval in Earth's geodynamic evolution. During this interval, almost all ancient cratons underwent a transition from vertical to horizontal tectonism. The interplay of these two tectonic processes emerges as a predominant geodynamic mechanism governing the tectonic style of the Neoarchean era.

Cabox Aspiring Geopark – Our world in motion

Paul Wylezol¹, John W.F. Waldron^{2,3}, Martin Schwangler²

¹Cabox Aspiring Geopark, ²University of Alberta, ³Acadia University.

E-mail: pauhwylezol@gmail.com

An aspiring UNESCO Global Geopark in western Newfoundland takes its name, “Cabox” from the highest peak on the island. The park spans the Bay of Islands Ophiolite (representing Paleozoic oceanic lithosphere), Little Port island arc complex and sedimentary rocks of the adjacent Laurentian continental shelf and slope. The region includes the core of the Humber Arm Allochthon and exemplifies the Humber Zone of the Appalachian Orogen. The area has been referred to as the Galapagos of Plate Tectonics for the role it played in supporting the scientific theory of plate tectonics in the 1960s and 70s. The Aspiring Geopark spans approximately 3,747 km² and features dramatic topography including coastal sea cliffs, glacially carved river valleys and mountain ranges rising to elevations of 700–800 m. It includes three of the four massifs of the Bay of Islands Ophiolite Complex, from Lewis Hills and Blow Me Down Mountains in the south to North Arm Hills/Gregory Mountains in the north. It adjoins Gros Morne National Park which offers visitors a complementary experience. Culturally, Cabox is rooted in the region's Indigenous and European legacies, including Mi'kmaq, French, English and Irish, and many others. Its mission is to preserve and promote the geological, ecological and cultural heritage of the

Lower Humber Valley and Bay of Islands region, while developing sustainable recreation and educational infrastructure for the benefit of both residents and visitors.

Petrological modelling with trace elements – How far is too far?

Chris Yakymchuk

University of Waterloo.

E-mail: cjakymchuk@uwaterloo.ca

Phase equilibrium modelling of metamorphic processes has become commonplace. Such models continue to be enhanced by the addition of new minerals and solution models to better reflect experimental results and natural parageneses. Layered on top of these calculations are mass balance-based models that include trace element partitioning and accessory mineral behaviour that are grounded in experimental results but are commonly used without assessing if they are reasonable reflections of natural processes. Here, I ask if we are misleading ourselves into understanding petrological processes by using an equilibrium approach to evaluate trace element systematics in anatectic melt and in accessory minerals. Linking the trace element compositions of granitoid rocks to petrological models of partial melting emphasizes source P-T conditions, but commonly negates other facets of granitoid petrogenesis, such as fractional crystallization. Modelling applied to accessory mineral petrochronology glosses over the widespread observation that these minerals are complexly zoned. Empirical examples of intragrain zoning in monazite and zircon are hard to reconcile with an equilibrium petrological modelling approach. Although the divergence of modelling results from empirical data represents a cautionary tale about extrapolating the results of trace element-focused petrological modelling to real petrological processes, it opens new opportunities for understanding microscopic and macroscopic processes that contribute to the variability in natural sample suites. Future endeavours should ensure that we routinely go back to basics – thin section observations, assessing microstructures and establishing major and trace element variability in minerals, samples and rock suites, as well as ground-truthing our model results with well constrained samples.

Are there any alkaline granitoids in the Paleoproterozoic Lynn Lake greenstone belt, northwestern Manitoba?

Xue-Ming (Eric) Yang¹, Fazilat Yousefi²

¹Manitoba Geological Survey, ²University of New Brunswick.

E-mail: eric.yang@gov.mb.ca

Bedrock geological mapping in the Paleoproterozoic Lynn Lake greenstone belt of northwestern Manitoba reveals a record of diverse and episodic granitoid magmatism. Based on mineral assemblages and geochemical signatures, these granitoid rocks are classified into four petrogenetic types: I-type, A-type, adakitic and S-type granitoids. These distinct suites likely formed in disparate geodynamic settings – ranging from plate subduction, slab roll-back to lithospheric failure triggered by terrane collision – during the evolution of the Trans-Hudson orogen. While these granitoids are primarily calc-alkalic to calcic, certain adakitic intrusions (ca. 1857 to 1829 Ma) plot as alkali-calcic series (or suites) on the modified alkali–lime index (MALI) versus SiO₂ diagram proposed by Ronald Frost and others. Although this might suggest an alkaline affinity, the absence of diagnostic sodic minerals (e.g. sodic amphibole or pyroxene) indicates that the MALI classification may have been misleading in the petrological context. Consequently, we employ the alkali–lime index (ALI) proposed originally by M.A. Peacock in his “classification of igneous rock series” almost a century ago, integrated with the Rittmann serial index (σ) to accurately determine magmatic alkalinity. These discriminant results are supported further by the total alkali–silica (TAS) classification diagram that is widely used for assessing compositional variation in igneous rocks. Notably, our study demonstrates that the variations in magmatic alkalinity of temporally–spatially associated granitoid intrusions across the Lynn Lake greenstone belt, coupled with precise U–Pb zircon geochronology, trace-element and Nd isotope geochemistry, serve as indicators of subduction polarity. We propose a transition from an early, steep southward subduction – evidenced by ca. 1857–1854 Ma adakitic magmatism – to a subsequent period of shallow northward subduction, as indicated by its ca. 1834–1829 Ma counterpart. The generation of these adakitic magmas likely required a chemical equilibrium with significant amounts of garnet in the mantle source, facilitated by multiple phases of mantle enrichment or metasomatism previously by slab-derived fluids and/or melts.

The effects of (de)glaciation on sedimentary carbon cycling and storage in Maktak fjord, Auyuittuq National Park, Baffin Island, Canada

Thomas Young, John Hilliard, Hilary Corlett, Brette Harris

Memorial University of Newfoundland.

E-mail: tabrahamy@mun.ca

The cycling of carbon within various environments is a major focus of Earth systems research, particularly in recent decades with the backdrop of anthropogenic climate change. This study pertains to the effects of sediment transport and bioturbation intensity on sequestration of terrestrial and marine carbon in marine sediments in Maktak fjord, Auyuittuq National Park, Baffin Island. Arctic fjords represent a critical yet understudied frontier in carbon cycling research. Maktak fjord is a partially glaciated environment that presents an opportunity to investigate how deglaciation affects sedimentation and carbon storage. Several push cores were collected from box cores aboard the CCGS Amundsen in July 2024 and August 2025. Computerized-tomography scans of the cores were taken and used to identify sedimentary and biogenic structures. Each facies was assigned a bioturbation index (BI) score on a 0–6 scale to assess the variations in bioturbation with depth in each core along a transect from the head to the mouth of the fjord. Cores exhibit evidence of two sedimentation regimes in the fjord: one which predominates during warmer intervals amidst an outstanding cooler period, and another which prevails during warmer periods. Initial results suggest BI intensity covaries alongside changes in the

depositional regime, with BI intensity peaking during warmer periods. Along the transect, changes in BI reflect shifts in depositional energy and salinity from the head to the mouth of the fjord. Differences in core properties may represent progressive shift from terrestrially-controlled to marine-controlled sedimentation regimes. Carbon storage in Maktak may be influenced by fluctuations in sedimentation rates and BI associated with warming or cooling climates, suggesting a connection between deglaciation and the fjord carbon cycle.

