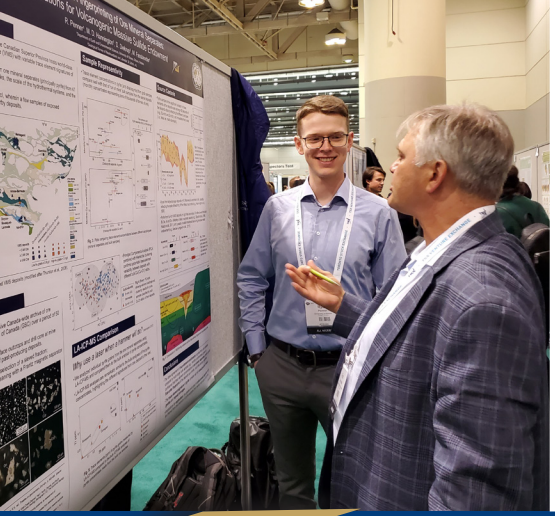


15th annual

PDAC - SEG

Student Minerals Colloquium

POSTER EXHIBIT

MARCH 3 - 6, 2024

Metro Toronto Convention Centre (MTCC)

PDAC

PROSPECTORS & DEVELOPERS ASSOCIATION OF CANADA

SOCIETY OF ECONOMIC GEOLOGISTS FOUNDED 1920

Laurentian University Université Laurentienne

HARQUAIL School of Earth Sciences École des sciences de la Terre

METAL EARTH

MERC Mineral Exploration Research Centre at the HARQUAIL School of Earth Sciences

Meet the students and discuss their research on

Tuesday, March 5, 10:00 a.m. - 12:00 p.m.

The Student Minerals Colloquium (SMC) brings together geoscience students and industry professionals at the annual Prospectors & Developers Association of Canada Convention.

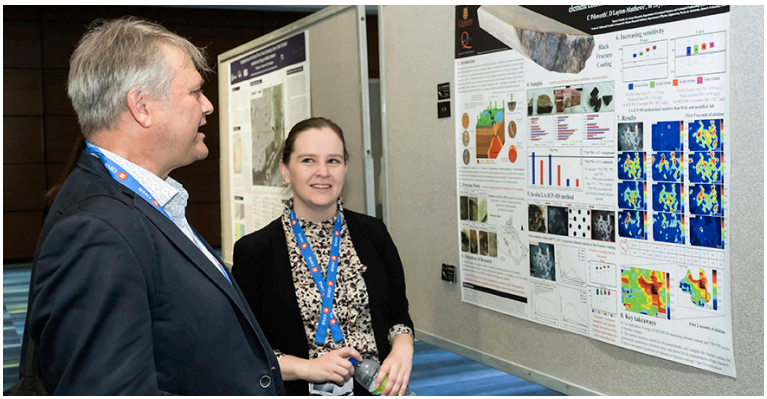
The Colloquium highlights student research focused on innovative projects essential for the successful evolution of the modern mining industry. Since 2009, this event has featured more than a thousand presentations from BSc, MSc, and PhD students studying mineral deposits and related disciplines such as mineralogy, geophysics, geochemistry, hydrogeology, and sedimentology, to name a few. It provides industry professionals with an unparalleled opportunity to discover and support student research related to the mining industry.

None of this would be possible without continued support from our volunteer judges and generous funding from our named sponsors, the Prospectors & Developers Association of Canada (PDAC) and the Society of Economic Geologists (SEG). We also would like to thank past sponsors and volunteers who have contributed to our success, and to this year's sponsors and student organizers, from the Mineral Exploration Research Centre, Metal Earth, and the Harquail School of Earth Sciences at Laurentian University.

This year, we are pleased to showcase 87 participants from 30 universities across 12 countries. Judges will select nine winners (1st, 2nd, and 3rd) from in-person poster presentations at the BSc, MSc, and PhD Levels.

Poster judging for the PDAC-SEG Student Minerals Colloquium will take place from **10:00 am - 12:00 pm on Tuesday, March 5,** followed by an **awards ceremony and reception** from **3:30 pm - 5:00 pm in Room 203D**.

*For details about this year's event, news and announcements, past winners, and more, visit **merc.laurentian.ca/seg-smc**.*



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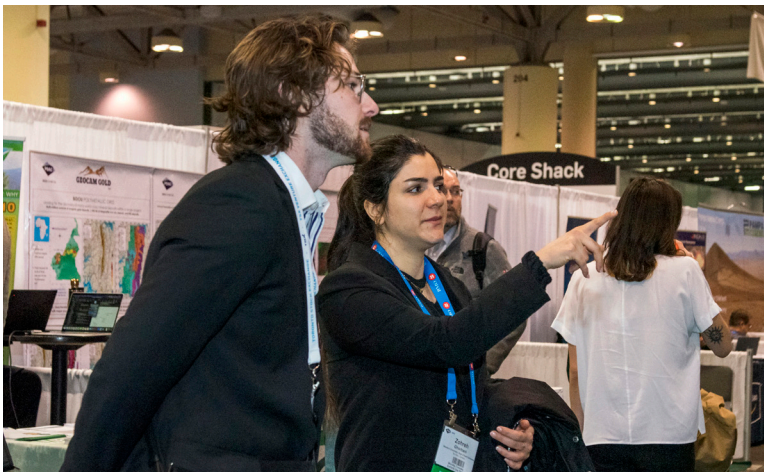

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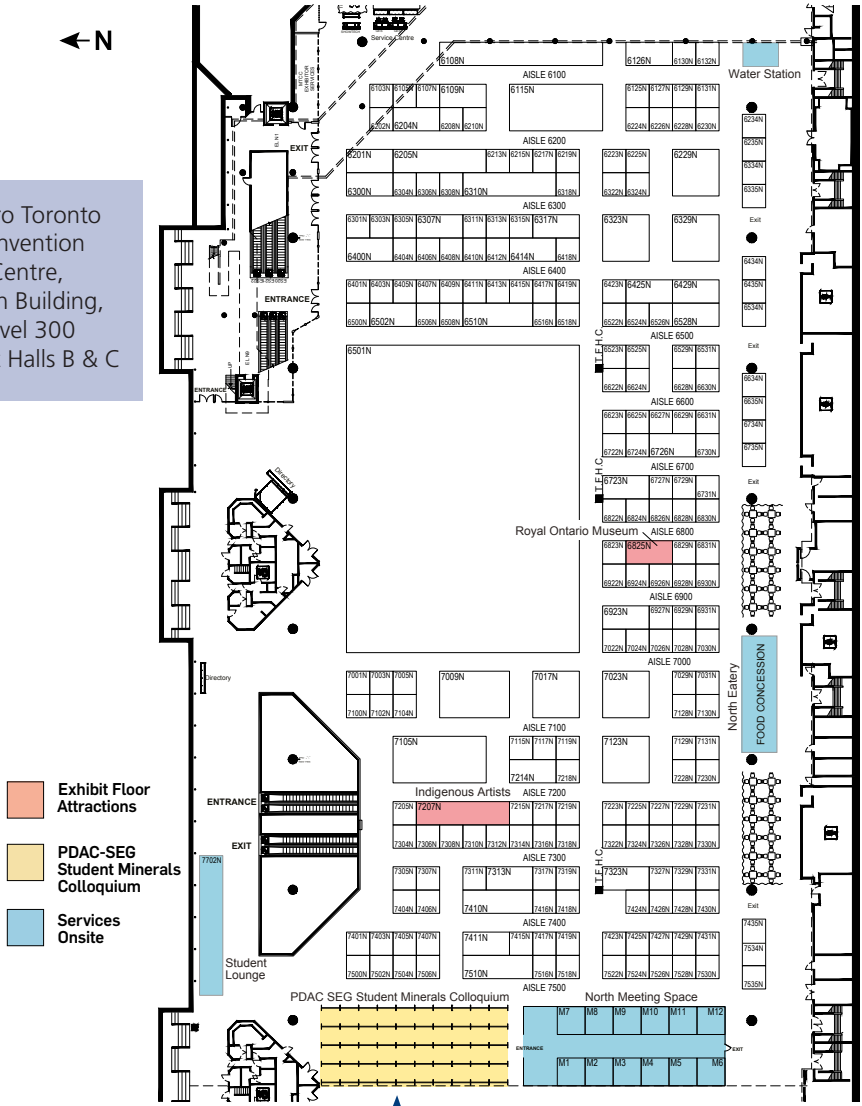

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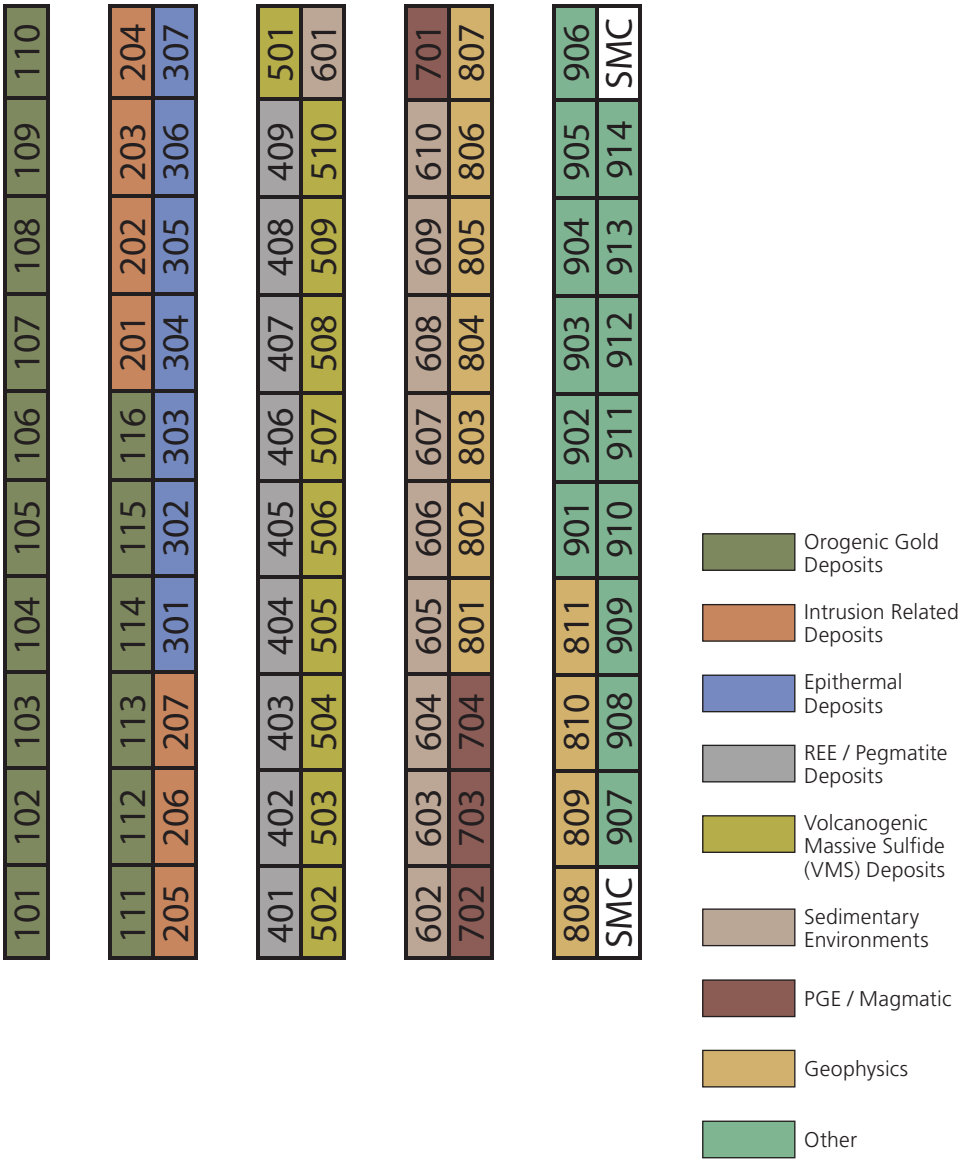
SMC Exhibit Location

The poster exhibit for the 15th Annual Student Minerals Colloquium is located in the **Trade Show North, Hall B.**

Poster Locations



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Abstracts

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Structural Controls of the Ayanfuri gold deposit of the Paleoproterozoic Kumasi basin in Ghana: Evidence from pit mapping on RL 1020m.

T.K. Agbenyezi[1], K. Adomako-Ansah[2], G. Foli1, S.K.Y. Gawu[1]

[1]Department of Geological Engineering, Kwame Nkrumah University of Science and Technology (KNUST), PMB University Post Office, Kumasi, Ghana; [2]Department of Geological Engineering, University of Mines and Technology, P.O. Box 237, Tarkwa, Ghana

The Ayanfuri deposit is the earliest notable occurrence of gold-bearing granitoid in the Birimian of Ghana, West Africa. The deposit hosts > 9 Moz total aggregate gold with auriferous intrusions mainly of granodiorite composition contributing about 80% of total endowment. Gold mineralization within steep shear zones of the metasedimentary country rock also contribute to the gold endowment in the region. Litho-structural mapping has become necessary at lower mining levels in bedrock to ascertain structural fabrics and deformation history established within saprolite material. Detailed mapping was carried out by measuring and recording all planar and linear elements observable on the steep pit walls with a scale of 1:2000. Pit mapping displays a plethora of structures resulting from the superposition of three generations of structures (D_1, D_2, D_3). D_1 is expressed by a bedding-parallel foliation (S_1) involving a thin-skinned tectonic event. D_2 records a NW-SE shortening and resulted in regional upright folding and development of a penetrative regional S_2 foliation and steep brittle-ductile faults recording evidence of reverse and strike slip displacements within the metasedimentary country rocks. D_3 deformation resulted in the formation of conjugate EW- and NW-trending steep crenulation cleavages and minor folds of the primary layering, S_1 and S_2. Within the intrusives, series of NE trending faults developed in response to the D_2 deformation; they are sub-parallel or at a low angle to the NE-trending narrow shear zones of the metasedimentary. These faults recorded reverse, reverse-oblique and strike slip movements as the results of multiple tectonic reactivations. Third order structures are NW, WSW-, EW- and WNW-trending, low angle, south-verging thrust faults that crosscut obliquely the second order structures and contain very significant gold mineralization. Veins within the deposit are controlled by the geometry and orientation of structures hosting them. V_1 veins are bedding parallel quartz carbonates veins that are deformed and folded and clearly postdate mineralization. V_2 are quartz-carbonates-sulphide veins sub-parallel to S_2 foliation and the steep NE shear zones. V_3 veins are predominant within the intrusive body. They trend NW and crosscut earlier planar structures and veins. Structural mapping at lower mining level (i.e. 1020mRL) resonates with earlier findings of the Ayanfuri deposit.

102 **Ryan Barkley - MSc**
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The Kinematics and Geochemical Footprint of the Eagle River Gold Deposit in Northwestern Ontario

R. Barkley[1], N. Phillips[1], P. Hollings[1]

[1]Geology, Lakehead University, Thunder Bay, Ontario, Canada

Wesdome Gold's Eagle River mine, a 2.7 Ga Neoarchean orogenic gold deposit, is hosted in the Mishibishu greenstone belt of the Wawa subprovince, approximately 50 km west of Wawa, Ontario. At the end of 2021, the Eagle River Mine had produced 7.4 Mt of ore, averaging

9.86 g/t Au, yielding 1.5 M ounces of gold. A series of techniques have been used to investigate the geological setting, kinematics, and geochemical footprint of alteration at the Eagle River deposit, including detailed structural field mapping, petrography, whole-rock geochemistry, Sm-Nd isotope analysis, macro and microstructural analysis of shear zones and faults, U-Pb geochronology, EBSD mapping of quartz grains and Ti-in-quartz geothermometry.

Trace element chemistry of near-mine field samples distinguished two suites. The first suite consists of calc-alkaline basalt, andesite, dacite, rhyolite, diorite, and granite. It is characterized by enriched La/Smn ratios of 2.06 to 6.83 and negative Nb anomalies (Nb/Nb* of 0.09 to 0.43), consistent with magmas formed in a supra-subduction environment. Suite two consists of tholeiitic basalt and basaltic andesite. This suite is characterized by flatter trace element patterns with La/Smn ratios of 0.83 to 1.48 and minor Nb anomalies (Nb/Nb*of 0.40 to 0.85), consistent with primitive arc tholeiites.

The Eagle River mine and area has undergone a regional D_2, N-S directed, shortening event that produced a well-defined, E-trending, S_2 regional foliation that dips at 75° to the NE. The major vertical movement along the Eagle River Mine shear zone is interpreted to have occurred during this compressional event. The deposit is associated with a simple shear-dominated, transpressional, high-angle reverse shear zone. Gold mineralization occurs in sub-vertical to steeply north dipping, east-west striking, lenticular, dynamically recrystallized quartz veins with grain boundary migration microstructures indicating a high temperature and low-stress environment. The quartz veins include a strongly developed stretching lineation that plunges down dip at 75° to the NE. This detailed approach of analysis helps us understand the transpressional kinematics of the Eagle River deposit and its geochemical footprint.