Petrogenesis and geodynamic settings of alkaline bimodal igneous suites in New Brunswick, Canada: Implications for associated mineralization

Fazilat Yousefi¹, David R. Lentz¹, Kathleen G. Thorne²

¹University of New Brunswick, ²New Brunswick Department of Natural Resources.

E-mail: fazilat.yousefi@unb.ca

Late Silurian–Early Devonian bimodal igneous systems, comprising alkaline mafic intrusive to extrusive rocks and peralkaline granites to alkali rhyolites, comendites, occur in northeastern to southwestern New Brunswick (NB) within the northern Appalachians. The felsic rocks display A-type geochemical affinities and are associated with variable degrees of mineralization, reflecting their petrogenetic evolution in an extensional within-plate setting. U–Pb ages for some selected peralkaline rocks in NB include 410.1 ± 1.8 Ma for the Benjamin River complex, 412 ± 1 Ma for the Welsford granite, 416 ± 5 Ma for the Parks Brook granite, and 418 ± 2.3 Ma for the Jake Lee granites. Rittmann index values ($3.5 < \sigma < 8.8$) and agpaite indices ($AI > 1$) confirm their alkaline character formed in a post-collisional extensional setting, displaying potential for extreme fractionation, i.e. pronounced HFSE and REE enrichments. Although the classification and petrogenesis of A-type granites remain debated, two main end-member models are recognized: 1) low degree partial melting of mantle with differentiation of parental mafic magma, and 2) partial melting of dehydrated continental crust. Geochemical data from these peralkaline intrusive suites in NB, including average Zr (688 ppm), Y (~102 ppm), Ga (~16 ppm), Ce (~164 ppm) and Nb (~34 ppm), indicate that these rocks likely formed through extensive fractionation of mantle-derived melts (A1) and partial melting of F–Cl-rich granulitic lower crustal (A2) residues remaining after orogenic granite extraction. Elevated FeO_t/MgO, Zr/Ti, Nb/Y, HFSE and REE, along with redox-sensitive traits such as relative Fe enrichment, reflect melt evolution under lower redox conditions, governed by differing degrees of mantle metasomatism. Regarding the emplacement of these bimodal systems in NB, the rapid transition from compressional to extensional magmatism (transpression to transtension) during the latest Silurian–Early Devonian in this part of the Northern Appalachians was driven by the Late Silurian Ganderia–Laurentia oblique collision (Salinic Orogeny), with slab break-off.

A geochemical survey of clay-sized fluvial sediment eroded from contrasting lithologic terranes of Newfoundland

Jia-wei Louis Yun, Michael G. Babechuk

Memorial University of Newfoundland.

E-mail: jyun@mun.ca

Clay minerals are the ultimate products of terrestrial chemical weathering that are subsequently transported from the continents to the oceans, dominantly in suspension load, and constitute an archive of integrated geochemical information that reflects factors such as source-rock composition and weathering intensity within a drainage basin. Existing research has focused on large fluvial systems where provenance and weathering signals are substantially homogenized. This creates a challenge to reconstruct how sediment may preferentially inherit geochemical signatures from specific rock types or more localized environmental factors. More studies are needed to systematically examine the geochemical characteristics of the clay-sized fraction ($< 2 \mu\text{m}$) of streams in smaller and more lithologically uniform catchments where the latter challenges can be best addressed. For this study, major and trace element geochemistry was conducted on the clay-sized fraction trapped in bedload sediment collected from small streams and major rivers across Newfoundland. Samples were obtained from catchments underlain by contrasting rock types, including the ultramafic–mafic ophiolitic complexes of the Bay of Islands and Gros Morne, the peralkaline St. Lawrence Granite and selected large river systems. A targeted separation protocol was employed to physically isolate the $< 2 \mu\text{m}$ fraction while the primary mineralogical components dictating its geochemical signature could be discerned. Preliminary results demonstrate a pronounced lithological control on clay fraction geochemistry, superimposed by the effects of chemical weathering and authigenic Fe–Mn oxyhydroxides. Distinct geochemical contrasts between ultramafic–mafic and felsic catchments underscore the sensitivity of clay-sized sediment in fluvial systems as provenance indicators, but several elements show enrichments in conflict with source rock abundances and instead reflect local environmental conditions that drive authigenic mineral formation and associated scavenging processes. Overall, these findings highlight the value of clay-sized fluvial sediments as integrated archives of source rock composition, dynamic weathering and authigenic processes, and environmental tracing at both local and regional scales.

Evaluating continuity of subduction in the lapetus

Alex Zagorevski, Cees R. van Staal

¹Natural Resources Canada, Geological Survey of Canada.

E-mail: alex.zagorevski@nrcan-rncan.gc.ca

Tectonic reconstructions of ancient orogens are typically biased towards continuity of terranes and orthogonal convergence which simplify tectonic cross-sections and plate tectonic reconstructions. Whereas many studies in the Appalachians have attempted to reconcile oblique convergence, evaluating the lack of continuity of terranes and subduction zones is much more difficult despite its requirement in the Appalachians. For example, the peri-Gondwanan Moretown terrane was accreted to Laurentia prior to the termination of subduction beneath peri-Laurentian terranes to the north, requiring termination of peri-Laurentian terranes and related subduction at the present latitude of the Canada–US border. To identify possible

geological criteria for subduction termination we re-examine the continuity of terranes in the Canadian Appalachians. Although ophiolites, specifically those containing boninites, are typically interpreted as markers of subduction zone initiation, subduction initiation in recent and modern settings does not immediately result in magmatism and generation of ophiolites. An exception to this is the conversion of the subduction-bounding transform into a subduction boundary beneath the Hunter Ridge, triggered by the collision of the New Hebrides arc with the Loyalty Ridge, east of New Caledonia. This conversion, or subduction initiation, is ca. 2 Myr old and occurs beneath the back-arc crust of the North Fiji basin and is spatially associated with magmatism and boninites in the hanging wall. We compare this setting to the Ordovician ophiolites in Quebec and Newfoundland, to evaluate whether the Hunter Ridge analogue can be used as an indicator of a subduction-transform boundary and a proxy for peri-collisional ophiolites in the Appalachians.

Crystallography and texture differences between pristine, anode incorporated, recycled and end-of-life graphite

Christoforos Zamparas, Steffen Kaiser, Elisabeth Eiche, Jochen Kolb

Karlsruhe Institute of Technology.