103 Eve Carrothers - BSc
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The pyrite trace element chemistry of the Crestaurum gold deposit, NWT

E. Carrothers[1], D. Gregory[1]

[1]Department of Earth Sciences, University of Toronto, Toronto, Ontario, Canada

Here we investigate the shear-zone hosted Crestaurum gold deposit near Yellowknife, NWT. The study focuses on the analysis of ore petrology, and LA-ICPMS analysis of trace element chemistry of samples near and distal to the Crestaurum deposit to assess the feasibility of using pyrite trace element chemistry as a tool for exploration. The gathered data will then be utilized to identify differences in trace element content between pyrite at the Crestaurum deposit to other deposits, such as the Con and Giant mines along the Yellowknife Greenstone Belt, to inquire how their hydrothermal interactions may be related. Additionally, the chemical characteristics of mineralized pyrite will be compared with databases containing information on non-mineralized (barren) pyrite and other pyrite associated with other ore deposits. The aim is to identify significant differences in trace element content between mineralization associated pyrite at the Crestaurum deposit and other pyrite samples. This comparative analysis will offer insights into whether detrital pyrite found in glacial till could potentially serve as a tool for guiding exploration towards similar deposits in the region.

104 **Antoine Cuckovic - PhD**
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Soil-Gas geochemistry applied to the exploration of sulfide mineralized zones and faults localization in the Abitibi-Témiscamingue and Appalachians

A. Cuckovic[1], M. Richer-LaFlèche[1], L.Z. Cheng[2], J. Moorhead[3], E. Allard[4], P. Riopel[5], C. Blanchet[6], M. Guay[6]

[1]INRS, Quebec City, Quebec, Canada, [2]UQAT, Rouyn-Noranda, Quebec, Canada; [3]MRNF, Val-d'Or, Quebec, Canada; [4]Leopard Lake Gold Corp, Langley, British Columbia, Canada; [5]Globex Mining, Montreal, Quebec, Canada; [6]Vior inc., Montreal, Quebec, Canada

The research project focused on a multidisciplinary exploration method, including soil-gas geochemistry and geophysics, targeting the exploration of sulphide mineralized zones masked by Quaternary deposit covers (overburden). The first part of the project consists by detecting the presence of orogenic gold mineralizations by soil-gas geochemistry, and verifying the presence of carbonate alteration zones in the footwall of these mineralized zones. The second part of the project consists in locating, the presence of faults or other structural discontinuities also masked by the Quaternary deposits. The detection of the sulfides and carbonate alterations is based on the analyses of gases, such as SO_2, H_2S, CH_4S, CS_2, AsH_3, CO_2, O_2, H_2 and CH_4 sampled in the vadose part of soils. Field studies were realized on the sites of gold deposits and showings from the Abitibi Greenstone Belt, in the regions of Duparquet, Cadillac, Malartic, Val-d'Or and from the Temiscamingue area in the regions of Belleterre and Laverlochere-Angliers. Surveys have also been carried out on porphyry polymetallic mineralizations in the southern Appalachian Mountains (St-Robert area).

In Abitibi, the mining sectors of Duparquet, Malartic, Val-d'Or and Louvicourt were studied to document the soil-gas geochemistry along kilometric sections intersecting the Porcupine Destor, Parfouru, Villebon faults and the Cadillac tectonic fault zone area. The geochemical survey of detection of faults will be completed in 2024 by the analysis of radon, thoron and helium. Those gases are very sensitive to the presence of major structural discontinuities. The interpretation of the soil-gas geochemical data will be linked to gravimetric, magnetic and audiomagnetotellurique (AMT) data, in order to check the bedrock anisotropy in the sectors of interest. Our integrated method of prospecting, presented in this study, is efficient, cost effective,relatively simple using and very useful to prioritize electrical chargeability anomalies from IP surveys which are very often associated with sulfide baren sources (graphite, clays, anthropogenic EM noises). Such discrimination method should make it possible to optimize exploration work by reducing drilling costs. In addition, the proposed exploration method could be used in direct field exploration despite the absence of geophysical data.

105 **Chaoyi Dong - PhD**
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Control of crustal deformation on orogenic Au mineralization in Himalaya: a case study from Buzhu

C.Y. Dong[1,2], D.D. Gregory[2], Q.F. Wang[1]

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The Buzhu Au deposit in the Himalaya orogen, witnessing Cenozoic uplift of the Himalaya, provides a window to study the control of crustal deformation on Au mineralization. The Au mineralization is characterized by quartz veins controlled by an extensional fault system, comprising E-W-trending shear zones/faults and superposed N-S-trending normal faults. The vein system witnessed three deformation stages, stages I and II occurred in shear zones, and stage III developed in normal faults. The deformation comprises hydraulic brecciation in stage I and crack-sealing processes during stage II shear deformation in the brittle-ductile transition, followed by solution breccias progressively crosscut by veins in newly-formed normal faults in stage III. Stages I and II contain invisible-Au-dominated sulfides, while native Au and pyrrhotite formed in stage III.

Blocky quartz with oscillatory and sector zoning patterns implies fluid pressure build-up processes in stage I. Pyrite displays coupled Au-As variation, high Au contents (<19 ppm), and restricted $\delta^{34}S$ values (-3.6 to -2.4‰), supporting that fluid-rock reaction was responsible for Au precipitation. Elongated quartz of stage II displays contrasting bright and dark cathodoluminescence bands with corresponding high and low Al-Li concentrations, indicating fluctuating fluid pressure. Pyrite shows a negative correlation between Au (<45 ppm) and $\delta^{34}S$ values (5.4 to 1.7‰, from cores to rims), consistent with fluid oxidation associated with a fluid pressure drop. Minor late quartz in open spaces transected earlier quartz, implying the hydrothermal system dropped to near hydrostatic conditions. The partial replacement textures of pyrite and arsenopyrite from stage III, with varied $\delta^{34}S$ values (5.9 to 9.3‰), and the existence of micro-inclusions and visible Au along the contact, suggest a fluid-mediated dissolution-reprecipitation process. From this rare window into the Au-mineralized young orogen, it can be demonstrated that mineralization occurred as the hydrothermal system transitioned from the relatively ductile to brittle domain, with varying Au precipitation mechanisms.

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Superimposed mineralization at the Archaean Troilus Gold-Copper Deposit, Quebec. The role of evolving mineralization in building a world-class gold deposit

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The Troilus gold-copper deposit in northern Quebec is situated in the eastern limb of the Frôtet-Evans greenstone belt, Opatica Subprovince, Superior Province, Canada. This Archaean low-grade, high-tonnage deposit hosts gold-copper mineralization with a weakly polymetallic signature and is currently in the advanced exploration stage. Current resource estimates of the Troilus deposit confirm an indicated 11.21 million ounces (Moz.) gold equivalent, with past production totalling 2 Moz. gold and 70,000 tonnes copper.

The deposit lies within a structural corridor of deformed volcano-plutonic rock capped by late tectonic granite intrusions. Mineralization is centred around a dioritic intrusion bordered by intermediate to mafic volcanics crosscut by felsic dikes. Characterization of the deposit has been hindered by the scale of the deposit, geographic variability of mineralization, and complications attributed to syn-tectonic reworking of ore phases.

This work seeks to constrain the physico-chemical conditions of ore formation and understand the behavior of metals during transportation and deposition with the aim of developing an internally

consistent genetic model for the Troilus deposit. To achieve these goals, a multi-technique analytical program was employed using petrographic analysis, electron probe microanalysis (EPMA), quantitative fluid inclusion gas analysis mass spectrometry (QFIGA-MS), and both synchrotron radiation and laboratory micro-X-ray fluorescence imaging (μXRF).

Four geochemically distinct, superimposed stages of mineralization were identified in ore grade mineral assemblages collected from the Troilus deposit. In relative chronological order these stages are, 1) early deformational intrusion related gold-copper mineralization, 2) prograde syn-deformational orogenic gold-copper mineralization, 3) retrograde syn-deformational orogenic gold mineralization, and 4) late deformational gold-REE mineralization. Stages 1 and 2 represent initial metal endowment and subsequent remobilization of mineralization under primarily ductile, greenschist-amphibolite conditions. Ore assemblages are characterized by a magmatically derived signature, hosting reduced assemblages of chalcopyrite-pyrrhotite-sphalerite±electrum-silver-acanthite-cubanite-pentlandite-molybdenite. Stage 3 represents gold endowment during cooling under semi brittle, greenschist conditions. Gold occurs in quartz-chlorite veins crosscutting the regional foliation. Stage 4 hosts late gold-REE mineralization under more oxidizing conditions with likely addition of fluids sourced from nearby granites. Gold fineness calculated using EPMA identified three distinct populations of gold from the Troilus deposit; 1) moderately altered intrusion related gold mineralization (400-825), 2) heavily remobilized intrusion related gold mineralization (0-350), and 3) stage 3 and 4 gold mineralization (>900). QFIGA-MS and petrography indicate condensation and sulphidation as principal mechanisms of gold deposition. The results of this study indicate that the current metal endowment of the Troilus deposit is the result of an evolving mineralizing system.

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The Archean Ulu gold deposit: An early structurally overprinted and metamorphosed gold deposit in the High Lake greenstone belt, Nunavut

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Controls on mineralization in metamorphosed and deformed gold deposits are often cryptic because primary textural and structural features, commonly observed in lower-grade metamorphic environments, may be absent or obscured. The Ulu gold deposit is the largest gold deposit within the High Lake greenstone belt (HLGB) in the Archean Slave Craton; approximately 523 km north-northeast of Yellowknife, Northwest Territories. Ulu is hosted in amphibolite facies mafic metavolcanic rocks and has been overprinted by multiple deformation events. A NNW-plunging F_2 anticline is the dominant structural feature and is defined by geochemically distinct volcanic units and sedimentary units. Field mapping identified a NW-trending fault along the west limb of the anticline. The fault shows a sinistral offset of ~200 m manifested by abrupt changes in the thickness of volcanic units across the fault. The latter is cut by a gabbroic syn-volcanic dyke suggesting that the fault is also syn-volcanic. The Flood Zone, which is the main mineralized zone at the Ulu deposit, lies along the fault. Gold mineralization occurs as free gold and is associated with acicular arsenopyrite in intensely silicified and brecciated volcanic rocks, surrounded by a metamorphosed calc-silicate and biotite alteration envelope. The axial-planar S_2 foliation of the anticline overprints the Flood Zone, suggesting that alteration and mineralization either predated or formed early during the formation of the anticline. The zone was subsequently overprinted by

open F_3 folds that developed syn-peak metamorphism. These observations collectively suggest that the formation of the Flood zone was controlled by the reactivation of a syn-volcanic structure either early during the D_2 event or before the D_2 event, and was then metamorphosed during an amphibolite facies metamorphic event that coincided with the formation of D_3 structures.

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Structural architecture of mineralized veins in a Cenozoic orogenic gold deposit along the North Cycladic Detachment System, Greece

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The Kallianos Au-Ag-Te deposit, located on southern Evia island in the NW Aegean Sea, is a Cenozoic orogenic gold deposit hosted in carbonate-epidote-phlogopite schists and phlogopite marbles of the Cycladic Blueschist Unit (CBU). Fluids that generated the deposit were channelized by a crustal scale post-orogenic extensional structure, the North Cycladic Detachment System (NCDS), which facilitated Miocene exhumation of the CBU into the brittle crust. Whereas ore deposits in the Cyclades have been broadly related to late Miocene granitic intrusions, magmatism of this age is notably undocumented on Evia. Field observations illustrate the connection between the structural architecture hosting mineralization and deformation associated with the post-orogenic structures, refining the paragenetic model for Cenozoic gold deposits in the Cyclades. Mineralized veins, alongside unmineralized tension gashes, faults, conjugate faults, and joints, occur in parallel sets that locally define en echelon arrays. Younger sub-vertical tension gashes cross-cut older boudinage mineralized veins. The vein orientations of the Kallianos deposit trend NW-SE and NNW-SSE, which is generally orthogonal to the sub-horizontal ~NE stretching lineations related to crustal extension and thinning accommodated by the NCDS. Brittle-ductile kinematic indicators such as shear bands exhibit top-NE displacement, consistent with footwall deformation related to the NCDS documented elsewhere along strike of the detachment. The two populations of vein orientations are not evident based on structural data alone, but field observations show clear cross-cutting of the earlier NW-striking vein set by later NNW-striking veins. The mineralization is hosted in subvertical mm- to m-scale veins composed of quartz, calcite, albite, with minor titanite and epidote and notable sulfide mineralization including pyrite, galena, chalcopyrite, bornite and hematite concentrated in cm-scale veins. Obvious native Au and Ag are not observed in the veins. NNW-striking vein sets contain significantly more albite and mineralization than the NW-striking veins and generally exhibit greater evidence of strain, with an abundance of sutured and bulging grain boundaries preserved in the quartz. Vein arrays developed within the cataclastic deformation zone below the exposed NCDS detachment plane are parallel to those observed deeper in its footwall. Structural data strongly imply a connection between mineralized veins of the Kallianos Au-Ag-Te deposit and the regional stress field imposed by displacement along the NCDS. Comprehensive study of the structural architecture of younger Cenozoic orogenic deposits like the one on Evia, where mineralizing structures sustained minimal subsequent deformation, will clarify the original structural controls of older polydeformed systems such as many Precambrian orogenic gold deposits.

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Structural Evolution of the Gold-Bearing LP Fault Zone on the Great Bear Property, Red Lake, ON

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The Great Bear property, which is located south of the productive Red Lake gold camp (>29 Moz gold) in the NW Superior craton, is host to a new world-class structurally controlled gold deposit with a combined resource estimate of 5.0 Moz Au. The property comprises two distinct domains, a northern felsic domain and a southern mafic domain, separated by the SE-trending LP Fault. The LP Fault Zone is a ~500m wide high-strain zone with a penetrative, NW-striking, steeply NE-dipping, foliation and transposed isoclinal folds. The LP zone is located in the hanging wall of the fault and is characterized by gold-bearing deformed quartz veins oriented parallel and oblique to the foliation, as well as occurring disseminated in altered felsic volcanics. A mineral stretching lineation plunges steeply (~79°) to the NE along the foliation. Later Z-shaped folds strike E-W and are associated with steeply dipping dextral shear bands.

The development of structures along the LP Fault may be explained by (1) early thrusting along the early foliation followed by late dextral transcurrent faulting or (2) a single long-lived dextral transpressional event. Several lines of evidence suggest that the LP Fault is a regional dextral transpression zone. First, mafic dykes are transposed parallel to the main foliation in the high-strain zone and contain a steeply-plunging stretching lineation along an internal steeply-dipping foliation, which is oriented anticlockwise to the main foliation. Second, fold axes of both early isoclinal and later Z-shaped folds are parallel to the stretching lineation and were rotated into parallelism during concurrent dextral shearing and oblique to near-vertical extension. Third, within deformed intrusions, dextral strain shadows formed on the horizontal surface around vertically stretched quartz phenocrysts. These structures collectively suggest that dextral transcurrent shearing was coeval with oblique to vertical stretching. Thus, gold in the LP zone is controlled by structures that formed during a regional dextral transpressional event.

110 **Théo Lombard - PhD**
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Metasomatic footprints of the Wabigoon deformation zone in Dryden area using hyperspectral, geochemistry and quartz and pyrite chemistry

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Major deformation zones act as conduits for mineralized fluids, which react with country rocks, altering the chemistry and the mineralogy and leaving behind evidence of their migration. This research project seeks to differentiate gold-poor and gold-rich Archean deformation zones through identification and comparison of key physicochemical parameters of the fluid:rock interactions. This study focuses on the Dryden area, an example of a poorly endowed gold district,

where deposits are primarily distributed south of the crustal-scale Wabigoon deformation zone (WDZ), in the western Wabigoon subprovince. The WDZ marks the tectonic boundary between the metavolcanic rocks (2745-2730 Ma) of the Wabigoon group to the south and the iron-rich metaturbidite rocks of the Thunder Lake Group (2715-2710 Ma) to the north. The metavolcanic package includes felsic to mafic massive flows, locally pillowed, at greenschist metamorphic facies. Northward, the metasedimentary rocks show a rapid increase of the metamorphic grade, from biotite to garnet to staurolite facies. The area is bounded in the north and south by intermediate to felsic intrusions and is crosscut by quartz-feldspar porphyry NW-SE dikes. The main foliation post-dates these dikes, is subvertical and is oriented E-W. Most veins are subparallel to the foliation, laminated, and spatially associated with high-strained zones. Veins proximal to high-strained zones are composed of quartz-tourmaline-carbonate and can bear sulfide minerals such as pyrite, arsenopyrite, pyrrhotite, and chalcopyrite. Distal veins are widely dispersed and composed of quartz-carbonate. The deformation intensity and alteration types across the WDZ were mapped through fieldwork. Deformation intensity decreases rapidly with distance from the WDZ and secondary high strain zones. 160 samples have been analyzed by hyperspectral imaging (short, mid and long-wave infrared imaging) and 54 samples by whole rock geochemical analysis, which both outline mineralogical changes such as carbonate, white mica and chlorite and elemental gains and losses related to fluid-rock interaction within the metasomatic halo of the WDZ. Wavelength-dispersive spectrometry of pyrite using As, Cu, Pb, Ni, Co, cathodoluminescence imaging of quartz and energy-dispersive spectrometry on both of these two minerals have been acquired in veins, revealing multiple stages of growth, and therefore making possible to establish the metamorphic-hydrothermal history of the veins along the WDZ.

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Micro- to nano-scale analyses for understanding Au paragenesis in metamorphosed banded iron formations north of Rankin Inlet, Nunavut, Canada

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The Kivalliq region in Nunavut is an important host for banded iron formation (BIF) hosted gold deposits, including the Meliadine and Meadowbank deposits. The region northeast of Meliadine had not previously been studied in any detail, so this project can help provide a broader understanding of the evolution of BIF. The region of interest sits in a complex transition zone of Archean and locally Paleoproterozoic deformation, containing greenschist-amphibolite facies between the Rae and Hearne cratons. The goal of this project is to gain insight into the relative timing and paragenesis of precious metal-bearing minerals in BIF, and any relationships between metal mobility and tectono-metamorphic processes that would inform exploration in the region. The BIF samples were collected on site in July 2023. These samples were then slabbed and polished for LA-ICP-MS analysis on transects running perpendicular to bedding planes. Chemical maps were also generated on the slabs using micro-XRF. Preliminary results show gold concentrations as high as 68 ppm in discrete micron-scale domains within silicate layers, particularly near boundaries with Mn-rich garnet or magnetite layers. Gold tends to be associated with silver, but there is limited correlation between gold and sulfur or arsenic concentrations, which may suggest a detrital origin for much of the gold. Evidence of late veining (mm scale) associated with elevated gold concentrations was also observed in one of the slabs. The next steps

will be to perform detailed phase analysis of gold and other precious metal-bearing domains using SEM-EBSD and additional nano-analysis techniques. Integration of this micro- to nano-scale data with detailed LA-ICP-MS element mapping and geochronology will improve our understanding of the timing and factors concerning metal mobility in this geologically complex region.

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P-T-fluid evolution of the Quetico basin: a metamorphic origin for Archean gold?

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The Quetico basin in Northern Ontario is among the world's largest Archean sedimentary basins: a ~100-1200 km belt separating the Wabigoon and Wawa greenstone belts to the north and south, respectively. It is characterized by turbiditic sedimentary rocks metamorphosed to higher grades than the metavolcanic rocks of the adjacent greenstone belts, which are variably endowed in gold. A prominent model for greenstone-hosted deposits is that Au-bearing fluids were sourced by the metamorphic devolatilization of supracrustal rocks, a model based on major reactions occurring at mid-crustal temperatures which cause the breakdown of Au-bearing sulphide phases and a bulk release of H_2O and ligands. A sequence of regional low- to high-grade porphyroblastic assemblages from the margins to the core of the Quetico presents a window into the nature of such processes. The metamorphic zones (or isograds) in the Quetico are somewhat unusual compared to more modern metasedimentary terranes, involving a progression through chlorite, biotite, garnet, staurolite + andalusite, cordierite, sillimanite, in-situ melt and orthopyroxene. This confounds field gradients typically associated with higher P/T (garnet-staurolite) and lower P/T (andalusite-cordierite) conditions. A combination of thermodynamic modelling, mineral chemistry, and petrographic analysis reveals a continuous three-stage tectono-thermal history for the Quetico: (i) increasing P and T (burial) up to 6–8 kbar and ~550–600 C, forming garnet1 + staurolite; (ii) near-isothermal decompression to 3-4 kbar and ~600 C, forming cordierite and andalusite; (iii) near-isobaric heating at ~3–4 kbar up to ~800 C to form garnet2 + orthopyroxene + melt. This evolution suggests a massive diapiric rise of the core of the Quetico, and the formation of major vertical faults at the margins, which may have served to transport and localize fluid flow. Along the inferred P-T-t path, the largest pulse of H_2O release occurs at the chlorite → biotite continuous reaction (~450–500 C, 4–5 kbar), in roughly the same P-T space as the pyrite → pyrrhotite continuous reaction, which exposes Au in pyrite to the fluid and releases some S into the fluid. This is the P-T window in which gold-fluid mobilization potentially took place and can explain, in part, gold endowment along structures near biotite isograds.

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Metal mobility during prograde metamorphism of metasedimentary belts in the Superior Province: Implications for Au endowment

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This study focuses on the Pontiac and Quetico subprovinces, two highly-metamorphosed metasedimentary belts in the Superior Province adjacent to and overthrust by the Au-endowed Abitibi and Wabigoon greenstone belts, respectively. This tectonometamorphic setting suggests that the devolatilization of metasedimentary belts may have sourced significant volumes of (metal-bearing) fluid to the overlying greenstones. Tracking metal mobility during prograde metamorphism of the metasedimentary piles is therefore key to assess this conjecture. We performed whole-rock geochemistry combined with ultra-low-detection-limit analysis for Au on representative metasedimentary rocks, from greenschist to granulite facies, sampled along three transects featuring contrasting Au endowments: well-endowed (Rouyn-Noranda, Pontiac), moderately-endowed (Geraldton, Quetico), and poorly-endowed (Thunder Bay, Quetico) transects.

The results reveal a systematic decrease of As and Sb concentrations with increasing metamorphic grade in the three transects, suggesting mobilization of these elements during prograde metamorphism. However, decreasing gold concentrations with increasing metamorphic grade, indicative of Au mobilization, is only detected in endowed transects (from 1.03 to 0.16ppb in Rouyn Noranda, and from 1.04 to 0.25ppb in Geraldton), while no depletion was recognized in the poorly-endowed transect (average of 0.86ppb in Thunder Bay).

We evaluate the apparent contrasting Au mobility between the different transects by tracking the textural and chemical (LA-ICP-MS) evolution of sulfides throughout different metamorphic grades. The sulfide textures reveal a general evolution featuring two main reactions: (1) pyrite-I – pyrrhotite transition at lower metamorphic grades, followed by (2) pyrrhotite – pyrite-II transition at higher metamorphic grades. Pyrite-I is the main host of Au, As, and Sb (up to 918ppb, 1967ppm, and 750ppm, respectively) and pyrite-I – pyrrhotite transition is the main reaction controlling the release of these elements. This reaction was efficient in the endowed areas, although spreading over different ranges of metamorphic conditions in Rouyn Noranda (biotite zone) and Geraldton (from the biotite to cordierite zones), resulting in low modal proportions or absence of pyrite-I at high metamorphic grades. However, in Thunder Bay (poorly-endowed) the breakdown of pyrite-I was incomplete, leading to higher modal proportions of Au-bearing pyrite-I at high metamorphic grades, which explains the absence of Au depletion with increasing metamorphic grade in this area.

The spatial correlation between Au mobility in the metasedimentary belts and Au endowment in the overlying greenstones suggests that the devolatilization of metasedimentary rocks may have been a key factor controlling Au endowment of greenstone belts. Preliminary whole-rock multiple sulfur isotopes data may further emphasize the veracity of such link.

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Geochemical fingerprints of mineralization at the gold deposits in the Klondike gold district, Yukon

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The Klondike gold district in west-central Yukon, world-famous for its historical placer production, is host of several orogenic gold occurrences, including those at the Lone Star, Dominion and Gold Run areas. Despite the importance of these gold occurrences as exploration targets in the district, the key elements associated with gold mineralization are not well constrained. Understanding this is critical for efficient exploration in the Klondike, since it would permit the use of certain elements as vectors towards mineralization, and it would provide a basis to compare occurrences in the Klondike with other orogenic gold deposits worldwide, enabling the application of successful exploration approaches used elsewhere. In this study, we combine pyrite LA-ICP-MS spot and map data with whole-rock geochemical data to reveal the fundamental geochemical fingerprints of mineralization of gold deposits in the Klondike.

At Lone Star, preliminary results show that gold and tellurium concentrations in pyrite decrease from gold-bearing veins outwards into the host rocks, while cobalt shows the opposite trend. In some low-grade samples distal from veins (>1 m), gold and arsenic are correlated in pyrite, an association related to late carbonate veining. The direct correlation between gold in tellurium concentrations in pyrite is also found in whole-rock geochemical data, confirming the fundamental link between these elements. This suggests that tellurium in strongly related to gold mineralization, constituting a key element for tracking gold mineralization in the Klondike.

Future work related to this project includes sulfur isotope analyses by SIMS and analyses of fluid inclusions aimed toward understanding the sources of gold and associated elements. The results of this research are expected to aid in exploration efforts in the Klondike gold district and elsewhere in Yukon.

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An evaluation of structural and mineralogical controls on gold mineralization on the GoldRich property in the Abbie Lake area, Wawa, Ontario

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The GoldRich property in the Abbie Lake area is an active gold prospect in the Wawa subprovince of the Archean Superior province of the Canadian shield. The property is located 30 km northeast of Wesdome's Eagle River mine and 10 km northeast of Wesdome's Mishi property in northern Ontario. The Main Shear trench on the GoldRich property is an area of regional metamorphism dominated by ductile deformation hosting orogenic gold. The Main Shear trench hosts felsic and mafic mylonites with varying strain intensities and mafic dykes trending east-west. The mafic mylonite is characterized by having ladder veining in the highest strain zone. Gold occurrences have been found in zones of high strain, in both felsic and mafic mylonite lithologies. This BSc thesis project relies on detailed trench mapping, microstructural and petrographic analyses, and

geochemical methods to discover how gold is hosted on this property. Understanding the controls on gold mineralization will guide future exploration.

Gold mineralization is related to deformation. Gold is concentrated in very high strain zones seen within mylonites in both mafic dyke and felsic lithologies. Both lithologies are mineralogically quite different, however the microstructures which host the gold are comparable. Gold is associated with deformation microstructures such as boudinaged veins, deformed quartz grain boundaries, mica-rich shear bands and strain shadows.

Based on these results, it is recommended that further exploration on this property should be focused on locating zones of similar structure and strain intensity, regardless of lithology, to continue building the gold prospect.

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Structural geology and hydrothermal alteration related to gold-bearing quartz veins in the Menarik Property, Eeyou-Istchee James Bay, Quebec: initial results

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The Menarik property, owned by Harfang Exploration Inc., is located 45 km south of Radisson, Eeyou Istchee James Bay, in the La Grande Subprovince. On the property outcrops greenschist facies volcanic and sedimentary rocks of the Yasinski Group (~2,751 - 2,725 Ma), which are unconformably overlain by conglomerate and wacke of the Ekomiak Formation (<2,714 Ma). These units are intruded by porphyritic monzodiorite (~2709 – 2716 Ma) dykes and stocks. This work presents a preliminary summary of the structural controls and hydrothermal features associated with the gold-bearing vein arrays. It is based on detailed mapping of eight showings aligned along a NE-trending corridor, aiming to understand the structural architecture of the area, and sampling the different vein types and hydrothermally altered host rocks for a detailed mineralogical and geochemical investigation. The earliest deformation phase (D_1) is represented by a steeply dipping ENE-trending penetrative schistosity (S_1), subparallel shear zones and tight to isoclinal steeply plunging folds. D_2 is associated with subvertical SW-NE-trending crenulation cleavage (S_2) and shear zones. The mineralized veins are hosted in mafic rocks, sedimentary rocks, and porphyritic intrusions. Two main vein styles are distinguished based on texture and host rock lithology: pre- or syn-D_1 N-S quartz veins that are restricted to the intrusions, and syn-D_1 quartz-carbonate-albite ± tourmaline shear veins subparallel to S_1 (predominant in the area), with spatially associated sub-horizontal and N-S sub-vertical extensional veins. Both contain pyrite (up to 15%) and occasional galena and malachite. Wall-rock alteration is dominated by sericite, chlorite and locally ankerite, with disseminated pyrite. Future work will be concentrated on petrography and whole-rock geochemistry of veins and host rocks, pyrite chemistry (LA-ICP-MS), and U-Pb geochronology of hydrothermal monazite to determine the conditions and timing of vein formation concerning the regional context of the Superior Province.

200 Intrusion-Related Deposits

201 **Gabriel Ariza-Benavides - PhD**
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Geological Setting and Genesis of the Whisker Valley Au Mineralization, Baie Verte Peninsula, Newfoundland.

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The Whisker Valley Au mineralization is located in the historic Baie Verte mining district of Newfoundland in the Northern Appalachians. Mineralization consists of a series of sub-parallel narrow sulfide-bearing quartz veins with pyrite, chalcopyrite, pyrrhotite, arsenopyrite, bornite, sphalerite, galena, pyrargyrite, and native gold. The veins occur in two vein systems, the Gary-Jackson-Ben vein and Gold Pit vein systems. The systems are hosted by both the ~445-431 Ma calc-alkalic Burlington granodiorite and the ~430-427 Ma alkalic/peralkalic (A-type) King's Point Complex. Host rocks present variably sericitic and propylitic alteration mainly as replacement of the pre-existing magmatic assemblages and fracture infilling. Petrographic textures and mineral assemblages suggest that the veins are potentially magmatic-hydrothermal in origin product of a switch in the tectonic regime from convergence to post-collisional extension as a consequence of a slab break-off. Lithogeochemical and mineral chemistry data are useful in identifying key element associations and alteration assemblages. Short-wave infrared (SWIR) spectroscopy data provide an effective vector for Au mineralization and correlate with whole-rock geochemistry. Lithogeochemical and SWIR data have been used to recreate a three-dimensional alteration model of the Whisker Valley mineralization that may be useful in further mineral exploration.

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The Temporal and Geochemical Placement of the Goldstorm Cu – Au Porphyry Deposit within the Sulphurets Trend, British Columbia's Golden Triangle

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The Goldstorm deposit is a Cu – Au porphyry located at the northern extent of the Sulphurets Trend in the southern portion of British Columbia's Golden Triangle. It is hosted in monzodiorite stocks and andesitic to basaltic volcanic fragmental and flow units of the Early Jurassic Lower Hazelton Group of the Betty Creek Formation. The source of the syn-mineral intrusions in this region is the Texas Creek Plutonic Suite. Along the Sulphurets Trend are a series of 6 known, roughly 2 km spaced, gold-rich porphyry centres – including, from south to north: the Kerr – Sulphurets – Mitchell - Iron Cap deposits and Tudor Gold's recently discovered Perfect Storm and Goldstorm deposits. While sharing many similar characteristics, there are distinct differences between porphyry centers. New Re/Os and U/Pb age dates give the temporal context of the Goldstorm intrusions and the age of mineralization. Comparisons of spatial relationships and whole rock geochemistry shed light on differences that could account for the variations in metal endowments observed along the trend. Additionally, a SWIR and geochemistry-based alteration model of Goldstorm is presented and its relationship to mineralization is compared to those interpreted at the neighboring deposits. This work is being done as part of UBC - MDRU's Golden Triangle Stratigraphy Project and will represent the first academic work undertaken on Tudor Gold's Treaty Creek - Goldstorm deposit.

200 Intrusion-Related Deposits

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Rapid Cu-porphyry indicator mineral characterization by µXRF: a case study investigating µXRF corescanners as a prospective automated indicator mineral analytical tool on HMC stream samples from central British Columbian Cu-porphyry exploration properties

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As the global population rises and the world economy transitions towards decarbonization, electrification upgrades to energy, transportation, and industrial infrastructure will result in an increase in copper demand by upwards of 350% worldwide by 2050. Continued exploration for Cu-porphyries is critical to meeting this demand, however, the remaining undiscovered deposits are in regions that are mostly or entirely obscured by post-mineral surficial cover. Effective, timely, and economically feasible exploration approaches must be developed to meet the rise in copper demand and address the challenges associated with exploring for obscured deposits. Indicator minerals (IMs) are minerals that contain textural or chemical information indicating the presence of specific mineralization in the bedrock from which the minerals were derived and are commonly used to vector towards and/or assess the fertility of a potential deposit. In Cu-porphyry exploration, IMs have been widely used in regions of extensive surficial cover to explore for obscured deposits. The project's research goal is to improve, quantify, and expedite the identification of porphyry copper IMs by investigating rapid cost-effective analytical technologies and approaches. In this study, Cu-porphyry IM identification methods were developed utilizing benchtop micro-X-ray-fluorescence (µXRF) corescanners and automated scanning-electron-microscopes with energy-dispersive-detectors (ASEM-EDS). Heavy-mineral-concentrates (HMCs) of stream sediment samples from Northwest Copper's Cu-porphyry exploration properties in central British Columbia were analyzed using µXRF corescanners and ASEM-EDS. The IM mineralogy of the HMCs was characterized using the Bruker AMICS automated mineralogy software to identify IMs from µXRF and ASEM-EDS data. HMC mineral characterization and IM identification by µXRF corescanners and ASEM-EDS is presented, and the opportunities and challenges associated with applying µXRF corescanners to rapid Cu-porphyry IM characterization are discussed. Benchtop µXRF corescanners appear to be a promising IM analytical tool, however, the relatively low spatial resolution and resulting mixed mineral spectra may complicate the identification of fine minerals or textures.

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Geology and mineral alteration characterization: Santa Cecilia porphyry Au-Cu deposit, Maricunga belt, Northern Chile

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The Santa Cecilia porphyry gold-copper deposit is located within the Maricunga gold-silver-copper belt in northern Chile. Santa Cecilia presents a complete porphyry copper system alteration column, from potassic alteration at depth to shallow advanced argillic and silicic assemblages near the surface and, it has not been clear where the highest ore grade is located.