E-mail: christoforos.zamparas@kit.edu

Graphite is a carbon polymorph and is described as a critical and strategic raw material by the European Commission. Its layered structure enables a wide range of applications, e.g. lithium-ion batteries, fuel cells, lubrication and refractories. Our contribution focuses on graphite, in the context of direct recycling and regeneration of the anode-active material as used in lithium-ion batteries, by building a reference framework between different stages of its life cycle. X-ray diffractometry, crystal refinement, mathematical formulation and scanning electron microscopy are used to distinguish major structural and textural differences between pristine and partially pre-lithiated graphite, and graphite pasted on laboratory-produced, production scrap, recycling processed and end-of-life electrode material. Lithiated graphite (Li_xC_6) space groups are reported as P6/mmm and P6₃mc. Our XRD data show three different graphite allotropes: (1) hexagonal graphite-2H; (2) rhombohedral graphite-3R; and (3) a variety of hexagonal symmetry. They additionally show lithiated graphite. Preliminary Rietveld refinement indicates crystal symmetry defined by the space groups P6₃/mmc, R-3m and P6/mmm, respectively. The average graphite particle size decreases from approximately 50 nm to less than 5 nm, corresponding to the same order as presented above. Based on these results, none of the lithiated graphite space groups can be a subgroup of R-3m, as required for a second order phase transition such as Li-intercalation and an increased fraction of rhombohedral graphite is demoting the overall electrochemical quality. Decreasing particle size could lead to a decreased graphite flake size, especially during mechanical recycling processes. Additionally, the lowering degree of crystallinity, excess microstrain and potential lattice-bound and intercalated impurities set the stage for graphite downcycling. Finally, this could potentially force an even higher increase in demand for natural hexagonal graphite of high flake quality in the coming years, as a response to lowered quality of recycled graphite for high-end applications.

The Permo–Carboniferous Graissessac-Lodève Basin (France) – new insights into Variscan exhumation processes revealed by detrital zircon and apatite

Johannes Zieger, Mandy Zieger-Hofmann, Andreas Gärtner, Ulf Linnemann

Senckenberg Natural History Collections Dresden.

E-mail: johannes.zieger@senckenberg.de

The Permo–Carboniferous Graissessac–Lodève Basin in the southern French Massif Central records sedimentation during the late stages of the Variscan orogeny and subsequent post-orogenic extension. This study combines sedimentological observations with detrital zircon and apatite U–Pb geochronology, zircon morphology and Lu–Hf isotopic data to constrain sediment provenance, exhumation processes and basin evolution. Detrital zircon age spectra reveal several recurring populations: a dominant Neoproterozoic–Cambrian group derived from Paleozoic metasedimentary rocks overlying the Montagne Noire dome, a prominent Ordovician population sourced from regional granitic orthogneisses, a subordinate Late Devonian–Early Carboniferous population likely linked to syn-orogenic magmatism, and a Carboniferous–Early Permian population associated with Variscan to post-Variscan granitoid rocks. Zircon morphology and ϵHf values indicate predominantly short transport distances and heterogeneous crustal sources involving both juvenile and reworked components. Detrital apatite U–Pb ages cluster mainly around ca. 300 Ma, with subordinate Ordovician ages, recording cooling and exhumation of Variscan source rocks during Early Permian extension. The appearance of Permian detrital zircon populations constrains the onset of Montagne Noire dome unroofing to ca. 295 Ma, followed by continued but slower exhumation. These results support a model of synchronous dome exhumation and sediment recycling during post-orogenic collapse of the Variscan belt. The integrated application of detrital zircon and apatite geochronology, coupled with morphological and Lu–Hf data, provides robust constraints on sediment routing and exhumation dynamics in intramontane basins and highlights the potential of this multi-proxy approach for tectonically complex regions.

Sedimentary patterns and provenance of the Rosenhof Member (Nama Group, southern Namibia)

Mandy Zieger-Hofmann, Johannes Zieger, Andreas Gärtner, Ulf Linnemann

Senckenberg Naturhistorische Sammlungen Dresden.

E-mail: mandy.hofmann@senckenberg.de

The Rosenhof Member is part of the Lower Cambrian Fish River Subgroup of the Nama Group in southern Namibia (Groß Aub Formation). The sediments of the Nama Group are deposited in two basins, the northern Zaris Subbasin and the southern Witpütz Subbasin. Both are separated by the Osis Arch, a basement updoming. While the basal two Nama subgroups are influenced by these two basins and their paleorelief, the uppermost Fish River Subgroup sediments overstep the Osis Arch and cover previous deposits with an unconformity. Deposits of the Fish River Subgroup are

represented by Lower Cambrian shales and sandstones. The sandstones of the Rosenhof Member show distinct sedimentary patterns that allow their interpretation as fluvial deposits originating from the north. They were deposited after the final collision of the Kalahari Craton (south) and the Congo Craton (north) that created the Damara Orogen. The latter is discussed as a major sedimentary source area for the studied deposits covering southern Namibia (Kalahari Craton). For this purpose, the Rosenhof Member was sampled and studied at various locations, covering occurrences from its northern outcrops until its most southern ones. This sample set allows the study of changes in the sedimentary pattern of a particular member over an area of about 300 km². This talk presents sedimentary structures combined with heavy mineral analyses (U–Pb geochronology on zircon and apatite) and discusses possible sedimentary source areas, as well as sedimentary mixing and homogenization.

Hydrologic timing matters: How climate change may impact soil carbon mobilization and stores in humid boreal forest landscapes

Susan E. Ziegler¹, Lindsey M. Butt¹, Allison Myers-Pigg², J. Alan Roebuck¹, Karl Kaiser³

¹Memorial University of Newfoundland, ²Pacific Northwest National Laboratory, ³Texas A&M University.

E-mail: sziegler@mun.ca

Terrestrial to aquatic fluxes of dissolved organic matter (DOM), an important component of the landscape C balance, are hypothesized to increase with climate change in boreal forests. Through four years of soil solution flux monitoring along a humid boreal forest climate transect, we observe increased DOM mobilization in years with warmer winters and reduced snowpack duration. These trends may be due to decreased soil organic matter degradation with reduced snowpack insulation and thus lower loss to respiration, but increased loss through DOM mobilization over winter. To assess this hypothesis, we evaluate the seasonal flux and composition of soil DOM across this transect. We further evaluate how such variation in DOM composition may impact DOM retention, via adsorption, within the mineral soils of these forests. Increased annual soil dissolved organic carbon and nitrogen (DON) fluxes were associated with greater fluxes specifically in the winter/spring season in years with warmer winters. The DOM associated with elevated winter/spring fluxes more closely reflected autumn soil DOM composition exhibiting lower C:N ratios, %DON as amino acid-N, total lignin content and higher lignin phenol acid to aldehyde ratios (Ad/Al). In colder winters with longer snowpack duration, Ad/Al was lower and more consistent with bulk soil composition and the release of soil lignin-cellulose. This suggests warming-enhanced mobilization of DOM in these forests is due to reductions in degradation of C-rich plant-derived polymers from soil in warmer winters. On an annual basis this may result in a shift toward less degraded, higher molecular weight DOM directed to deeper mineral soils or downstream aquatic systems. Integrating this knowledge with our understanding of soil and catchment hydrology, and the composition of DOM participating in mineral soil organo-metal interactions will help inform the fate of soil DOM and thus the carbon balance of these humid boreal landscapes in a warmer climate.

Variations in geochemical signatures and volcanic intensity controlled by converging rifts crossing variably stretched continental crust, Faroe Islands, NE Atlantic

Heri Ziska, Uni Árting, Uni Petersen

Faroese Geological Survey.