Therefore, part of this study aims to narrow down this information and identify the specific location within the alterations. The deposit is hosted by early Miocene volcanic rocks (~500 m thick), comprising mainly pale-colored dacite to andesite lavas, tuffs, and breccias with local intercalations of poorly welded felsic-dacitic ignimbrite and lacustrine sediments. This deposit was extensively explored during the late 1980s, early 1990s, and in 2012. Currently, Torq Resources is exploring this project. Adjacent to Santa Cecilia is the Caspiche porphyry Au-Cu deposit (proven and probable mineral reserve of 1,091 million tonnes (Mt) averaging 0.55 g/t Au), separated by a 250-m-wide valley. The deposit formed in the latest Oligocene (~24 Ma) during the first of two volcanic and corresponding metallogenic epochs that define the Maricunga belt.

The main objectives of this study are: (1) identify the mineral assemblages and timing of each of the magmatic-hydrothermal alteration and veining stages present in the deposit; (2) evaluate the degree of Cu and Au mineralization of the different alteration assemblages or stages; (3) study the relationship between the different alteration and mineralization centers existing within the Santa Cecilia property. These objectives will be addressed through field mapping and petrographic, mineralogical, geochemical and isotopic techniques, including XRD, micro-XRF and radiometric dating. Currently, preliminary results exist for the first two objectives.

Preliminary results indicate that this deposit has different alteration zones: (1) potassic alteration consisting of biotite-magnetite (at ~1,400 m); (2) chlorite-sericite alteration with chlorite-muscovite-albite (at ~550 m), (3) sericitc (white mica) alteration with quartz-muscovite-albite (at ~1,100 m), and in the lithocap (4) quartz-pyrophyllite alteration is present with advanced argillic alteration which comprises quartz-alunite with alunite ledges and vuggy residual quartz, some of which were mineralized and subject to the earliest exploration activity in the property. Finally, further work will involve field mapping and sampling, generating a model of the deposit, and understanding the genesis of the mineralization with an emphasis on the magmatic and structural setting and evolution of this sector of the Maricunga Belt.

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High Sulphidation Overprint Associated with High Cu-Au Grades of the Filo del Sol Porphyry Cu-Au deposit, Argentina-Chile

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The Filo del Sol porphyry Cu-Au deposit on the Argentine-Chile border is associated with middle Miocene-age dikes of diorite porphyry; the deposit contains high metal grades due to an overprint of the initial mineralization: early typical porphyry Cu-Au type and later high-sulphidation Cu-Au mineralization. Samples from deep (1000+ m) zones were studied to document the mineralogy and paragenesis of the two mineralization events and associated alteration, plus sulfur isotope analyses (> 1mm grains) of sulfide and sulfate minerals. The early association consists of mushketovite and biotite with anhydrite (Anh), plus chalcopyrite (Ccp), bornite, and pyrite (Py), the latter as subhedral aggregates. The Py did not form at the same time as the Ccp, as confirmed by Py on average being ~3‰ $\delta^{34}S$ lower than Ccp (if in equilibrium, Py would have higher $\delta^{34}S$ than Ccp). The overprint event was more oxidized and formed a high-sulphidation association of enargite, covellite, chalcocite and pyrite related to the higher grades, as well as alunite. Sulfur isotopic analyses of co-existing Anh and Ccp yield temperatures

between 550 and 450°C, which are consistent with typical hydrothermal temperatures of the biotite-magnetite (after hematite) assemblage, similar to other porphyry deposits with early anhydrite. Open spaces between these subhedral Py aggregates are infilled by late alunite, with $\delta^{34}S$ data indicating that the two are not in isotopic equilibrium (with unrealistic calculated temperatures of 400 to 800+ C). An intergrown Alu-Eng pair from the same sample indicates a reasonable $\delta^{34}S$ temperature of 260°C. A later stage of Py typically occurs as blebby, anhedral grains, finer grained than the early Py occurrence, and is commonly intergrown with Eng and as rims around Eng and the early Py. The results of this study of the Filo del Sol Cu-Au deposit adds detail to the understanding of the nature of the high sulphidation overprint at depth.

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Genesis and mineralogy of the Golddigger Property in British Columbia, Canada

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The Golddigger property is a recent discovery in the Golden Triangle of British Columbia which has drawn interest for its high-grade gold. At Golddigger, structurally-controlled quartz veins containing semi-massive to massive sulfide accumulations are hosted in Upper Hazelton volcanic and sedimentary rocks. Gold grades vary throughout the deposit, with quartz veins in the Surebet shear zone having an average grade of 9.04 g/t AuEq and a modeled volume of 6.8 million m^3. The Bonanza shear zone grades 8.14 g/t AuEq and has a modeled volume of >15 million m^3. Ongoing research is focused on developing a deposit model for Golddigger to aid in further exploration at the property and in the region. Research includes core logging, transmitted and reflected light microscopy, optical cathodoluminescence microscopy, scanning electron microscopy, fluid inclusion petrography, sulfur isotope studies, and Re-Os geochronology. Petrographic analysis of quartz veins and fluid inclusion petrography indicate that these veins formed close to the brittle-ductile transition, with the hydrothermal fluids having a high CO_2 content at a paleodepth of >5-6 km. A comprehensive ore mineralogy study indicates that pyrrhotite, chalcopyrite, pyrite, arsenopyrite, sphalerite, and galena are the main ore minerals. Minor ore phases include molybdenite, Bi-Te minerals, Sb minerals, native silver, and native gold. Petrographic investigations suggest the presence of spatial mineralogical gradients, which is supported by chemical statistical analysis indicating a southerly depletion of Sb and enrichment of Bi. Re-Os geochronological investigations suggest that the gold mineralization is Eocene in age and can be potentially linked to the Eocene Alice Arm intrusions, which have been previously linked to several molybdenum and polymetallic deposits in the region. The deposit characteristics, including the depth of mineralization, the ore mineral assemblage, apparent zoning, and temporal link to intrusive activity suggest that Golddigger can be classified as a reduced intrusion-related gold deposit. This discovery has significant implications for future exploration in the region, as this deposit type has distinct characteristics that are unique relative to orogenic or epithermal deposits.

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Camp Creek Porphyry Alteration, Mineralogy and Geochemistry: A Treasure Map to Explore in Northern British Columbia

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Camp Creek is a Late Cretaceous calc-alkalic Cu-Au-(Mo) porphyry deposit located within the Stikine terrane in northern British-Columbia. Bedrock geology is comprised of Late Triassic mafic volcanic and clastic sedimentary rocks of the Stuhini Group, intruded by Late Cretaceous granodiorite to monzonite. Successive 2021-2023 drilling programs have discovered high-grade Cu-Au-(Mo) mineralization at depth. Multiple porphyry units have been classified at Camp Creek (e.g. PZ, PY, PX) based on detailed trace element analysis. Mineralization is typically hosted within PX, a hornblende-quartz-biotite-plagioclase porphyry that is cut by A-type quartz-vein stockwork, occurring together with K-feldspar and biotite alteration. The primary goal of this study will be to establish mineralogical, geochemical and alteration vectors to mineralized porphyry units. Secondary objectives are to determine how significant changes in grade within drillcore correlate to rock type, and to investigate contact relationships between porphyry units, in addition to late mineral dykes. The research methods used in this work are as follows: (1) Use petrography to establish modal mineralogy for porphyry units; (2) MicroXRF element mapping to characterize distinct chemical changes and contact relationships; (3) Shortwave infrared (SWIR) spectroscopy to characterize pyrophyllite zoning, sericite composition and sericite crystallinity within recent 2023 drillholes; (4) U-Pb zircon dating (LA-ICP-MS) of DKMF, DKIN, DKFL units to understand the timing of dykes relative to the main porphyry intrusive age (~86Ma); (5) Whole rock geochemistry to characterize primary and alteration geochemistry of porphyry units. Results are expected to provide insights on how to vector towards blind porphyry Cu-Au-(Mo) mineralization within porphyry belts in BC.

300 Epithermal Deposits

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The characterization of breccias at the Iska Iska silver-tin polymetallic project, Bolivia

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The Iska Iska silver-tin polymetallic project is a new discovery and the focus of ongoing exploration by Eloro Resources Ltd. It is located in the southwestern part of the Eastern Cordillera of the Bolivian Andes within the famous Bolivian Tin Belt, which for about 1100km, hosts a number of world-class deposits including Cerro Rico de Potosi, Llallagua and Chorolque.

Like other deposits, breccias are identified as one of the key host rock of the higher-grade mineralization during the exploration stage at Iska Iska. This is because they tend to be the conduit of hydrothermal fluids, and they usually prepare the bedrock to host mineralization. At Iska Iska, evidence for both mineralization mechanisms are evident. There are several stages of brecciation that seem to be closely related to the polymetallic mineralization within the volcanic/plutonic system. Macroscopically, the breccias have been systematically described according to their descriptive characteristics such as the types of clasts and matrix, in addition to other internal/external features. As a result, four main types of breccias have been defined that also display facies changes and overprinting by hydrothermal alteration. Some examples exhibit possible phreatic, phreatomagmatic, and/or intrusion events as well as hydrothermal activity. Detailed characterization will be complemented with mineralogical and geochemical analytical techniques in order to improve their classification and objective identification. Through petrography and EPMA (Electron Probe Micro-Analysis), the main goal is to define the link between these breccias and the higher-grade mineralization as well as to build a preliminary paragenetic sequence of the mineralizing system. The first results show that there are pre-, syn- and post-events of mineralization cutting and within the breccias. The current study is expected to find more evidence to support these findings. Finally, a combination of mineralogical and geochemical analytical techniques along with the AI technology of GeologicAI, will allow us to turn these breccia classifications into vectors to aid in looking for additional higher-grade mineralization at Iska Iska. These combined data will be used to develop a consistent and predictive model, which will help target additional promising areas as well as improve the efficiency and effectiveness of the exploration drilling strategy.

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SWIR hyperspectral imaging of drill core: Case study of the Tuvatu alkalic-type epithermal deposit

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The Tuvatu alkalic-type epithermal deposit is located on the southern edge of the Navilawa caldera on the island of Viti Levu, Fiji. The steeply dipping and flat-lying ore-bearing lodes of the Tuvatu deposit are hosted within the Navilawa monzonite and Sabeto volcanic rocks, which are spatially and genetically associated with the Navilawa caldera, an eroded shoshonitic volcano. The Tuvatu deposit was recently commissioned as an underground mine and comprises an indicated resource of 1,000,000 metric tons of ore with an average grade of 8.4 grams/ton Au for a total of 274,600 oz Au and an inferred resource of 1,300,000 metric tons of ore with a grade of 9.0 grams/ton Au for a total of 384,000 oz Au.

Hydrothermal alteration of the Navilawa monzonite at Tuvatu is complex and includes early porphyry-style potassic alteration in addition to late-stage alteration associated with the epithermal veins. The narrow, high-grade veins at Tuvatu are typically associated with narrow alteration halos, the mineralogy of which is difficult to determine macroscopically. However, alteration associated with the veins resulted in the formation of minerals that are active in the shortwave infrared (SWIR) range of the electromagnetic spectrum and can be detected using hyperspectral imaging.

A hyperspectral survey was conducted by scanning ~18,000 m of exploration diamond drill core using a Hyspex SWIR-384 hyperspectral imaging camera with a spectral range of 930 to 2500 nm. Whole core boxes were placed on a translation stage and images were captured using Breeze GEO imaging software by Prediktera AB. The Breeze GEO software utilizes the open-source USGS Material Identification and Classification Algorithm (MICA) to classify spectrally active minerals on a per-pixel basis. The objective of the survey was to gain new insights into the alteration mineralogy associated with the high-grade ore zones and the spatial distribution of alteration phases. The ongoing project will culminate in the creation of a subsurface alteration model facilitating exploration for yet undiscovered zones of high-grade ore.

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Unravelling the geochemical complexity of the Pefka HS- to IS-type epithermal deposit in northern Greece: Insights from pyrite geochemistry and fluid inclusions in quartz

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The high- (HS) to intermediate-sulfidation (IS) epithermal Cu-Au-Te-In-Se Pefka deposit is located in the Rhodope metallogenic province of northern Greece. This study combines textural observations from optical and electron microscopy with bulk ore and in-situ pyrite trace element data, and fluid inclusions microthermometry. This provides insights into the processes causing the extreme enrichment of metals like Au, Te, and In in the HS-quartz and IS-quartz-carbonate veins of the Pefka deposit. The high-grade ores host up to 2300 ppm Se, 1160 ppm In, >1000 ppm Te, 390 ppm Ag, 345 ppm Au, and 250 ppm Bi, and thus the epithermal mineralization has one of the highest Te and In grades in Greece.

The paragenetic sequence of ore formation is complex, but pyrite is ubiquitous in most assemblages and occurs in association with tennantite-(Cu), enargite, colusite, native-Au, tetrahedrite-(Zn), chalcopyrite, sphalerite, and galena. Thus, pyrite plays a crucial role in understanding the epithermal formation and evolution of the deposit. The textural habit of pyrite is highly variable between these assemblages, including early anhedral, porous, and inclusion-free to late euhedral and inclusion-rich pyrite. Back-scattered electron (BSE) imaging revealed zoning patterns in some pyrite grains, exhibited by dark cores, bright intermediate zones, and dark rims. The dark zones are depleted in As relative to the bright zones, where the As contents 2.3 wt. %. Trace element micro-analysis of pyrite yielded up to 19800 ppm Te ppm, 430 ppm Se, 200 ppm In, 180 ppm Bi, 35 ppm Au, and 50 ppm Ag. Time-resolved intensity profiles by LA-ICP-MS are indicative of the presence of micro-inclusions of tellurides and sulfosalts in pyrite. The trace element variations in pyrite suggest that the Au deposition occurred during both the HS and IS stages, while Te mainly precipitated in the late IS stage from more reduced fluids. Microthermometry data of primary two-phase (L+V) fluid inclusions of quartz that is cogenetic with the pyrite of the HS stage, revealed homogenization temperatures of 220 to 276°C.

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Paragenesis and magnetic properties of Mn-Ag-Cu-Zn deposit at Berenguela, Southern Peru

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The Berenguela epithermal Mn-Ag-Cu-Zn deposit is hosted in the mid-Cretaceous, collapsed carbonate platform of the Ayavacas Formation, Southern Peru. Mn-oxide is the primary ore mineral group that occurs in association with Ag, Cu and Zn within the carbonate dominated stratigraphic succession. Mn-oxide is concentrated along host rock fractures and within fold hinges, and is crosscut by late stage calcite and malachite bearing veins. The working model for mineralisation favours a carbonate replacement style deposit with low temperature hydrothermal alteration enriching dolomitised limestone via structural pathways to ultimately form a massive enriched Mn-body. However, a paragenetic sequence has yet to be established, limiting our understanding of both the structural controls over Mn mineralisation and the geochemical processes that formed Ag, Cu and Zn mineralisation. This study aims to establish a paragenetic sequence with a view to addressing three key questions: 1) How many distinct mineralisation events occurred during the formation of this Mn, Ag, Cu, Zn deposit? 2) Which minerals hold high concentrations of these metals? And, 3) in light of the data provided, can the geometallurgical model be enhanced by more effectively targeting strategic minerals?

We present preliminary petrographic, microprobe and rock magnetic data to address the above questions. Our data reveals a systematic relationship between Fe-Ti oxide compositions, the type and intensity of precursor hydrothermal alteration and the spatial distribution of at least two distinct mineralisation events.

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Cathodoluminescence Spectroscopy as a Tool for Unravelling the Complex Ore Forming Processes of the Bonanza Grade Brucejack Au-Ag Deposit, Northern British Columbia

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Cathodoluminescence (CL) textures, which document variations in trace element contents, record the history of crystal growth in the mineralised hydrothermal of the Brucejack Au-Ag deposit and the evolution of the ore-bearing fluids. Quartz and carbonates, which are the most common hydrothermal minerals in the deposit, occur in all vein generations and are the immediate host to bonanza grade gold mineralisation. An integrated petrographic study, with emphasis on CL microscopy, focussed on the bonanza grade gold-bearing veins in order to investigate (1) the paragenesis and (2) the ore-forming process, including the control on nuggety electrum occurrence.

The SEM-CL textures reveal that the Type 1 quartz crystals comprise (1) CL-homogenous cores and (2) oscillatory-zoned overgrowths that predate bonanza grade mineralisation. This quartz was followed by CL-unresponsive Type 2 quartz, which hosts electrum. It accompanied deformation and the destruction of Type 1 quartz growth textures. Ankerite crystals (10-µm in diameter), which formed during this deformation, are in textural equilibrium with electrum aggregates and enclose electrum nano-inclusions, record the passage of a hydrothermal fluid that mechanically transported gold as a colloidal suspension. This fluid was also responsible for depositing the bonanza ores at Brucejack.

Microstructural petrography helped decipher the role of post-emplacement deformation in modifying the mineralisation style of the deposit, and in determining the mode of occurrence of the high-grade electrum, as (1) millimetre-wide layers along pressure dissolution seams in quartz, (2) centimetre- to micron- scale tensional fractures perpendicular to shear fabrics and (3) clots along grain size reduction structures concordant with foliation.

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Characterization of Magmatic-Hydrothermal Alteration Mineralogy and Geochemistry at the 4.6Moz Au, 24.3Moz Ag, Springpole Deposit, Northwestern Ontario.

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Many Precambrian gold deposits and prospects worldwide may have been misclassified as orogenic gold. The Springpole deposit is located ~100 km northeast of the Red Lake mining district, northwestern Ontario, Canada. It was first interpreted as orogenic gold but then reinterpreted as epithermal gold in the late 1990s possibly revealing an atypical mineral system in Archean greenstone belts. This study examines the Portage zone of the Springpole deposit, using a series of least altered, to altered and highly mineralized samples in specific rock units. Greenschist-facies metamorphism has been previously hypothesized for the area despite the absence of chlorite and amphibole minerals in metavolcanic rocks. A total of 21 samples of trachyte, andesite, banded iron formation, and quartz veins were taken from the site to be

examined. Herein, hyperspectral imaging is used to assess alteration signatures associated with mineralization; optical microscopy to determine textural relationships and mineral paragenesis; SEM-EDS to obtain semi-quantitative mineral chemistry, and validate hyperspectral data; and whole rock geochemistry to assess metal enrichments. Trachyte is the major host for mineralization. It displays a brown to grey aphanitic groundmass with euhedral tabular feldspar megacrysts. The andesite is dark grey with an aphanitic groundmass and anhedral fine- to medium-grained quartz clasts. These clasts commonly exhibit well-defined shear structures. Both the trachyte and andesite experience similar trace-element enrichments in Te, Hg, Ag, Se, Re, Au, and Mo. Significant concentrations in F are also inferred from the presence of fluorite-rich zones. The Au:Ag ratio in the Springpole deposit ranges between 1:2 and 1:8, which is distinct from the typical 9:1 Au:Ag ratio observed in orogenic gold. The presence of an atypical Au:Ag ratio and metal enrichment, rare colloform textures, characteristic alteration mineralogy including phengitic alteration, and a possible low metamorphic facies suggest the Springpole deposit is a preserved Archean analogue of modern epithermal systems.

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Volcanism During the Mineralization at the Hishikari Gold Deposit, Japan

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The Hishikari deposit (> 409t Au) is a high-grade low-sulphidation epithermal gold deposit on the southern Kyushu Island of Japan. The high-grade veins of the Honko and Sanjin Zones formed at 1.11-0.75 Ma and are hosted by the Cretaceous Shimanto metasedimentary rocks. The Shimanto rocks are overlain by the Hishikari Lower Andesite (1.62-0.84 Ma), Hishikari Middle Andesite (~0.78 Ma), Shishimano Dacite (1.1-0.66 Ma), Hannyaji Rhyodacite (0.7-0.6Ma) and Hishikari Upper Andesite (0.58-0.51 Ma). The Hishikari Lower Andesite is contemporaneous with the mineralization. It is composed of lavas and pyroclastic rocks with basaltic andesite composition and some andesite lavas. They show initial $^{87}Sr/^{86}Sr$ values of 0.704398 (pyroclastic) and 0.705868 (andesite lava), suggesting that the parental magmas significantly assimilated basement Shimanto sedimentary rocks especially for lavas. The pyroclastic rocks are Mg-rich (MgO ≥ ~ 3.3wt%) containing olivine phenocrysts (77Fo, Ni (<500ppm), Mn (<3600ppm), Ca (<1030ppm), Ti (<45ppm) and Al (<130ppm)). Al contents of olivine suggest its crystallization at temperatures over 800 °C using the thermometry of De Hoog et al (2010). The pyroclastic rocks and lavas contain phenocrysts of plagioclase (~An60), zoned augite (Mg#84-73), zoned hypersthene (Mg#87-76), magnetite (9.64wt% TiO^2) and apatite. The andesite lavas contain phenocrysts of plagioclase (~An64), zoned augite (Mg#84-73), hypersthene (Mg#~70), magnetite (~12.0wt% TiO^2), ilmenite (13.6 % hematite component) and apatite. Primitive mantle-normalized patterns of trace elements for augite are similar to those for bulk rocks where LREE in the bulk rocks are 100 times and augite is 10 times the primitive mantle values. Oxide pairs yield ~ 820°C, and FMQ+1.1, suggesting slow cooling of lavas. Inclusions of Cr-magnetite (1.58 % Cr^2O^3) in Mg-rich olivine, high Mg# (<87) of pyroxenes, and bulk rock suggest partial melting in the mantle for volcanism during the gold mineralization.

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The source of uranium for the Lac Cinquante uranium deposit, Nunavut, Canada

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The Lac Cinquante uranium deposit is hosted in an Archean greenstone belt below the Paleoproterozoic Baker Lake Basin, Nunavut, and is currently characterized as a vein-type uranium deposit. Vein-type uranium deposits consist of uranium mineralization concentrated in fractures, shear zones, and stockworks. The source of uranium in the Lac Cinquante is unknown and will be determined in this study through petrographic work, trace element analysis and geochronology of uranium minerals. We hypothesize that the uranium was sourced in one of two ways: either uranium was leached from apatite, zircon, or monazite, from nearby c. 1.84 Ga Hudsonian granites or the uranium was sourced from glass of the potassic volcanic rocks (Christopher Island Formation) of the Paleoproterozoic Baker Lake Group. Petrographic work including micro-XRF mapping scanning electron microscopy confirm the complete paragenesis for the deposit is i) primary minerals of the host rock including plagioclase and quartz, ii) albitization of plagioclase, iii) disseminations of hematite, pyrite, chalcopyrite within host rock, iv) formation of uraninite, brannerite, uranophane in carbonate (calcite to dolomite) veins, and v) hematite, carbonate, and chlorite alteration. Laser ablation inductively coupled plasma mass spectrometry will be carried out on uranium minerals to date discrete mineralization events and identify sources of uranium. Preliminary data of uraninite shows flat (i.e. none) to positive Eu anomalies with otherwise flat-lying chondrite normalized REE patterns, distinct from typical vein-type uraninite associated with granitoids. The REE patterns together with the presence of brannerite ($(U,Ca,Ce)(Ti,Fe)_2O_6$), may indicate a mafic source for REE and Ti, potentially the local albitized host volcanics. High contents of Ba, Zr, and U may be sourced from alkaline rocks such as the Baker Lake Group volcanics.

402 **Saeid Baghban - PhD**
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Hunting for rare earth elements and yttrium in highly-fractionated granitic systems: Insights from the polymetallic Mount Pleasant Mine, New Brunswick, utilizing cost-effective multi-analytical approaches

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Considering the increasing need for rare earth elements and yttrium (REY) to support the transition to a green economy, the concentration and distribution of REY within the Late Devonian orebodies at the polymetallic Mount Pleasant Mine are being examined. These deposits are linked to the cupolas of evolved A-type granite intrusions: the fine-grained granite-I (Gr-I) produced the high-tonnage, low-grade W-Mo-Bi ore of the Fire Tower Zone (FTZ); the porphyritic granite-II (Gr-II) formed a limited-tonnage, high-grade Sn-Zn-Cu-In ore in the North Zone (NZ); and the medium-grained granite-III (Gr-III) that transects the earlier phases at depth, but has yet to be

linked to a mineralized cupola. A small W-Sn-Zn-In occurrence in the Saddle Zone (SZ) is associated with the intersection of Gr-I and Gr-II.

To categorize the full range of mineralized zones, alteration types, causative granites, and host rocks, 125 pulp and 220 borehole core samples were analyzed by portable X-ray fluorescence spectrometry (pXRF) for ore-related elements, including REY. Based on pXRF data, the FTZ exhibits average REE concentrations of ~800 ppm, ranging from 20 to 2100 ppm, while the NZ has average concentrations of ~370 ppm, with a range from 10 to 1100 ppm. Greisen, chloritic, and sericitic alteration types with fluorite, Fe-rich chlorite, and muscovite as the dominant minerals, respectively, are intimately associated with the mineralized zones, in particular, REY. Fresh and unaltered metasedimentary and rhyolitic host rocks exhibit low REY content and have minimal contribution to the system. Based on pXRF data and principal component analysis, there is an intimate relationship between REY and W, Mo, and Bi in the mineralized zones. Therefore, FTZ and the remnants of this zone in the NZ, are the principal host for REY mineralization.

The integration of micro-XRF (μXRF) and pXRF data reveals that REY minerals are initially widespread in the matrix of matrix-supported brecciated zones within the FTZ. Moreover, they are predominantly found within fluorite veins containing W-Mo-Bi in the FTZ and in areas where the second stage of mineralization overprints the initial stage through a dissolution-repricipitation process. Utilizing scanning electron microscopy (SEM) images, fluocerite, fluorite, bastnäsite, parisite, monazite, thorite, xenotime, and zircon have been identified as the primary carriers of REY. The enriched yttrium content of fluorite, characterized by oscillatory to chaotic zoning, was identified as yellowish-white growth zones using shortwave ultra-violet (UV) and μ-XRF. Therefore, brecciated zones associated with W-Mo-Bi mineralization together with chloritic, sericitic, and greisen alteration represent a field-based exploration vector for REY at Mount Pleasant, and thus could potentially be applied for similar granitic systems.

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Petrology and evolution of the Main Dyke Pegmatite, Northeast Ontario

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The Main Dyke of the Case Lake pegmatite swarm is the largest rare earth element (REE) pegmatite in Northeastern Ontario, 80 kilometers east of Cochrane. Pegmatites are igneous bodies characterized by very coarse grain size that can host rare earth elements and are often mineralogically zoned. Critical minerals which can be extracted from REE-pegmatites supply lithium, cesium and tantalum for use in battery manufacture, as catalysts or in capacitors. Economic minerals present in the Case Lake pegmatite swarm include spodumene (Li- aluminosilicate), pollucite (Ce- aluminosilicate) and columbite-tantalite (Ta-Nb oxides). The objectives of this study are to classify the pegmatite, describe mineralogical and petrological zonation, then interpret the degree of fractionation. This study will contribute to the current understanding of mineralized pegmatites in a relatively underexplored region.

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Understanding the Zonation of Lithium Cesium Tantalum Pegmatites in Northern Ontario

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The demand for critical metals is surging, particularly for renewable energy technologies, and Northern Ontario is helping to fill this demand by becoming an important source for essential elements like lithium, cesium, and tantalum. My study aims further the development of this resource by better understanding the zonation and altered mineralogy of a group of pegmatite dikes near Armstrong Station, Ontario. If more is known about the deposit this could contribute to improved exploration techniques both in Armstrong Station and across Ontario. My techniques include transmitted light optical mineralogy, scanning electron microscopy, electron microprobe analysis, paired with comprehensive bulk rock geochemical analysis. I am analyzing samples, each a 5 cm segment of a quarter core, sourced from two mineralogically rich areas within the pegmatite dike. The purpose of this analysis is to ascertain the mineral zoning within the dikes, which may reveal the presence of multiple magma pulses. Any zonation of the minerals will also provide temporal information about the change in composition of the magma as it cools. Furthermore, I am exploring variations in mineral composition throughout the dike and the nature of alterations, with a special emphasis on lithium-rich pyroxene spodumene, lithium micas and muscovite.

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Preliminary investigation of the Winnipeg River gneisses and overlying English River and Thunder Lake supracrustal sequences, NW Ontario, Canada

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The western Superior Province between the Quetico deformation zone and the Sydney Lake / St-Joseph Lake deformation zones comprises three primary crustal blocks, namely the Wabigoon, Winnipeg River and English River subprovinces, thought to be accreted during the Neoarchean "Kenoran Orogeny" (2.7-2.6 Ga). However, recent structural and geochronological investigations challenge this model of distinct crustal components. The stratigraphy, age, and composition of >2.7 Ga supracrustal assemblages of the English River and northwestern Wabigoon (Thunder Lake group) "subprovinces" suggest they were unconformably deposited on top of the Paleo to Mesoarchean (3.5 to 3.2 Ga) orthogneisses of the Winnipeg River. Both supracrustal rocks and their gneissic basement were then deformed, metamorphosed (~2.65 Ga), and intruded by late orogenic granites and associated pegmatites (including Mavis Lake Li pegmatite prospect near Dryden, ON). In this work, a representative set of 35 samples was collected on a ~100 km N-S transect along Highway 105 and the western coastline of Lac Seul near Ear Falls, Ontario. This set includes metasedimentary rocks (including paragneiss), orthogneiss, mafic gneiss, granitoid and pegmatite units. Furthermore, the set contains samples from the Thunder Lake group, the English River group and the Winnipeg River's Clay-Twilight-Mystery-Cedar domes. Structural analysis, petrography, whole rock geochemistry and isotopic analyses of detrital and inherited zircons will be performed to document a billion years of crustal evolution, to delineate the spatial extent and relationships within the supracrustal sequences as well as provide insight into the processes governing critical metal-bearing pegmatite formation.

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Investigation of accessory minerals within the Athabasca Basin for assessing potential origins of uranium (U) and rare earth elements (REE) in unconformity-related uranium (URU) deposits

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The unconformity related uranium deposits in the Athabasca Basin hosts some of the world's largest high-grade uranium deposits many of which are also enriched in rare earth elements. However, the question of origin for U and REE remains debated. While the presence of high uranium concentrations in the basement rocks and their proximity to URU deposits provide strong evidence to the basement source model, recent studies propose a potentially significant source within the basin sediments themselves. This study aims to analyze the petrographic features and major/trace element compositions of detrital and diagenetic accessory minerals in Athabasca Basin sandstones to contribute new data to source debate.

Scanning electron microscope – energy dispersive spectroscopy (SEM-EDS), SEM-cathodoluminescence (SEM-CL), Raman spectroscopy, TESCAN integrated mineral analyzer (TIMA) mapping revealed intense alteration patterns within U- and REE-rich minerals like zircon, rutile, and anatase. Notably, alteration halos of U and REE depletion were observed not only at the mineral rims but also deep within their cores, indicating their release into the basinal fluids during alteration. In contrast, analyses of aluminum phosphate sulfate (APS) and hematite minerals revealed enrichment of REEs, primarily in their outer rims, suggesting capture of these elements from the fluids and potentially pointing towards their role as important "sink" minerals for REEs within the basin.

These findings provide compelling evidence for the multifaceted role of accessory minerals for U and REE storage and mobility in the URU deposits in the Athabasca Basin. The observed release from altered minerals like zircon and rutile, coupled with REE uptake by APS and hematite, paints a picture of mineral-fluid interaction between these minerals and the basinal fluids. Further quantification of elemental exchange using combined LA-ICP-MS and EPMA data, alongside existing whole-rock analyses, will allow us to estimate the potential volume of U and REE sourced from the Athabasca Basin. Results from this study may provide exploration strategies for exploration models and resource assessment in URU deposits in the Athabasca Basin and similar geological settings.

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Muscovite and K-feldspar compositions as geochemical fractionation indicators in the exploration for LCT pegmatites: A case study from the Yellowknife Pegmatite Province, Northwest Territories, Canada

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Granitic pegmatites of the Yellowknife Pegmatite Province (YPP) are important potential sources of rare metals, including lithium, tantalum, and tin. These pegmatites occur as dykes, commonly in

clusters. The geological and mineralogical characteristics of these pegmatites vary significantly, with both mineralized and barren pegmatite bodies occurring together in the same cluster; this variability hinders regional assessment of these important critical mineral resources. Fertility indicators of rare-metals mineralization in granitic pegmatites include high concentrations of incompatible alkali elements (Li, Rb, and Cs) in primary muscovite and K-feldspar occurring both within the pegmatites themselves and in other late tectonic granitic plutons. This study highlights the suitability of using mineral chemistry to rapidly assess the mineralization potential of pegmatites in the YPP, particularly their usefulness in cases where outcrops are limited.

Laser ablation-multicollector-inductively coupled plasma-mass spectrometry (LA-MC-ICP-MS) was used to determine the concentration of alkali (including Li, K, Rb, Cs) and high field strength (Ti, Ta, and Nb) elements within primary muscovite and K-feldspar in 29 samples collected from several pegmatites in YPP during reconnaissance field visits in 2022. Over 120 spots were analyzed in each mineral.

Preliminary results indicate that muscovite grains contain up to 577 ppm Li, 92,421 ppm K, 21460 ppm Rb, 2324 ppm Cs, 259 ppm Nb and 158 ppm Ta, and K-feldspar up to 2,004 ppm Li, 158,441 ppm K, 3,731 ppm Rb, 199 Cs, and 27.6 ppm Tl. These give average K/Rb and K/Cs ratios of ~4 to 75 and 35 to over 6,800 for muscovite and ~40 to over 2,500 and ~539 to over 66,272 for K-feldspar. The lower the ratios, the higher the degree of fractionation and the mineralization potential. Over 75% of the approximately 140 analyses on muscovite grains had K/Rb ratios less than 40, which indicates a high degree of fractionation and a corresponding high rare-metals mineralization potential. This was corroborated by the high Li content (>200 ppm) of the analyzed spots.