E-mail: h.ziska@jf.fj

The emplacement of the volcanic succession of the North Atlantic Igneous Province (NAIP) has frequently been ascribed to a singular volcanic cause, while the onshore volcanic succession observed on the Faroe Islands is characterized by two distinct volcanic phases. In order to tie the regional evolution of the NAIP to the volcanic phases on the Faroe Islands, we have re-interpreted all available 2D-seismic reflection and refraction data. The results were correlated with geochemical data from offshore wells in addition to boreholes and outcrops onshore in the Faroe Islands. The pre-breakup succession of the Faroe Island Basalt Group, which was protracted with up to several tens of thousands of years between individual volcanic episodes, is characterized by N–S oriented dykes, eastward-flowing units in the Faroe–Shetland Basin and a geochemical signature which is dominated by high-Ti lavas during the first phase with lower Ti units appearing in the uppermost part. The syn-breakup succession, which was very intense with nearly continuous volcanism during the entire phase, is characterized by dominantly E–W trending dyke orientations, southward flowing units and includes two geochemical phases. A first phase comprises low-Ti lavas, while the later stages include both low-Ti and high-Ti lavas. We propose that the pre-breakup volcanic units are linked to a NNW–SSE oriented transient rift west of the Faroe Islands, seen on refraction data as significantly thinned crust, exploiting Precambrian (Laxfordian) structural grain. The evolution of the geochemical signature reflects continued thinning of the crust within the rift. During the latest Paleocene to early Eocene two rifts converged on the area north of the Faroe Islands. The ENE-trending Ægir Ridge propagated west-southwest reaching the northern end of the Faroe Iceland Ridge, resulting in high-intensity volcanism, and high-Ti lavas propagated southwards. Concurrently, the Reykjanes Ridge crossed the pre-breakup rift system, further stretching thinned crust, resulting in emplacement of low-Ti MORB-type lavas.

Author Index

A

Aajli, Brahim 1
 Acevedo, Jorge 73
 Acharjee, Amit 26
 Adam, Zachary 83, 119
 Adetunji, Ademola 52
 Adlakha, Erin 1, 50, 102, 135
 Agard, Philippe 81
 Aird, Keeley A. 1
 Alam, Rayan 2
 Alfonso, Pura 113
 Allen, Luke 47, 116, 123
 Almusned, Baian 104
 Álvaro, J. Javier 2, 77
 Alves, Pedro 3
 Amidon, William 26
 Ammerlaan, Fenna 3
 Amor, Stephen 3
 Anderson, Kristina 4
 Anderson, Melissa 4
 Angombe, Moses 123
 Annesley, Irvine R. 16, 18, 111
 Ansdell, Kevin 4, 38, 43
 Applin, Dan 97
 Archambault, Lily Rose 5
 Archibald, Donnelly 5, 21, 24, 58, 76, 80, 93, 122
 Ardakani, Omid H. 39, 99
 Arhonditsis, George 109
 Ariza-Benavides, Gabriel 5
 Arnason, Knutur 6
 Arnott, Bill 6, 121
 Arshian, Marzieh 6
 Árting, Uni 142
 Ashraf, Asif 79
 Ashton, Ken 12, 23
 Aubourg, Charles 43
 Avery, Gracie 102
 Awolayo, Adedapo N. 7, 29
 Aylward, Wanda 75
 Azad, Ayda 7
 Azetsu-Scott, Kumiko 8

B

Baarli, B. Gudveig 122
 Babechuk, Michael 8, 57, 91, 93, 113, 117, 140
 Bachynski, Ryan 125
 Baird, Elizabeth 137
 Baker, Don 8, 23, 108
 Baker, Oliver 107
 Baker, Tim 31
 Barker, Ivan 104
 Baron, Frédérique 20
 Barr, Sandra 9, 58, 60, 128

Barré, Guillaume 66
 Barrera Cortes, Marcela 9
 Beard, Charles D. 10
 Beaudoin, Georges 12, 31, 66–68, 75, 106, 108, 121, 134
 Beaulieu, Louis-Philippe 9
 Beckett-Brown, Chris 94
 Bédard, Jean H. 10–11, 20, 81, 95
 Bekker, Andrey 103
 Belanger, Joleen 11, 14
 Bell, Natasha 48
 Belley, Philippe 11
 Bendimerad, Chaouki 12
 Benoit, Mathieu 19
 Beranek, Luke 59, 101
 Berlo, Kim 28, 42, 128
 Bertauts, Maxime 12, 31, 108
 Bethell, Erin 40
 Bethune, Kathryn 12, 23, 103
 Beyer, Steve 102, 130
 Bhakta, Jake 19
 Bhattacharjee, Joyeeta 17
 Bhattacharya, Janok P. 13
 Biesinger, Mark C. 104
 Blereau, Eleanore 13
 Blight, Mackenzie 49
 Boateng-Dwomoh, Leslie 13
 Bodnar, Matthew M. 14
 Boehme, Wieland H. 11, 14
 Boggs, Katherine 88
 Bohus, Caleb 123
 Bollwerk, William 47
 Bonnell, Jayme 14
 Booker, Simone 50
 Borisova, Anastassia Y. 53
 Boscaini, Andrea 101
 Bosman, Sean 134
 Boucher, Brandon 49–50
 Bouffard, Jean-Sebastien 97
 Bouvier, Anne-Sophie 27
 Bovay, Thomas 27
 Bowyer, Fred T. 94
 Boyce, Joseph I. 1
 Boyce, Tyler 15
 Boyd, Eric 26
 Bradley, George 15, 78
 Braga, Carlos 40
 Brake, Virginia 99
 Bravo, Joseph 16, 18, 111
 Breen, Jake J. 98
 Brennan, James 49
 Brink, Kirstin 16, 32, 58, 126
 Brouard, Etienne 106

Brown, Caleb 32, 126
 Brueckner, Stefanie M. 11, 14, 125
 Brunelli, Daniele 16–17
 Brushett, Denise 94
 Buchan, Kenneth L. 34
 Butt, Lindsey M. 142
 Button, Mark 47
C
 Cadenas, Patricia 73
 Calder, John 47
 Callegaro, Sara 8, 108
 Camacho, Alfredo 32, 65, 118
 Campbell, Heather 3, 17, 106
 Campbell, Linda 63, 71, 98
 Canam, Rebecca 23
 Caraffini, Francesco 108
 Carapetian, Rene 18
 Card, Colin D. 12
 Cardenas-Vera, Alan 18, 111
 Carl, Guilmette 11, 13, 20, 45, 61, 68, 81, 105, 125
 Carter, Maria 18
 Casas, Josep Maria 2
 Castillo-Carrión, Mercedes 36
 Castro, Antonio 111
 Caverson, Mya 104
 Cawood, Tarryn 48, 90
 Ceuleneer, Georges 19, 53
 Chakhmouradian, Anton 19
 Chalmers, James 19
 Chan, Sabrina 84
 Chang, Xavier 32
 Chapman, E. Emily V. 63, 71, 98
 Chatterjee, Sreejita 20
 Cherdantseva, Maria 69
 Chew, David 133
 Chi, Guoxiang 9, 134
 Ciazela, Jakub 20
 Cipriani, Anna 17
 Clark, James 80, 131
 Cleven, Nathan 126
 Cloutis, Ed 97
 Coleman, Mark 20
 Collett, Stephen 21, 114
 Colpron, Maurice 79
 Conliffe, James 5, 21, 66, 76, 80, 93, 113
 Conroy, Tara 21
 Constantin, Marc 100
 Coqueiro Sanches, Willian Valentin 22
 Corlett, Hilary 50, 54–55, 75, 88, 90–91, 98, 119, 139
 Côté-Roberge, Myriam 61

Couëslan, Chris	22	DiMascio, Grey	30	Foley, Tyrin	38
Cox, Richard	22, 31	Dingman, Jennifer	123	Forshaw, Jacob	51
Coxon, Ian N.A.	117	DiPietro, Lauren	31	Foulger, Gillian	38, 66, 130
Creaser, Robert	121	Dolphin, Glenn	31, 88	Fountain, Tyler	8
Crook, Connor	23	Donaghy, Erin E.	79	Fournier-Roy, Francois	20
Crotty, Catherine	128	Donnelly, Laurance	88	Fraino, Patricia E.	39–40
Crouzal, Tom	23	Donze, Mike	92	Frangeskides, George	37
Crowley, James	1, 76, 86, 97, 125	Dorado-Troughton, Mateo	49	Frank, Kyle	48
Cruikshank, Rebecca	39	Drouillot, Valentin	31	Fraser, Daniel	123
Cubley, Joel F.	24	Duan, Wenyong	20	Frazer, William	39
Cuggy, Michael B.	24	Duarte, Luis V.	46	Frost, Natasha	26, 122
Cunningham, Celeste	24, 80	Dubacq, Benoît	81	Furio, Marta	111
Currie, Victoria	137	Dubois Gafar, Amrine	88	Furlong, Carolyn M.	39–40
Cuthbertson, Jennifer P.	25	Dubosq, Renelle	115	G	
Cutts, Jamie	45, 90, 97, 103, 113	Ducat, Thibault	26	Gadd, Micheal G.	135
Czas, Janina	20, 85	Dunning, Greg	36, 93, 96, 124	Gaidies, Fred	90
D		Durant, Zailynne	78	Galley, Christopher	40
D'Amato, Dominic	128	Durkin, Paul	32, 126	Garcia, V.B.	41, 92, 95
Dafoe, Lynn	116	Dyck, Brendan	32, 54, 62, 67, 82, 126	Gardideh, Sara	41
Dalrymple, Robert	25, 37	Dyer, Sabastien	64	Gartman, Amy	40
Dang, Duc Huy	113	E		Gärtner, Andreas	9, 13, 41, 72, 141
Darbyshire, Fiona	135	Eaton, David	88	Gastaldo, Robert	116, 123
Dare, Sarah	66	Ebel, John E.	80	Gastonguay, Jean-Michel	42, 122
Darveau, Jérémie	61	Edinger, Evan	8	Gavel, Heidi	63, 98
Dauphinee, Morgan	26	Eglinger, Aurélien	42	Gebru, Ayalew	60
Davidson-Lindfors, Naya	7	Eglington, Bruce	32, 89, 124	Geliot, Mathieu	42
Davies, Ethan T.	1	Ehrman, James M.	61	Geng, Meixia	96
Davies, Joshua	3, 5, 26, 42, 96, 101, 103, 122	Eiche, Elisabeth	141	Gensel, Patricia	123
Davis, Bret H.	26	El Bilali, Hafida	33–35	Geoffroy, Laurent	42–43
Davis, William	97	El Bourki, Mhamed	76	George, Freya R.	43
Daxberger, Heidi	109	El Ghawi, Karim	33	George, Kacia	43
Day, J.M.D.	41, 95	Elliott, Holly A.L.	33	Geraki, Kalotina	8
Day, Stephen	84	Enkelmann, Eva	34, 59, 101	Gerard, Kayla	116
De Leijer, Noralinde	27	Ernst, Richard E.	33–35	Gervais, Félix	10, 44
De Paula Garcia, Pedro	22	Ersay, Lütü	35	Gerya, Taras	20
Maciel	28, 42, 96, 103	Escribano, Alicia P.	36	Ghantous, Sam N.	44
De Souza, Stéphane	28, 42, 96, 103	Escuder-Viruet, J.	36, 128	Gibson, Dan	18, 60, 67, 113
De Toledo Queiroz, Lorena	27	Evans, David	30, 32, 98	Gillespie, Richard	70
Deady, Eimear	33	Eyles, Carolyn	29–30, 68	Gingras, Murray K.	88
Dean, Madison	48	F		Girard, Réjean	44, 127
Deane, Jordan	23	Faehrich, Karol	79	Glasspool, Ian	123
Del Oro, Trent	10	Farquharson, Colin	59	Glodny, Johannes	137
Delafosse, Romain	28	Fassbender, Marc	28	Godbout, Pierre-Marc	17, 106
Demers, Isabelle	69	Fayek, Mostafa	36, 50, 95	Godet, Antoine	35, 42, 45, 54, 61, 105, 122
Dentelbeck, Rhian	28	Fernández-Rodríguez, F.J.	36	Gold, Virginia	16
Denyszyn, Steven	14, 69	Fernandez-Viejo, Gabriela	73	Gomes, Juliette	45
Deriaz, Julie	28	Filina, Dr. Irina	79, 110	Gomez, Nicolas	45–46, 57, 74, 83
Devries, Justina T.S.	29	Finch, Adrian	37	Gonzalez-Cortina, Juan Manuel	73
DeWolfe, Michelle	29	Fiorentini, Marco	69	Goodger, Kristin	104
Dick, Daniel	29–30	Fipke, Charles	47	Goonetilleke, Muditha	46
Diekup, David	30	Fitzgerald, Danielle M.	37	Gosse, John	106
		Flemming, Roberta L.	37	Goudie, Dylan	99
		Florian, Pierre	110–111		