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Petrographic, Geochemical, and Structural Analysis of Pegmatite-Hosted REE Mineralization in the Forget Lake Area, Northern Saskatchewan

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Rare earth elements (REE) have become an integral part of the economy as they provide for green technology, which is currently in high demand. In recent years, a number of REE occurrences have been found in the Beaverlodge Domain, northeast of Lake Athabasca. Even though exploration has been on the rise in these areas, many deposits remain to be discovered. Geological characterization and genetic studies of the REE mineralization are required to guide further exploration. In particular, the southeastern part of the Forget Lake area, which contains known REE mineralization, has yet to be documented. In the summer of 2023, a three-hole drilling program was conducted in this area to discover its possible REE mineralization hosted by pegmatites. This study will provide documentation of field geological, structural, geochemical, and petrographic analyses of this area. Additionally, it will discuss about the genesis of the REE mineralization and its implications for future exploration in the area.

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Fluid inclusion analysis of mineralizing fluids of the Maw Zone REE deposit, Athabasca basin – significance for REE and unconformity-related uranium mineralization in the Athabasca basin

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REE mineralization is a crucial source for critical metals, and while most mineralization is related to carbonatite or granites, significant REE concentrations and mineralization in Proterozoic sedimentary basins has been observed. The Athabasca basin is known worldwide for its rich endowment in unconformity-related uranium (URU) mineralization and has therefore been the subject of previous studies to constrain the fluid characteristics and evolution history to understand the genesis of these deposits. Most URU deposits within the basin contain elevated REE concentrations, and the discovery of the Maw zone REE deposit, which occurs in proximity to URUs but is barren in uranium, has provoked consideration of a potential genetic link between URU and REE mineralization and the investigation of the REE potential of Proterozoic basins. Fluid inclusion within minerals occupying the same paragenetic sequence as mineralization (drusy quartz), provide samples of paleofluids, and can be used to obtain compositional, geochemical, and pressure/temperature data on these fluids. Previous studies on fluid inclusions related to ore-forming fluids of the Maw zone have not used quantitative geochemical analysis, and studies on the ore-forming fluids of the basin have analyzed inclusions with regard to U and not REE. Preliminary microthermometric studies on samples from the Maw zone show much higher salinity and temperature variations within single fluid inclusion assemblages than previously reported and may give new insight on fluid properties and conditions. Ongoing study of inclusions from these samples (including microthermometry, cryogenic Raman spectroscopy, and LA-ICP-MS) will be conducted, and results will be compared to fluid inclusions from background portions of the basin to investigate the fluid histories and mixing properties, potential genetic link between REE and URU mineralization and REE potential of the basin, as well as to address potential sources, fluid pathways and chemical traps responsible for REE and URU mineralization in the basin.

500 Volcanogenic Massive Sulfide (VMS) Deposits

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Hydrothermal alteration and volcanic stratigraphy at the Paleoproterozoic Kay Mine volcanogenic massive sulfide deposit, Black Canyon City, Arizona, USA

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The Kay Mine volcanogenic massive sulfide deposit is hosted by 1.79 – 1.76 Ga bimodal volcaniclastic rocks of the Black Canyon Creek Group in the southernmost portion of the Central Volcanic Belt of Arizona. The deposit has a historic resource of 6.4 million short tons of massive sulfide grading 2.2% copper, 3.0% zinc, 2.8 g/t gold, and 55 g/t silver, using a cut-off grade of 2% copper-equivalent. The massive sulfides are hosted in an interval of intermediate to felsic volcaniclastic rocks, with textural evidence suggesting that much of the mineralization formed by subseafloor infiltration and replacement. The seafloor position within the volcaniclastic-dominated volcanic succession is marked by carbonaceous mudstone located at the transition from intermediate and felsic volcaniclastic rocks to overlying mafic coherent and volcaniclastic deposits. The massive sulfides are stratigraphically underlain by a zone of intense chlorite alteration that hosts abundant chalcopyrite stringers.

The massive sulfides of the Kay deposits and their volcanic host succession are located within a high-strain zone. Primary volcanic textures are difficult to recognize macroscopically, which complicated reconstruction of the volcanic architecture through core logging. This study employs state-of-the-art core scanning techniques, which includes the use of a Minalyze continuous X-ray fluorescence core scanner to provide chemostratigraphic information and to determine alteration-induced geochemical gradients. In addition, hyperspectral core scanning is conducted using a core scanning system equipped with a HySpex SWIR-384 camera. New advancements now allow for the co-registration of these datasets based on depth. Interpretation of the data has identified geochemical and corresponding mineralogical gradients that can be used to determine proximity to the massive sulfides. Ongoing research will allow for the creation of a more robust exploration model for massive sulfide deposits in central Arizona.

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A Review on Modified Volcanogenic Massive Sulphide Ore Bodies: Scale, Processes, and Implications

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The architecture of ancient volcanogenic massive sulfide (VMS) ore bodies is the result of both initial depositional settings and subsequent metamorphic and deformational events. Given the dynamic nature of the tectonically active settings where VMS deposits form, these massive sulphide ore bodies inevitably undergo modifications through deformation and metamorphism. Volcanogenic Massive Sulphide deposits host significant resources of zinc and copper, with

smaller quantities of lead, gold, silver, and other metals. Understanding the syn- and post-depositional features of VMS ore bodies aids in interpretation of ore body formation, modification, and preservation, and advances the creation of mineral exploration targets. This poster reviews typical structural characteristics frequently found in ancient VMS deposits in Canada.

Syn-depositional or primary ore body structures are significant and can be difficult to distinguish from post-depositional modifications. Primary ore body structures include vertical stacking of ore bodies as they become buried by subsequent volcanic sequences and zoning of metals related to thermal changes over the evolution of VMS systems. Hydrothermal alteration of ore and host rocks in VMS systems are substantial, creating platy and fibrous minerals (e.g., chlorite, sillimanite) that are excellent in recording syn- and post-depositional deformation phases in what would otherwise be rocks with fine grained and equidimensional minerals. Tectonic settings also affect primary ore body architecture, particularly as VMS centres subside creating truncated, thickened, and sometimes fault-offsets of the ore bodies and the hosting volcanic and volcaniclastic sequences.

Controls on the grade and tonnage of VMS deposits remain poorly understood. Primary processes that lead to relatively higher grades and tonnes of ore include sub-seafloor replacement (rather than exhalative systems) and syn-depositional ore mineral zone refining via mineral dissolution and replacement by relatively higher temperature metal-bearing fluids. Post-depositional deformation events may have important roles in further increasing grades, tonnage, and feasibility of mining of VMS ore bodies. These upgrading post-depositional deformation processes include ore body stacking via faulting and folding and the creation of mono-mineralic banding via shearing. Elements of interest, such as germanium and gallium, may coalesce into economically viable concentrations by metamorphic partial melting of sulphides. The scale and impact on grade and tonnage of these post-depositional processes remains open to debate. The roles of fluids in the chemical remobilisation and fluid-assisted mechanical remobilisation remains an interesting research area, particularly with respect to the temporospatial relationships to primary rift-related faults and later orogenic faults that provide fluid pathways.

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

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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 identify future targets. Carbonaceous argillites or black shales are common ore-hosting units. Their electromagnetic properties resulted in many of these rocks being targeted during drilling campaigns. This resulted in a vast yet widely underappreciated archive that may hold valuable information to locate deeper mineral deposits. The black shales are mainly synvolcanic and formed in volcanosedimentary basins spatially correlated with magmatic complexes. This study uses data collected from a regional-scale sampling program that took place in 2011. Samples of carbonaceous argillite were collected from over 500 drill holes in cores at the Ministry of Northern Development and Mines as well as from 19 different private companies operating in

the area. Most samples (90%) were collected at a depth of less than 200 m below the surface. Whole-rock geochemical analysis was performed on 564 samples from more than 75 different townships.

The present study examines spatial variations in the geochemistry of the shales and evaluates their relationship to the host volcanic rocks. Mobile and immobile element ratios have been used to determine the likely provenance of the mudstone units (e.g., ranging from variably altered mafic-ultramafic to felsic volcanic source rocks). These data can identify potentially favourable volcano-sedimentary successions favourable for hosting different types of mineralization (e.g., VMS as well as orogenic Au). Map pair analysis in ArcGIS Pro and the software R were used to identify the different lithologic units represented in the data set. Trace element differences between the lithologic units suggest different geologic processes controlling their distribution, including units with a greater potential for mineralization such as ultramafic rocks or altered felsic volcanic rocks even where these rock types are not exposed or not intersected in near-surface drill holes.

Various elements were used to identify possible source volcanic rocks and potential hydrothermal input, including Zr/Ti/Sc and Hg. As the source rock undergoes igneous fractionation processes differences in compatibility and element ratios were used to discriminate between a mafic or felsic parent material. High field strength elements reflect weathering, heavy mineral sorting, and discriminate sediment sources and the degree of sediment recycling. This study differentiates the unique chemical signatures of shales derived from different source domains, deposited in different environments, and having different prospectivity.

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Crustal architecture of the EMARK Oceanic Core Complex south of the Kane Fracture Zone, Mid-Atlantic Ridge

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Oceanic core complexes are domal structures which have been uplifted and exposed at the seafloor by long-lived slip along deep-seated, low-angle, detachment faults. This is an important process of crustal accretion, exposing large sections of lower crust and upper mantle material at the surface, as well as for the formation of hydrothermal ore deposits. Oceanic core complexes have been observed in ultraslow and slow-spreading mid-ocean ridges, especially along the northern Mid-Atlantic Ridge, however most studies of oceanic core complexes and their associated hydrothermal activity focus on mature complexes in late to end stage development. Research herein examines a young, early-stage oceanic core complex called the EMARK (East Mid-Atlantic Ridge Kane) at approximately 23°N, just south of the Kane Fracture zone on the Mid-Atlantic Ridge and east of the Kane oceanic core complex, a well known, mature example.

In collaboration with Schmidt Ocean Institute, high-resolution bathymetry, remotely operated vehicle dive observations, and sampling at EMARK have uncovered this large, in-situ crustal section in detail. Results from remote predictive geologic mapping illustrate the crustal architecture of the EMARK oceanic core complex from the uppermost paleo-seafloor basaltic flows to sheeted dyke complexes to gabbroic sills and mainly gabbroic dome to serpentinites at the deepest part of the exposed fault surface. Adjacent active black smoker hydrothermal chimneys were also discovered on an offshoot of the spreading axis. The abundance of gabbro

sampled in addition to local high-temperature hydrothermal venting, suggest robust magmatism during the development of the oceanic core complex, in contrast to the general model of detachment faulting during periods of relatively low magmatism. Furthermore, these findings indicate that detachment faulting and oceanic core complex development may increase potential for hydrothermal ore formation providing fluid pathways, even in early stages of development. This work has implications for the understanding of oceanic core complex evolution, controls on the formation of hydrothermal ore deposits and future exploration of these deposits.

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The Structural and Volcanic evolution of the hydrothermally active Puy des Folles volcano at 20.5 °N on the axis of the Mid-Atlantic Ridge

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On the FKt230303 expedition to the Mid-Atlantic Ridge (MAR) aboard the Schmidt Ocean Institute's R/V Falkor in search of hydrothermal lost cities, the Puy des Folles volcano was discovered using multibeam sonar from both the ship and MBARI Mapping Autonomous Underwater Vehicles (AUVs). The Puy des Folles volcano has significant economic potential due to the presence of Sulphide Massive Sulphide (SMS) deposits. SMS deposits are mineral accumulations, including copper, zinc, lead, gold, and silver, formed through hydrothermal venting near the seafloor. Interesting areas were investigated and sampled using the Remotely Operated Vehicle (ROV) SuBastian. The AUVs conducted surveys at a 50-meter altitude, providing 1-meter lateral resolution bathymetry, sidescan, and chirp subbottom profiles for the entire summit.

The oval-shaped Puy des Folles volcano, measuring approximately 3.5 km by 7 km, is situated on the MAR axis at coordinates 20.5°N, 45.6°W, aligning with small transform offset and in between segments of non-transform motion, where magmatism is not expected. Unlike a summit caldera, the summit platform, located at approximately 1900 meters depth, is nearly level but heavily faulted. Scalloped landslide scarps define the platform's east and west boundaries, revealing steep, smooth slopes likely composed of talus material.

The unusual structure of the Puy des Folles volcano in an unexpected area raises speculation of why magmatism is focused on this region, what are the timing of the events, and what are the controls on where the vents form. Methods include remote-predictive mapping in ArcGIS software. The mapping will reflect the hydrothermal precipitates, fluid venting, flow morphology, structure, and sediment cover of the summit based on the AUV bathymetry and ROV dive tracks. Volume calculation of precipitates will be done as age detection for the summit based on sediment cover. Preliminary results feature the western half of the summit with a prominent ~1 km-wide complex of grabens and fault blocks, aligned with the ridge's spreading axis. In contrast, the eastern half displays deformation through faults parallel and oblique to the ridge, showcasing numerous lava flow channels, exposed lava flows combined with layered volcanic breccia deposits, and hundreds of pits.

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Mineralogy and Genesis of Critical-Metal Bearing Mineralization in the Betts Cove and Tilt Cove Volcanogenic Massive Sulfide (VMS) Deposits, Baie Verte, Newfoundland Appalachians

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This work focuses on the origin and genesis of critical metals (e.g., Cu, Co, Ni, Zn) in the Cu-Zn-Ni-Co-bearing Betts Cove and Tilt Cove volcanogenic massive sulfide (VMS) deposits, Newfoundland Appalachians. The mineralization at Betts Cove and Tilt Cove consists of stringer-type stockwork mineralization with lesser massive/semi-massive mineralization dominated by predominantly chalcopyrite, pyrite, pyrrhotite, and sphalerite with lesser acanthite, arsenopyrite, chromite, bornite, cobaltite, clausthalite, magnetite, pentlandite, electrum, silver telluride, and galena. Electron microprobe mineral chemical results show that Cu and Zn are unsurprisingly hosted in chalcopyrite and sphalerite, respectively, whereas Ni and Co are found in pyrrhotite and pyrite, respectively.

Evaluation of the assay database (n= 1066 analyses from Betts Cove and n= 343 analyses from Tilt Cove) using unsupervised machine learning algorithms, principal component analysis (PCA) and K-means clustering illustrate that in both the Betts Cove and Tilt Cove deposits there are specific metal associations, including: Zn-Cd-Au, Pb-Ag; and Cu-Mo-Se in Betts Cove; and Zn-Cd-Mo-Au-Ag and Cu-S-Pb-U in Tilt Cove. The clusters of data reflect different lithologies, alteration, and types of mineralization (Zn- vs Cu-rich), including barren from mineralized samples. Supervised machine learning methods, including logistic regression, neural networks, SVM, and K-nearest neighbour, were best at classifying assay data in the Betts Cove and Tilt Cove deposits, with model success rates of ≥ 99.0% and could be used for automated assay/cluster classification of future assay results. The elemental clusters also reflect VMS mineralization processes. The Zn-Au association suggests Au is associated with sphalerite-rich mineralization and was likely precipitated from a low temperature (< 300°C), near neutral pH, and reducing hydrothermal fluids. The Cu-Mo and Cu-Se association suggests Mo and Se are associated with chalcopyrite-rich mineralization and were precipitated from a high temperature (> 300°C), acidic, and reducing hydrothermal fluid with a potential magmatic-hydrothermal component of metals. Spatial models of the assay data and the mineralization in the Betts Cove and Tilt Cove deposits, exhibit VMS zoning of a Cu-rich inner zone surrounded by a Zn-rich outer zone and can be best explained by zone refining processes whereby the deposits grew through replacement of earlier formed lower temperature (< 300°C), Zn-rich mineral assemblage of sphalerite and pyrite by a higher temperature (< 300°C), Cu-rich mineral assemblage of chalcopyrite. The results of this work demonstrate that integrated fieldwork, spatial analysis, and integration with assay database evaluation using machine learning methods can provide insights into VMS deposit forming processes.

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Off-axis volcanism, its geologic controls, and associated hydrothermal activity in the North Fiji Basin

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Mid-Ocean Ridge (MOR) and Back-Arc Basin (BAB) volcanism accounts for two-thirds of global volcanic production. The majority of this volcanism occurs along the axis of the spreading centers as the dominant form of crustal accretion. Recently compiled high-resolution bathymetric data from the North Fiji back-arc Basin (NFB) reveals that a large number of off-axis or intraplate volcanoes may also contribute to the overall crustal growth. Intraplate volcanism may also provide the necessary heat to drive hydrothermal fluids in areas that are less well studied than along spreading centers. This study attempts to quantify the amount of off-axis and intraplate volcanism in the NFB and determine the underlying controls on the density and distribution of the observed volcanoes.

The NFB began opening at ~12 Ma and has reached nearly 1,000,000 km² in area. The cumulative length of actively spreading ridges is 2500 km. Many of the spreading ridges are hydrothermally active, and the anomalous heat flow of the basin may be an important analogue for VMS-hosting greenstone belts on land. In order to quantify the amount of volcanism in the NFB, volcanic centers have been mapped throughout the basin at a scale of 1:100,000 using Remote Predictive Mapping (RPM) techniques applied to different geophysical and acoustic datasets, such as ship-based bathymetry, acoustic backscatter where available, gravity and magnetics. Detailed geological maps were generated and compiled in ArcGIS Pro.