Grant, Caleb	47	Hodder, Tyler J.	14	Kendall, Brian	48
Green, Paul	19	Hodge, Joanna	55	Kendrick, Jillian	27, 62
Greenough, John D.	47	Hodgson, Jaimee	50, 55, 119	Kerr, Andrew	63
Grierson, Holly	48	Hoffman, Paul F.	55–56	Kerr, Kaitlyn	63
Grigoryan, Grigor	18	Hone, Peter	32	Khatrine, Grace	74
Groat, Lee	48, 104–105	Honsberger, Ian W.	56, 90, 111	Kidder, James	22
Groulier, Pierre-Arthur	48	Horne, Richard J.	65	Kim, Taehwan	64
Grunsky, Eric	107	Howes, Allison C.	5, 56	Kim, Yoonsup	49
Guest, Nicolas	48	Hsieh, Robert B.-J.	117	King, Olivia	47, 116, 123
Guna, A. Gusti	49, 96	Huang, Bing	122	Kinney, Carson	64
Gutierrez-Medina, Miguel	73	Huang, Chuan	138	Kjarsgaard, Bruce	64
H		Huston, David	32	Kjarsgaard, Bruce A.	20
Hadzovic, Alen	109	Hutton, Eric	50, 55, 119	Klever, Tosh M.	65
Halls, Henry C.	81	Hwang, Bohyun	7	Klick, Remy	48
Halverson, Galen	26, 101	Hymers, Lesley	57	Kneale, Jakob G.O.	48
Hamilton, Michael	83	I		Knobloch, Andreas	84
Hamilton, Mike	52, 81	Ikechukwu, Chidera	45, 57, 74, 83	Kohn, Simon C.	43
Han, Giun	49	Indares, Aphrodite	12, 15, 44, 124	Kolb, Jochen	141
Hanchar, John M.	75, 115	Isbister, James	15	Komendat, Isabelle	74
Hangle, Kurt	95	Iturralde, Jorge	58	Kommacher, Sebastian	75–76
Hanley, Jacob	1, 49–50, 69	J		Kondrasovas, Halina	65
Hannberg, Alexia	47	Jackson, Marie D.	26	Konig, Uwe	106
Hannington, Mark	28, 40	Jacques, Issac	95	Kontak, Daniel J.	65–67
Hanžl, Pavel	21	Jamieson, Heather	56	Koop, Jordan M.	114
Haproff, Peter	71	Jamieson, John	40, 114	Koptev, Egor	66
Harper, Tabitha	86	Jamieson, Rebecca A.	58	Kostyuk, Anastasia	129
Harris, Brette	50, 55, 119, 139	Japsen, Peter	19	Krampert, Luis	66–67
Harris, Lyal B.	51	Jautzy, Josué	99	Krause, Rita	81
Harris, Phil	92	Jébrak, Michel	42	Krause, Sebastian	81
Harris, Ryan	51	Jefferson, Charlie	97	Krossa, Kelsey	67
Härtel, Birk P.	34	Jeong, Youn-Joong	49	Krueger, Jacklyn	67
Hartmeier, Philip	51, 129	Jobbins, Melina	58	Krushnisky, Alex	85
Haugaard, Rasmus	52	Johanson, Zerina	58	Kuiper, Yvette D.	114
Hauzenberger, Christoph A.	71	Johns-Buss, Emily	34, 59	Kukkonen, Ilmo	38
Hayes, Ben	10	Johnson, Alexis	59–60	Kumpan, Tomáš	21
He, Xin	52, 138	Johnson, Susan	9, 60	Kunert, Alexandra	48
Heasman, Drew	53, 89	Johnstone, Dillon D.	12	Kupiec, Catherine	68
Hebert, Brian	47, 116, 123	Jonah, Brent	136	Kusiak, Monika	54
Hellebrand, Eric	126	Jones, Gabrielle	60	L	
Henderson, Charles M.	85	Jouhari, Mehdi	125	Labrousse, Loïc	81
Henry, Hadrien	11, 19, 53, 124	Jouvent, Marine	61	Lacinska, Alicja	33
Hermann, Jörg	126	Jowitt, Simon M.	35	Laflamme, Crystal	2–3, 31, 66–68, 108, 121, 134
Herzog, Michael	68	K		Lafrance, Bruno	11, 14
Heveran, Chelsea	26	Kaczmarska, Irena	61	Lambiv Dzemua, Gideon	68, 89
Hildebrand, Alan	53	Kadery, Nahin	109	Lamothe, Michel	47
Hill, Reghan J.	23	Kaiser, Karl	142	Lanari, Pierre	27, 51, 69, 129
Hill-Svehla, Carolyn M.	104	Kaiser, Steffen	141	Lang, Corey	68
Hilliard, John	54, 139	Kamo, Sandra L.	81	Lankoande, Faridah Alexandra	69
Hinchey, A.M.	3, 11, 20, 30, 41, 54, 82, 95, 111, 115–116, 119	Kaur, Si	61	Lardeaux, Jean-Marc	114
Hinchey, John G.	36	Kay Anderson, Julia	105	Larsen, Rune B.	69
Hinds, Steven	116, 123	Keefe, Emma	96	Larson, Kyle	1, 23, 35, 44, 65, 82, 87,
Hnatyshin, Daniel	48	Kehler, Collin	62		
		Keirs, Austin	62		
		Keller, Lisa M.	26		
		Kellett, Dawn	118		
		Kelly, Nicholas	107		

	100, 108, 125–126	MacIsaac, Graydon	78	Mérit, Louise	81
Laughton, Joshua	97, 103, 113	MacIsaac, Jessica	78	Messori, Fabio	94
Laureijs, Christiaan	61	MacLeod, Douglas	34	Methot, Marie France	82
Laverge, Margaret	11, 14	MacNaughton, Robert B.	85	Meyer, Romain	82, 135
Layne, Graham D.	93	MacRae, Andrew	47, 123	Michailow, Mateusz M.	17
Layton-Matthews, Daniel	22	Mactar-Dieng, Pape	31	Michalchuck, Benjamin	1
Lebeau, Lorraine	97	Maddin, Hillary	116, 123	Middleton, Maarit	84
Lebel, Daniel	88	Maggs, Manda	109	Migeul, Kélé	107, 137
Lecumberri-Sanchez, Pilar	18	Magyarosi, Zsuzsanna	66, 75	Miková, Jitka	21
Ledesma, Gabrielle	113	Maia, Marcia	17	Milidragovic, Dejan	60
Ledoux, Tegan	97	Maitra, Akeek	34	Milkowski, Ethan	54, 82
Leduc, Evelyne	102	Makvandi, Sheida	106	Mills, Andrea	2, 9, 17, 45–46, 57, 74, 83
Lee, Hao-Yang	117	Malay, Bailey	47, 116, 123	Minarik, William	61
Lee, Jong Ik	49	Malay, Kiersty M.	5, 76	Mitchell, Roger H.	19
Lee, Seung-Gu	49	Malcolm, Alison	7, 59–60, 107	Miyashita, Tetsuto	123
Legault, Marc	45	Mali, Brahim	76	Mloszewski, Aleksandra	84
Legros, Hélène	87	Mallory, Leanne	47	Mogk, David W.	26
Leitch, Alison M.	70	Maneta, Victoria	45	Momenipour, Sara	84
Lentz, David	9, 68, 70, 77, 89, 104–105, 113, 140	Marcelo Alejandre, Gema	111	Montreuil, Jean-Francois	67
Leroy, Ernie	70	Mendoza Marin, Daniela	41, 54, 119	Moore, Laura	40
Leslie, Louise	70	Markham, Keaton	76	Moore, Lyndsay	22, 84–85
Leung, Eunice Chit Yan	71	Marshall, Alfred	70	Moorehead, James	131
Lewis, David	63, 71	Martel, Edith	97	Morgan, Chad A.	85
Leybourne, Matthew	14, 20, 56, 84, 91, 105	Martínez Catalán, José Ramón	114	Morgan, Nathan	15
Li, Steven	104	Martínez-Benítez, Blanca	77	Morrill, Penny L.	91, 98
Li, Wenxuan	71	Martins, Tania	18, 33, 70, 77, 79, 104–105, 111, 113	Morris, William A.	1
Lian, Olav	106	Marzoli, Andrea	8	Moukhsil, Abdelali	1, 3, 13, 76, 100
Ligi, Marco	16–17	Matheson, Edward	15, 78	Moynihan, David	86
Lin, Shoufa	52, 71–72, 133, 138	Mathieu, Guillaume	45, 99	Moysiuk, Joseph	86, 121
Linnemann, Ulf	9, 41, 72, 81, 94, 141	Mayeesha, Anika	79	Mukherjee, Shreya	52
Linttell, Margaret	84	Nawar	71	Müller, Thomas	71
Liu, Jiahui	69	McBeth, Joyce M.	71	Mungall, James	33
Liu, Yan	19	McCausland, Phil	37, 49, 81, 96, 98, 132	Murphy, Brendan	86, 114, 132
Livak, Josephine	128	McClelland, William C.	79	Musajo, Claire	26, 101
Llana-Fúnez, Sergio	73	McClenaghan, Beth	22, 94, 107	Musiyachenko, Kira A.	87
Lombardi, Matthew	73	McCurdy, Martin	3	Mvondo, Hubert	131
Long, Darrel G.F.	117	McFarlane, Chris	9, 68, 77, 79, 113	Myers-Pigg, Allison	142
Long, Maureen	135	McIsaac, Ken A.	37	N	
Lopez-Fernandez, Carlos	73	McKeen, Dylan	128	Naber, Tiera	87
Lowe, David G.	21, 26, 45–46, 50, 55, 57–58, 74, 80, 83, 119	McKeough, Rachel	80	Nambaje, Claude	79
Loxton, Jason	78	McLeish, Duncan F.	80	Nance, R. Damian	86, 114
Lucas, Spencer	47, 116, 123	McLoughlin-Coleman, Thomas R.	117	Narbonne, Guy M.	37
Luijendijk, Elco	101	McMartin, Isabelle	75	Naulot, Rémi	87
Lussier, Aaron J.	51, 74	McNutt, Stephen R.	80	Navarro, Lilian	88
Lutfi, Wasiq	75	Melymuka, Natasha E.	81	Nawaz, Muhammad	88
M		Mende, Katja	72, 81	Nelsen, Julia	7
MacDonald, Kathryn	75	Menzies, John	95	Nelson, Lyle	98
		Mercier-Langevin, Patrick	85	Neves, Barbara de Moura	8
				Neyedley, Kevin	50
				Ngoran, Gilles	68, 89
				Nguyen-Ridgway, Hoang Anh Tu (Lavie)	32, 89, 124
				Nicholson, Alexander	109

Nigussie, Wubamlak	89	Pehrsson, Sally	32, 54, 67, 82, 97, 103	Rasbury, E. Troy	79
Nobre Silva, Inês G.	8	Percival, Jeanne B.	97	Rayner, Nicole	54, 119
Norman, Lauren	90	Perez-Huerta, Alberto	26	Rayner, Nicole M.	36
Novak, Daniel	90	Pérez-Varela, F.	36	Regis, Daniele	97
Novotná, Nikol	21	Peron-Pinvidic, Gwenn	3	Reguir, Ekaterina	19
O		Perrot, Morgann	3, 42, 101, 122	Rehm, Adrian	105
O'Brien, John	8	Peter, Jan	56	Rehman, Shumyla	105
O'Driscoll, B.	41, 51, 73, 95, 124, 131	Peters, Kristi	97	Reusch, Douglas	29
O'Neil, Jonathan	90, 92	Petersen, Emma	98	Reynolds, Merilie	125, 135
O'Neill, Maria	93	Petersen, Uni	142	Rice, Jessey	3, 17, 94–95, 106–107
Obst, Karsten	81	Petts, Duane	20, 85	Richard, Danny	108
Odlum, Margo L.	79	Peeverelli, Veronica	133	Richard, Keenan	116
Oeur, Arielle	90	Phethean, Jordan	43	Richter, Philipp	81
Offin, Sasha	91	Philben, Michael	127	Rieders, Nathaniel	26
Oguntuyaki, Tímilehin A.	91	Phillips, Logan	98	Rivers, John M.	25
Ojala, V. Juhani	92	Piazolo, Sandra	71	Rizo, Hanika	92
Oller, B.	41	Pierce, James	98	Rizza, Magali	5
Olona, Javier	73	Piercey, Stephen	2, 5, 36, 99	Roberts, Daniel	133
Onstad, Courtney	93	Pietruszka, Dorota K.	99	Roberts, Nick M.W.	33
Ordóñez Calderón, Juan Carlos	11, 14	Piilonen, Paula C.	74	Roddatis, Vladimir	62
Orlóci-Goodison, Ruth	52	Pilote, Claude	85	Rode Juhl, Christian	135
Ornelas Marques, Fernando	59	Pinet, Nicolas	42, 99, 122	Rodriguez Duran, Ivan	106
Ortiz-Chaparro, Miguel	93	Pingitore, Federico	100	Roebuck, J. Alan	142
Osfolk, Kari	22	Pinon, Héloïse	26, 101	Roglic, Martin	106
Ovtcharova, Maria	94	Pinti, Daniele	42, 45	Rojo-Perez, Esther	94
P		Pinto, Taís F.	101	Romppanen, Sari	84
Pabst, Thomas	69	Pippy, Ryan	102	Rooks, Curtis	37
Padgett, Joel	101	Plante, Benoît	69	Roozen, Stan	128
Paktunc, Dogan	11	Pluister, Emma	102	Roque, Ben	107
Palacios, Teodoro	77	Poduska, Kristin M.	98, 102	Rosener, Michel	107, 137
Panasiuk, Sofia	4	Poirier, Glenn	74	Rospabé, Mathieu	19, 53
Pando, Luis	73	Poirier, Justin	24	Ross, Carly	26
Papangelakis, Elli	29–30, 68	Pospiech, Solveig	84	Ross, Martin	107
Park, Adrian	60, 123	Powell, Jeremy	102	Ross, Pierre-Simon	76
Park, Jeffrey	39	Power, Randal	107	Rosselot, Renee	105
Partin, Camille	16, 18, 33, 43, 94, 111, 118	Prevec, Stephen	103	Rossiter, Steven	60, 84
Pattison, David	62	Priddell, Taggart	103	Rottier, Bertrand	3, 12–13, 31, 35, 66–68, 87, 100, 106, 108
Paulen, Roger	3, 17, 94–95, 106–107, 116	Prigent, Cécile	81	Rousseau, Moïse	23
Paulic, Ben	95	Provencher, Marie-Eve	106	Roy, Shreya	108
Paz Jaramillo, Carolina	95	Pufahl, Peir	15, 56	Roy, Swaraj	108
Peace, Alex	1, 29–30, 49, 66, 96	Pujana, Ignacio	105	Rozenbaks, Peteris	49
Peace, Alexander	68	Q		Rule, Roy	109
Pearson, D. Graham	20, 126	Qadri, Talha	101	Ruscica, Phillip	109
Pecharromán, Carlos	111	Qiao, Li	122	Ryan, James	60, 97, 126
Peddle, Cameron	56, 90, 111	Quénéa, Marie	103	Rygel, Mike	116
Pedemonte Castro, Giovanni	108	Quesada, Cecilio	2	S	
Pedersen, Per K.	39–40	Quinton, Page	116	Sabarinathan, Jayshri	37
Pedreira Pérez, Rocio	96, 103	Quist, Brynn A.	132	Sack, Patrick	18
Pedreira Pérez, Rocío	42	R		Sagawe, Anja	41
		Reimink, Jesse R.	122	Saha, Deepyaman	5
		Rader, Shelby T.	56	Salman, Md Abdullah	110
		Radisic Hoang, Maja	104	Samaradiwakara, Sisara	110
		Rafeeza, Muhammad	34	Samolczyk, Mary A.	24
		Rahabi, ZaneAldeen	104–105	Sánchez-Muñoz, Luis	110–111
		Rainbird, Rob	117, 136		
		Ramezani, Jahandar	125		