High-resolution volumetric measurements of the mapped volcanoes relied mostly on ship-based bathymetry to locate and classify the seafloor features. Magnetic data were used to pick crustal ages and thereby establish area-age relationships relative to spreading in the NFB. We then superimposed the on- and off-axis volumes of discrete volcanic edifices on the background crust. The assembled data included the total area, total volume, number of polygons, average area/polygon and average volume/polygon for each volcano and volcano class. These data were then compared to other sources of melt accretion in the basin, in particular at the active spreading ridges. In study area, we mapped >900 volcanoes, with dome type volcanoes being the most abundant. The total area of mapped volcanoes was >4525 km². Larger volcanic edifices are found in the northwest of the NFB compared to smaller volcanic edifices in the rest of the basin. These preliminary results suggest anomalous volcanism occurred in the northwest over the last 12 Ma.

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Characterizing mafic metavolcanic rocks and the nature and timing associated hydrothermal alteration rocks on Parker Island, Wollaston Lake, Saskatchewan

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The Wollaston Supergroup is a Paleoproterozoic succession of metasedimentary and metavolcanic rocks known to host base metal mineralization. This study is focused on the

Hidden Bay Assemblage, which comprises a distinct quartzite-psammite–mafic metavolcanic rock succession, interpreted to form the base of the Wollaston Supergroup. Such rocks are located on the west-central side of Wollaston Lake, Saskatchewan, and contain minor quantities of disseminated sulphide minerals. On Parker Island, the focus area of this study, mafic metavolcanic rocks are massive to foliated and contain primary textures. Other rocks of interest to this study include quartzite-psammite and alteration rocks that include nodular quartz-sillimanite, anthophyllite-cordierite rocks and garnetite. Pyrite and arsenopyrite are present in all rocks on Parker Island, which in addition has a known minor Au occurrence. This investigation studies the field characteristics, mineralogy and geochemistry of these mafic metavolcanic rocks, aiming to enhance understanding of their primary nature and tectonic setting. This will provide valuable insights which could guide prospective exploration efforts for base metal mineralization in the area. In addition, apparent related alteration rocks include cordierite - anthophyllite ± biotite ± sillimanite mineral assemblages which will be investigated to determine whether there is potential for base metals. As such, 11 rock samples were collected and prepared as thin sections which have been examined using transmitted and reflected light microscopy. Whole-rock geochemistry using ICP-OES and ICP-MS was performed on nine of these samples plus an additional three from previous field work. Mafic metavolcanic rocks were then geochemically characterized. The geochemical relationship between mafic metavolcanic rocks and the alteration rocks were evaluated using isocon analysis. The elemental exchange was modelled using mass-balance calculations from the isocon method to determine chemical gains and losses from alteration-related elemental exchange.

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Seafloor Lineament Mapping of the Grappe Deux Non-Transform Discontinuity, Mid-Atlantic Ridge: Implications for Off-Axis Hydrothermal Activity and Volcanism

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The Grappe Deux/Cluster-2 region (45.5°W / 24.9°N) demonstrates one of numerous Non-Transform Discontinuities (NTD) that exist along the Mid-Atlantic Ridge, located between the Kane and Atlantis Fracture Zones. NTDs represent accommodation zones for tectonic stresses that are not wholly characterized by strike-slip motion, but are instead comprised of diffuse faulting structures with interspersed basins and highlands arranged relative to the propagation direction of the ridge axis. It is typical of NTDs to be correlated with relatively low volcanic activity (slow-spreading ridges), which increases the role of tectonic accommodation structures (i.e. deep crustal faulting) and can result in exposures of Oceanic Core Complexes (OCC). Grappe Deux illustrates one such example of OCC exposure that was recently targeted for exploration by researchers from IFREMER.

A recent hydrothermal venting exploration cruise by Schmidt Ocean Institute's R/V Falkor (Too) visited the Grappe Deux OCC, and provided new insights into the tectonic history of NTDs and their capacity to host off-axis neovolcanic zones and hydrothermal vent systems. The off-axis setting, deep faulting, and elusive source of volcanism collectively demonstrate unique controls

on hydrothermalism that have not yet been studied in depth. The newly discovered Hydra vent field was identified here, and is hosted adjacent to a detachment fault surface within young basaltic flows directly overlying serpentinized mantle rock. Serpentinization reactions have contributed to this hydrothermal system, through exothermic reactions, resulting in highly reducing fluid conditions with abundant H_2 concentrations. Here we present lineament and polygon mapping from 1-meter lateral resolution AUV bathymetric maps of the Grappe Deux OCC, with integrated data from hydrothermal and igneous ROV grab samples. The results of these datasets provide new context to the tectonic, volcanic, and hydrothermal relationships in NTDs, which can thereafter be applied to the numerous other NTDs across the global oceans, to further assess the potential for hydrothermal and volcanic activity in previously overlooked segments of mid-ocean ridges, and the relationships between these phenomena and OCC exposure.

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Structural Model of the VHMS of La Plata, in the Western Cordillera of Ecuador

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The current study has developed the structural model of the VHMS la Plata in the Leapfrog Geo modeling software using the implicit modeling method. It integrates lithological, geochemical, and structural information collected on the terrain and subsurface. The project comprises 1,079 mapping points, 77 trenches, and 127 drill holes drilled from 1996 to 2017. The model defines the geometry, distribution, and spatial orientation of the host units, ore zone, and primary and secondary structural surfaces, potentially useful in developing the mineral resource and reserve estimation model. La Plata is a polymetallic mineral deposit dominated by massive sulfides of sphalerite, chalcopyrite, pyrite ± galena, gold, and silver, bounded by quartz, sericite, pyrite ± chlorite alteration halos. It is hosted by volcanic and volcano-sedimentary rocks from the Paleocene-Eocene Macuchi Unit in the Western Cordillera of Ecuador. Research results define that the VHMS is located within a 5 km long and 250 m wide north-south trending mineralized corridor controlled by dextral-reverse faults. It is affected by at least one tectonic deformation event, divided into two phases. The first phase developed in a dextral strike-slip regime, associated with asymmetric sigmoidal boudin structures generated by stretching in a ductile environment and NE-SW dolerite intrusions, while the second phase exhibits a progressive deformation linked to the first phase with the generation of transverse transfer faults, compressional structures associated with duplexes, fault fold geometries, and andesitic and rhyodacite intrusions parallel to the fault zones. East-west sinistral and northeast-southwest dextral transfer faults separate the corridor into five structural blocks from south to north: La Mina Sur, La Mina Norte, Quebrada Tajo, Guatuza, and San José.

600 Sedimentary Environments

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Germanium enrichment constraints in Zn-Pb sediment/carbonate-hosted mineral deposits

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Germanium (Ge) is a crucial mineral in advancing technology, especially in the field of solar energy. It is commonly recovered as a by-product of zinc (Zn), which introduces potential future supply risks, defining it as a critical mineral. Globally, Ge is often sourced from Zn-Pb sediment-hosted mineral deposits. So, understanding the factors leading to Ge enrichment in these deposits is essential. Here we present analyses from the Ge-bearing Zn-Pb (Ag) Prairie Creek sediment-hosted deposit in the Northwest Territories near the Selwyn Basin. This deposit exhibits three mineralization styles: stratiform, main quartz vein, and "stockwork", hosted in Ordovician to Silurian sedimentary rocks. Our objective is to elucidate the genetic model, as the relationship between these mineralization types is not completely understood, and to identify the major constraints to Ge accumulation by performing macro to nano-scale analyses.

We will present preliminary results from a field visit in the summer of 2023 including core-logging of 25 drill holes distributed across different sections of the ore zone, along with systematic sampling (150 samples). Samples comprise the three mineralization styles and various horizons of the host rocks, particularly the upper Whittaker formation. In addition, over 25 samples were collected from distal holes to understand depositional redox conditions during sedimentation. Initial analysis reveals a very low S/C ratio, indicating anoxic conditions.

To identify constraints in the formation and evolution of the Prairie Creek deposit, we will employ several analytical techniques such as optical microscopy, SEM, EPMA, LA-ICP-MS, EBSD, and APT. These analyses along with isotopic studies aim to recognize the Ge distribution in the deposit (macro to nano-scale), the sources of metals and sulfur, the ore-forming fluids nature, and conditions for metals precipitation and preservation. These insights will contribute to a better comprehension of Ge behavior in hydrothermal fluids in sedimentary environments, guiding mineral exploration strategies targeting these deposits.

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Li Sources in Western Canada Sedimentary Basin Brines

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Decarbonization of the economy is a major climate change goal of many nations and this will require a significant increase in the production of metals required in clean energy technologies including lithium (Li). Demand for Li has been projected to increase 8x by 2040, leading to a "lithium rush" to identify new sources and deposits of this critical metal. While current production is predominantly from pegmatites and continental brines, brine-hosted Li deposits from sedimentary basins are receiving significant attention and investment in recent years. In the Western Canada Sedimentary Basin (WCSB), Li enrichments have been discovered in brines hosted in Late Devonian-aged strata. However, the source of the Li and the reason why only these intervals contain Li enrichments remain the topic of debate, both in industry and academia.

This work discusses the proposed sources of Li in brine-hosted deposits of the WCSB and presents new geochemical and isotopic data from both brines and drill core. While previous studies have proposed a seawater origin, either through seawater evaporation or evaporite dissolution, or basement fluid sources, a growing body of evidence points toward in-situ water-rock interactions with Li-rich clays as the primary Li source. This includes, isotopically light δ^7Li signals, the presence of Li-rich clays, a lack of enrichment in over- and under-lying strata, and comparisons to continental brine deposits as a modern analogue. Constraining the source of Li is the first step in developing an exploration model for brine-hosted Li deposits in sedimentary basins that can be applied across the WCSB and other basins globally. These deposits are attractive as a Li source since they have significantly lower environmental impacts and productions costs than spodumene or continental brine deposits.

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Petrography and Economic Potential of Banded Iron Formation of the Neoproterozoic-Age Buem Formation, Ghana

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Historically, Ghana has relied mostly on gold, bauxite, and manganese as the major contributors to the domestic economy. Further investigation into other minerals to transform the mining sector in Ghana focused on detailed geologic field mapping and sampling. The Buem Formation of eastern Ghana, previously unrecognized as a potential source for ore deposits, was found to host banded iron formation.

The Buem Group comprises a complex series of metasedimentary, volcaniclastic, and volcanic rock units, including poorly-defined banded iron formation occurrences. This study reports initial petrographic observations and economic assessment of the Gyamurume – Wawase Range, one of the host regions for BIF. The petrographic studies show that stratigraphic contacts between dominantly steely hematitic ferruginous horizons and siliceous strata are distinctly sharp and abrupt. Most hematite comprises micron-scale, irregular grains interstitial to granular, undulatory-extinction quartz; cross-cutting coarse quartz veinlets are barren of iron oxides. Although some BIF strata show former magnetite skeletal textures, even cm-scale ferruginous strata show only trace residual or relic magnetite. Initial studies of the mineralogical composition of Beum Formation BIF show that steely hematite is abundant, with nominal or no magnetite. No other silicate minerals are observed. The studies will also assess the trace element contents of Beum Formation iron minerals, with emphasis on the P and Ti contents on hematite-dominant strata as a means of distinguishing low-contaminant, potentially economic horizons.

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Cobalt sulfide ore characterization of the Kwatebala and Mwadinkomba deposits, Tenke-Fungurume Cu-Co mining district, DRC

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The Tenke-Fungurume Cu-Co mining district (TFM) in the DRC is host to one of the largest Co resources known to date (2.48 Mt Co). The mining district is located in the northwestern tip of the Central African Copperbelt, the largest sedimentary rock-hosted Cu-Co metallogenic province in the world. The two main Co ore minerals present at TFM are the hydroxide heterogenite (CoO(OH)) and the sulfide carrollite ($CuCo_2S_4$). Heterogenite is the weathering product of carrollite, and is present from surface to depths of 70 to 150 m. Future mining at TFM will see a higher proportion of sulfide-bearing materials. Characterization of the Co sulfide ore is therefore needed to enhance its processing and improve recovery rates.

To better understand Co mineralogy at TFM samples with Co grades from 0.05 to 3% Co from the Kwatebala and Mwadinkomba deposits were examined. The samples are from the Mines and R.A.T. stratigraphic subgroups and comprise coarse-to-fine-grained dolomite, dolomitized shale and siltstone. Carrollite occurs as stratiform-to-disseminated grains or nodules in carbonate-rich, shale-poor layers. Carrollite was also observed as 50-to-100 µm-sized euhedral grains within the quartz-carbonate veins in the high-grade Co samples. Stratiform and disseminated carrollite commonly contain abundant chlorite, muscovite, dolomite and quartz inclusions, whereas vein-hosted carrollite is generally inclusion-free. Carrollite is spatially, but not necessarily paragenetically associated with bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$), and chalcocite-digenite (Cu_2S – Cu_9S_5). Higher grade Co samples display a large range of carrollite grain sizes, varying between 40 and 5,000 µm. Carrollite in the R.S.F. unit from the Mines subgroup is poor in most trace elements, with the exception of As (4,000 – 100 ppm), Ni (2,000 – 200 ppm), Sb (800 – 30 ppm), Se (100 – 3 ppm), and Mo (100 – 1 ppm).

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Mineralogical variation and paragenesis of the mineralisation and alteration at the Neoproterozoic Rosh Pinah Zn-Pb-Ag deposit, Namibia

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The Rosh Pinah Zn-Pb-Ag-Ba deposit in the Gariep Belt, southern Namibia comprises a significant sulfide resource (19.94 Mt @ 7.3 wt% Zn, 1.83 wt% Pb and 27.7 g/t Ag) hosted within the volcanosedimentary units of the Rosh Pinah Formation of the Port Nolloth Group. Silicification and dolomitization have previously been identified as the major alteration styles present which destroyed many of the original textures in the host rocks to the deposit. However, the timing and the possible presence of other significant alteration events have not been properly constrained, nor have the age and genetic relationships between alteration and mineralization

events. This study combines transmitted and reflected light petrography, scanning electron microscopy, hot cathodoluminescence, laser ablation ICP MS and whole rock geochemistry to elucidate types and timing of different alteration and mineralisation phases, and to relate the alteration/mineralisation to the stratigraphic and structural architecture. It also aims to elucidate the fluid pathways that may have helped localise mineralisation. Dominantly replacive pyrite, sphalerite, galena and minor chalcopyrite, are hosted within weakly metamorphosed altered argillites, siltstones, carbonate rocks and volcaniclastic rocks collectively known at the mine as the Ore Equivalent Horizon. This interval displays variable alteration, with the fine siliciclastic units (argillite and siltstones) affected mainly by silicification and barium enrichment of both detrital and authigenic feldspars and phyllosilicates. Carbonate rocks were affected by multiple dolomitization events.

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UV fluorescence as an exploration tool in carbonate replacement deposits

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Carbonate replacement deposits (CRDs) are challenging exploration targets because alteration haloes in carbonate rocks surrounding the deposits are often difficult to identify, a phenomenon known as cryptic alteration. The Olympias deposit is located in Greece and is associated with Oligocene magmatism within the West Tethyan Magmatic Belt. The replacement-style orebodies are hosted in marble, which is interlayered with feldspar-biotite gneiss of the Permo-Carboniferous Kerdylia Formation. The orebodies generally follow the gently-dipping marble horizons and steep normal faults, such as the Kassandra fault. Mineralization formed during the Late Oligocene synchronous with local magmatism. The ore mineralogy of the Olympias deposit consists of sphalerite, galena, and arsenopyrite, with Ag and Au strongly associated with galena and arsenopyrite, respectively. Olympias deposit contains significant resources of gold and base metals. Specifically, the total measured and indicated resources of Olympias deposit in September 2022 contains 3.3 Moz Au, 61.6 Moz Ag, 0.64 Mt Pb, and 0.83 Mt Zn, with significant average grades of 8 g/t Au, 143 g/t Ag, 4.8% Pb and 6.3% Zn. This study aims to characterize, quantify, and map the cryptic alteration footprint around the Au-rich Olympias polymetallic CRD.
A portable XRF instrument and a short-wavelength UV lamp were used on drill core and rock samples from Olympias to assess how carbonate mineral chemistry in veins and wall rocks varies with distance to known mineralization. Haloes of Mn enrichment around mineralization (and interpreted fluid pathways) were recognized from portable XRF measurements. Manganese-enriched calcite veins and marble layers typically fluoresce pink-orange colour under UV light with variability controlled by Fe content, making UV fluorescence a rapid, inexpensive, field-deployable tool for visualizing cryptic carbonate alteration.