Sandeman, Hamish	15, 30, 56, 90, 96, 111–112, 119	Slaney, Noah	50, 55, 119	Thalenhorst, Henrik	18
Sanfilippo, Alessio	16	Slater, Greg	120	Therriault, Isabelle	125
Santos, Ana Cláudia	18, 33, 111	Slotznick, Sarah P.	117	Thiessen, Eric	15, 44, 122
Santos, G.S.	41, 112	Smit, Matthijs	45, 87	Thompson, Margaret D.	9, 125
Santos González, José Ignacio	110	Smith, Darren L.	120	Thompson, Mira	32, 126
Sarim, Muhammad	112	Smith, I. Rod	135	Thorne, Kathleen G.	9, 140
Sarkar, Chiranjeeb	20	Smith, Lucy	116	Tian, Jianwei	7
Sarkar, Shramana	113	Smith, Richard	121	Tilhac, Romain	11
Sati, Manju	113	Smith, Rod	138	Timmerman, Suzette	126
Saumur, Benoit	28, 96	Smith, William D.	53	Ting, King King	98
Savard, Dany	66	Smyrak-Sikora, Aleksandra Anna	69	Tinkham, Doug	11, 14, 105
Sayles, Matthew	113	Snider, Urgan J.T.	86, 121	Tivey, Maurice	40
Scanlan, Emma	91	Snyder, Mo	76, 78, 135	Tollefson, Kyle	126
Schaarschmidt, Maria	106	Soejono, Igor	21	Tomacic, Jessica M.	97
Schaltegger, Urs	114	Sokol, Krzysztof	37	Tominaga, Masako	40
Scheffler, Johannes	114	Sole, Christian	92	Törmänen, Tuomo	84
Schiffer, Christian	43	Soltanmohammadi, Azam	11, 16–17, 20, 76	Toro Vivanco, Diego I.	126
Schindler, Michael	62, 110	Sommers, Matthew J.	85	Trefry, Devin	47
Schmidt, Patrik	120	Sonmez, Safak	134	Tremblay, Alain	26, 101, 127
Schmitz, Mark	37	Sönmez, Şafak Utku	121	Tremblay, Jonathan	127
Schofield, Marina	30	Sørensen, Bjørn Eske	69	Tsay, Alexandra	100
Schoonover, Erik	122	Sorger, Dominik	71	Tschirhart, Victoria	102
Schreiber, Anja	62	Soucy La Roche, Renaud	1, 13, 35	Turner, David	97
Schulmann, Karel	114	Sparkes, Greg	17, 83	Turtle, Samantha	127
Schwangler, Martin	114, 133, 138	Spence, Eleanor	123	Tutolo, Benjamin M.	7
Scoates, James	10	Spencer, Chris	37, 102, 116	U	
Scoates, James S.	115	Spinaci, Alessandro	122	Ugalde, Hernan	1
Scoates, R.F. Jon	115	Sproat, Colin	86, 122	Unger, André	138
Scoging, Victoria	115	Standjofski-Figolls, Livia	42	Uthup, Sam	117
Scorsolini, Ludovico	54, 115, 137	Standjofski-Figols, Livia	122	V	
Scott, Margaret	116, 123	Steele-MacInnis, Matthew	115, 118	Valverde-Vaquero, P.	36, 128
Sears, Gorman	65	Stephan, Tobias	34, 101, 123	Van der Flier-Keller, Eileen	93
Seguin-Gravelle, Isabelle	116	Stepner, Dan A.J.	92	Van Hinsberg, Vincent	42, 45, 62, 128
Serdyuk, Alena	129	Stern, Robert	20, 105	Van Rooyen, Deanne	9, 13, 21, 58, 128
Serna Ortiz, Santiago	74	Stimson, Matt	47, 116	van Staal, Cees	9, 71, 115, 128–129, 133, 137, 140
Seymour, Carol	137–138	Stimson, Matthew	123	Van Wagoner, Nancy	91
Sharpe, Ryan	50	Stix, John	85	Vanardois, Jonas	27, 129
Sharpe, Stewart	107, 137	Stracke, Andreas	126	Vasyukova, Olga	129, 131
Shaw, Colin A.	26	Strauss, Justin V.	79	Veinberg, Stanislav L.	37
Shaw, Richard	33	Strongman, Keaton	40	Verard, Christian	20
Shawwa, Nabil A.	117	Strowbridge, Susan	15, 124	Verhoest, Léna	17
Shellnutt, J. Gregory	117	Sudo, Masafumi	137	Verpaelst, Pierre	122
Sheppard, Arianna F.	117	Sun, Henry	26	Vervoort, Jeff	126
Sherlock, Ross	52	Sylvester, Jason	70	Viete, Daniel R.	43
Shillito, Anthony	118	T		Villeneuve, Michel	130
Shrestha, Sudip	47	Talla Takam, Francis	1	Vogt, Peter R.	130
Shugar, Aaron	102	Tamblyn, Renée	27, 69	Voinoit, Alexandre	14, 22, 84, 130
Silva, Ricardo L.	46, 58, 86, 121	Tarazona, Cesar	124	Voisard, Abby	131
Simmons, Jack	11, 14	Tarkyth, Dene	32, 89, 124	Volynets, Anna	131
Simoneau, Jacques	31	Tchomugna Kamleu, Dolvan	125	Voss, B.D.	131
Sinclair, Iain K.	132	Terlaky, Viktor	101	W	
Skeard, Janelle	118			Wach, Grant	88
Skipton, Diane	54, 118–119				

Waghorn, Kate	107, 132	White, Chris E.	9, 13, 58, 128	Yeo, Isobel	40
Wakabayashi, John	20, 132	White, Jacob A.	135	Yip, Ivan Cheuk Yin	54, 112
Waldron, John W.F.	114, 132–133, 138	White, Shawna	1, 76	Young, Graham A.	47
Walker, Richard J.	95	Williams, Henry	136	Young, Thomas	54, 139
Walker, Sharon	40	Williams-Jones, Anthony	80, 129, 131	Youngchief, Kayla	78
Wall, Corey	21, 133	Williamson, Marie-Claude	73, 136	Yousefi, Fazilat	139–140
Wang, Chenlu	120	Williamson, Nicole M.B.	10	Yu, Chenying	138
Wang, Lijun	133	Willner, Arne P.	137	Yun, Louis Jia-wei	140
Wang, Wei	52	Wilton, Derek	137–138	Z	
Wang, Xiao	52	Wirth, Richard	62	Zagorevski, Alex	140
Wang, Yumeng	134	Wise, Michael	70	Zagrtdenov, Nail	11
Warnock-Juteau, Trystan	123	Woodland, Sarah	20, 126	Zajacz, Zoltan	100
Wasilewski, Benjamin	92	Worthington, Quinn	24	Zak, Jiri	86
Waterton, Pedro	52	Wray, Nicholas	52	Zamparas, Christoforos	141
Webb, A. Alexander G.	71	Wright, David	86	Zhang, Jian	52, 138
Webb, Shane	121, 134	Wu, Qihang	52, 138	Zhao, Guochun	52, 138
Weging, Sylvia	135	Wylezol, Paul	133, 138	Zieger, Johannes	41, 72, 81, 94, 141
Weis, Dominique	10, 133	X		Zieger-Hofmann, Mandy	41, 72, 81, 94, 141
Welford, J. Kim	3, 7, 60, 89, 96, 107, 132, 135	Xiao, Shuhai	37	Ziegler, Susan	127, 142
Wertich, Vojtěch	84	Y		Ziska, Heri	142
Westrop, Stephen R.	24	Yakymchuk, Chris	64, 71, 115, 138–139	Zúñiga, Javier	111
White, Chris	60	Yang, Xue-Ming (Eric)	139		