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Redox setting of the stratigraphy that hosts the Prairie Creek Zn, Pb, Ag deposit

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Modeling economic deposits and understanding their nature is essential to the continued improvement of modern mining and exploration techniques. As the demand for critical metals rages, the continued improvement of models must match pace. One such deposit is the Prairie Creek deposit in the NWT. In an effort to better understand these sediment hosted deposits, geochemical analyses were performed on host rocks from the Prairie Creek deposit in the North West Territories of Canada. The Prairie Creek deposit is an Ag, Pb, Zn, Ge deposit with different ore phases exhibiting aspects of MVT, strata bound massive sulphide, and quartz carbonate vein mineralization. Black shale core samples from the deposit were analyzed to determine the paleo redox state of the depositional environment. To do this the samples were subject to sequential Fe extraction and total digestion to determine Fe speciation as well as chrome reduction sulfur extraction for sulfur isotope analysis. Geochemical analysis was performed via ICP-MS and isotope ratio mass spectrometry. Reflected light petrology and an analysis of sulphide framboid size in key structural regions of the deposit act as support for geochemical data and aid in interpretation of depositional conditions by giving insight into the composition of the ore fluids that interacted with the sediment and the degree of preservation of the deposit in the time since deposition.

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The genesis of vanadium-rich black shales in the Richardson Trough, Yukon, Canada

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Vanadium is an essential component of vanadium redox flow batteries, which are expected to play an important role in meeting the requirements of large-scale energy storage. As a result, vanadium is in high demand and is being explored in sediment-hosted deposits, which offer environmentally friendly alternatives to existing vanadium resources (e.g., petroleum ash residue). Here, we explore the genesis of potentially economic vanadium concentrations of the Middle Devonian shales in the Dempster area of the Richardson Trough, Yukon, Canada. The area features the Vittrekwa Formation (median 1249 ppm V), a transition zone (718 ppm V), and the Canol Formation (2120 ppm V). The vanadium in the Canol Formation is hosted primarily in late diagenetic illite, whereas in the Vittrekwa Formation and the transition zone, it occurs in detrital clays and mannardite. Depositional processes and diagenetic mineral reactions influence the deportment of vanadium. The illitization of smectite coincided with the release of organically bound vanadium. This was followed by a coupled redox reaction between V(IV) and S(II), which led to the substitution of V(III) in newly formed illite and the precipitation of pyrite. Acid production via feldspar precipitation and the thermal maturation of organic matter were accompanied by calcite dissolution and the formation of the quartz-hyalophane-barium carbonate assemblage.

The location and architecture of the Richardson Trough created an environment conducive to vanadium scavenging from the water column, with a connection to the surface waters sufficient to prevent trace-metal depletion (e.g., a basin reservoir effect) and hydrographic restriction sufficient to maintain deeper water euxinia. Additional mechanisms such as enhanced primary productivity, organic matter preservation and a stratified water column led to the partitioning of organically bound vanadium into clay and oxide minerals during late-diagenesis.

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Analyzing the abundance and distribution of trace elements using nanoscale techniques from sedimentary pyrite framboids

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Pyrite (FeS_2) formed in sedimentary environments serve as critically important sulfide minerals due to the inclusion of trace elements providing insight into paleoclimate. In addition, the result of isotope fractionation and the recorded ratio of sulfur isotopes offer detail on the evolution of ocean redox. Together, trace element abundance and sulfur isotopes can be used to reconstruct early conditions on Earth and better understand periods of ocean anoxia. Trace elements in marine systems are held in the structure of pyrite framboids (spherical clusters of microcrystals), though the exact mechanisms involved in the formation of these framboids are poorly understood. The distribution of trace elements at the nanoscale can give context for the timing and dynamics involved in incorporating a given element. Open vs. closed system dynamics (which provide further context for the formation of framboids), can also be determined by ratios of sulfur isotopes. In low oxygen conditions sulfate (SO_4^{2-}) is utilized instead of O_2 for respiration, producing H_2S which is ultimately incorporated into pyrite. Framboids forming in an open system are isotopically lighter than the original sulfate, as it is energetically favourable to use the lighter isotope (^{32}S). Recent TEM analyses from the Cariaco Basin and the Demerara Rise have shown that there is significant variation of trace elements in different parts of pyrite framboids. The relative timing of this later trace element enrichment and its relation to S-isotope ratios is unknown. Further research into differences in trace element distributions and sulfur isotope concentrations may provide detail not only about the formative settings, but the enrichment events that make up the formation of a framboid.

In the present study, sediment samples were taken from two sites located in Saanich Inlet (Vancouver Island, BC) – a seasonally anoxic fjord – as the cyclic nature of the site results in chemically distinct conditions over a relatively short period of time. On average, framboids are ~10 µm in size, making nanoscale analyses critical to observe variations within a single framboid, indicative of distinct periods of growth. This study employed the use of transmission electron microscopy (TEM) and atom probe tomography (APT) to observe the distribution of trace elements at the microscopic to nanoscopic scale and measure sulfur isotope ratios. Data will be compared between sites to obtain differences in open vs. closed system dynamics.

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Geological characterization of the Zn – Pb mineralisation of the Lisheen deposit in Ireland

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The aim of this study is to petrologically characterise a selection of sulphide samples, sufficient to bundle them into groups for the interpretation of petrophysical data. The Lisheen deposit consists of stratabound massive and semi-massive Fe-Zn-Pb sulphide lenses at the base of a massive dolostone unit, the Waulsortian Formation, at its contact with a bedded, argillaceous, bioclastic limestone - the Ballysteen Formation. The mineralisation formed by replacement of a hydrothermal dolomitic breccia (the black matrix breccia or BMB) that developed at or near this lithological contact and is intimately associated with mineralisation. BMB development preceded and likely continued throughout mineralisation. The rheological contrasts of contact lithologies resulted in fracture network development during extensional faulting. These combined with permeability contrasts of contact lithologies focused mineralization fluids which through dissolution and replacement augmented fluid conduits at the contact. This classification provides the basis to understand the variations in physical properties and test the effectiveness of geophysical methods on finding specific mineralisation types.

Through geological characterization of 423 samples, noting alteration types, structural features and fossil assemblages, 11 sample groups were devised. Group 1 are massive sulphides, groups 2-6 are types of carbonate host rocks and groups 7-11 are types of host rocks with sulphides. Alongside geological descriptions we conducted pXRF analysis, allowing us to calculate stoichiometrically the percentage of 3 sulphide minerals, sphalerite (ZnS), galena (PbS) and pyrite (FeS_2) and evaluate the total sulphide percentage. Samples with a total sulphide percentage of: ≥40% were categorised as massive sulphide, those <5% were classified as carbonate host rocks and those 5%-40% were classed as carbonate host rocks with sulphides. The preliminary results showed a difference in physical properties with increasing alteration intensity. Density increases with increased alteration intensity, as massive sulphides were denser than carbonate host rocks with sulphides and carbonate host rocks. Inductive conductivity increases with alteration intensity, as massive sulphides have higher inductive conductivities than both types of host rocks. Galvanic resistivity decreases with alteration intensity, as massive sulphides have lower galvanic resistivities than both types of host rocks. Massive sulphide samples were evaluated as either massive sphalerite, massive pyrite or massive galena, or exhibited varied concentrations of the 3 minerals. A subdivision of 6 groups of massive sulphides was formulated: group 1 - sphalerite rich, group 2 - pyrite rich, group 3 - sphalerite and pyrite rich, group 4 - sphalerite and galena rich, group 5 - galena and pyrite rich, and group 6 - galena rich.

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Unravelling the Origin and Evolution of Pentlandite in the Turnagain Alaskan-Type Ultramafic Complex, British Columbia

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The Alaskan-type Turnagain ultramafic complex (British Columbia) hosts a large magmatic sulphide nickel resource in which pentlandite is the principal ore mineral and pyrrhotite the main sulphide. Three main types of pentlandite have been distinguished based on their textures and compositions. Type 1 pentlandite occurs as flames, large blocky crystals within pyrrhotite, and as isolated crystals. The associated pyrrhotite is commonly net-textured. This pentlandite has a Ni/Fe atomic ratio between 0.6 and 1.2 and a Co/(Co+Ni+Fe) atomic ratio of 0 to 0.06. Type 2 pentlandite is vein-hosted, and is accompanied by pyrrhotite, magnetite, and serpentine. The Ni/Fe atomic ratio is between 0.8 and 0.9 and the Co/(Co+Ni+Fe) atomic ratio between 0.01 and 0.06. Type 3 pentlandite (and pyrrhotite) replaced olivine and has a roughly constant Ni/Fe atomic ratio of 1.0. The Co/(Co+Ni+Fe) atomic ratio is between 0.09 and 0.2.

Blocky Type 1 pentlandite is interpreted to be a peritectic phase that formed as a result of the reaction between the sulphide liquid and monosulphide solid solution (MSS), whereas the flame pentlandite is interpreted to have exsolved from MSS at lower temperature. The Type 2 vein-hosted and Type 3 replacement pentlandite provide evidence for the remobilisation of the sulphides during serpentinisation. The compositional overlap of the Type 2 pentlandite with the Type 1 pentlandite, indicates that it partly retained its magmatic signature, suggesting that some of the remobilisation may have been mechanical, whereas the constant Ni/Fe ratio and high Co content of the Type 3 pentlandite is consistent with its hydrothermal origin.

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Mineralogical, textural, and geochemical parameters of nickel mineralization at the Crawford Ni-Co-Cu-(PGE) Deposit, Abitibi Greenstone Belt, Superior Province, Ontario, Canada

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The 2704 ± 0.88 Ma Crawford deposit, located 50 km north of Timmins, is part of a mafic-ultramafic intrusion hosted within metavolcanic rocks of the Deloro Assemblage in the Abitibi greenstone belt. Identified as a low-grade, high-tonnage disseminated nickel sulfide deposit it is hosted in a dunite-to-peridotite body exhibiting progressive stages of serpentinization. The deposit is separated into two zones by a steep regional N-NW strike-slip sinistral fault: the Main-West zone on the western side and the East zone on the eastern side. The goals of the study are to characterize the preserved primary mineralogy as well as the effects of serpentinization to better understand what controls the Ni mineralization and extract mineralogical and geochemical parameters that may help locate and evaluate similar deposits in the district and elsewhere.
A total of 91 samples were collected during the summers of 2022 and 2023 from eight drill holes. Sampled lithologies include dunite, peridotite, pyroxenite and gabbro. Detailed optical petrography, backscattered electron imaging, and electron probe microanalysis have been used

to characterize mineralogy, alteration, textures, and mineral chemistry of the silicate-sulfide-alloy-oxide assemblages. Results from petrography show that the dunites are dominantly composed of ellipsoidal and prismatic adcumulate olivine with less than 5% pyroxene and chromite. The Main-West zone exhibit progressive serpentinization (from roughly 20% to 100%), resulting in the transformation of primary silicate and sulfide minerals to secondary altered minerals, which seem to correlate with their distance to the sinistral fault. In contrast, samples of the East zone are completely serpentinized throughout the unit (no primary olivine observed, abundant secondary sulfides, oxides, and alloys). Detailed petrography revealed that primary sulfides (pentlandite) transform into secondary sulfides (heazlewoodite and godlevskite), alloys (awaruite), and secondary magnetite. Native copper (from chalcopyrite) is also present in some samples. These mineralogical transformations imply loss of S (desulfurization) during serpentinization and metal (Fe, Ni, Cu) mobilization now captured in existing assemblages. Results, pending from already completed electron probe microanalysis, will include forsterite and Ni content in olivine, Fe/Ni in pentlandite, and will be used to estimate the Ni content (and variability) in the dunites prior to serpentinization as well as estimates of the enrichment factors required for the Ni grades documented for the deposit.

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Building a 3D model for Cu/Pd inflection points throughout the Marathon PGE-Cu Deposit

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The Marathon PGE-Cu deposit is a part of the North American Midcontinent rift system, a failed continental rift. Magmatic activity in the area created an optimal environment for the formation of economically significant sulphides bearing Cu and PGE at the Marathon deposit. The deposit lies in the Two Duck Lake Gabbro, a subophitic, coarse grained part of the Coldwell Complex. The deposit is made up of three sections with distinct mineralization, the Footwall zone, the Main zone, and the W Horizon zone. Each zone is characterized by specific ranges in copper/palladium so developing an understanding of how Cu/Pd varies in 3D space at the deposit scale will provide important insight for continued exploration. This study is interested primarily in the abundances of Cu and Pd, and the Cu/Pd ratio. The 1993 paper by Barnes et. al suggests that the Cu/Pd ratio is an important indicator of magmatic and magma-sulphur relationships. Therefore, the ratio of Cu/Pd is a useful marker of the enrichment of Pd in rock relative to the mantle. The Cu/Pd can be utilized in this way since low Pd relative to Cu indicates previous Pd depletion due to the early formation of sulphides in the intruding magma that formed the deposit. Conversely, a higher Pd concentration relative to Cu would imply Pd enrichment. This project aims to visualize patterns for large shifts (inflection points) in Cu/Pd ratio throughout the Marathon deposit. Identifying and modelling Cu/Pd inflection points will assist in recognizing trends in the grade of ore at the Marathon deposit. A data filtration process was employed to define wide mineralization intervals of economic Cu and Pd mineral concentrations. First, samples with very low Cu (<80 ppm) and Pd (<0.15 ppm) were removed from the dataset. Then, zones of continuous mineralization over at least 16m in length were identified. Next, each of these intervals were searched for positive or negative changes (inflection points) in Cu/Pd that are >5000 or <-5000, as this was established as the threshold constituting a trend reversal in Cu/Pd. Approximately 700 inflection points have been identified from a dataset of nearly 1000 drill

holes and almost 62000 assays. The points appear in 395 of the drill holes. The research will be continued by modelling the inflection points in 3D and looking for patterns in the points relative to Cu and Pd grade.

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A reactive in-situ crystallization origin for the base of the UG2 chromitite of the Bushveld Complex, South Africa

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The UG2 chromitite of the ~2 Ga Bushveld Complex (South Africa) is one of the largest platinum-group element (PGE) deposits on Earth. It is ~1 m thick and can be traced for virtually the entire circumference of the eastern and western lobes of the Bushveld – a cumulative length of several 100s of kilometers. Despite its economic importance and a plethora of studies devoted to understanding its petrogenesis, there is no consensus on how the UG2 body formed. Models invoking fractional crystallization, in situ crystallization, gravity settling within crystal-rich slurries and crustal contamination have all been proposed. In addition, recent studies on chromitite formation in other layered intrusions have demonstrated significant mineral chemical and textural disequilibrium features associated with chromitite layers, attributed to a reactive origin for these bodies. This study aims to test the hypothesis that reaction between incoming magma and anorthositic footwall may have triggered crystallization of the massive UG2 chromitite layer. Specifically, we focus on microtextural variations at the cm-scale across the footwall chromitite contact from a drill core sampled on the Magazynskraal farm in the western lobe of the Bushveld intrusion. We have carried out petrographic analysis and quantitative textural approaches including crystal size distribution (CSD), dihedral angle measurements, and mineral chemical analysis on nine (pyroxenitic) footwall samples over 10 cm leading up and into the base of the UG2 chromitite as well as on four samples at ~30 cm intervals above the contact (within the chromitite). Initial petrographic observations reveal disequilibrium textural relationships in the footwall pyroxenite: chromite is typically separated from orthopyroxene by thin (typically µm-scale) rims of plagioclase. Interstitial plagioclase is chemically zoned and the anorthite content of the plagioclase shows a distinct increase (from An58 to An92) in close proximity to chromite. CSD analysis yields log-linear plots suggesting in situ crystallization with some evidence for postcumulus textural modification. Apparent chromite-chromite-plagioclase dihedral angle measurements reveal mean values (for a given ~1 cm thick interval) of 65-75° suggesting that textural equilibrium has not been achieved. The combined observations suggest disequilibrium between mineral phases at the base of the UG2 chromitite and point to a reactive origin in-situ crystallization origin for this globally significant precious metal deposit.

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A comparative airborne geophysical analysis of Aguinaldo and Luizão Deposits, Juruena Mineral Province, Brazil: Assessing mineralization styles in a prospective belt

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The Juruena Mineral Province (JMP), situated in the southern part of the Amazonian Craton, north of Mato Grosso (MT), consists of a has Paleoproterozoic continental magmatic arc in which there is considerable potential for gold and base metal mineralization. Within this region, mineral occurrences primarily manifest as Au ±Cu ±base metals mineralization of varying styles, including disseminated and vein-hosted types. These occurrences are commonly associated with structural features such as shear zones and faults. Despite potentially critical controls by these structures on mineralized zones formation, location and preservation, a comprehensive understanding of the structural settings, relative chronology, and ore-forming processes on contrasting mineralization styles remains elusive at deposit to belt scale. This study compares disseminated- and vein-style gold zones within the JMP, exemplified by the Luizão and Aguinaldo deposits, respectively, utilizing gamma ray spectrometry and magnetic field data. Both deposits exhibit strong magnetic signals, situated at the periphery of magnetic highs in Total Horizontal Gradient (THG) Examination of the regional distribution of lineaments, crosscutting relationships evident in TILT derivative data, and the deformation of magnetic anomalies in THG collectively reveal two distinct deformation stages. The first stage consists of a Riedel-type shear system (N30E, N80E, and N70W) characterized by sub-simple shear with a notable compressive component. The second stage is associated with the reactivation of stage 1 shears, also under sub-simple shear conditions, but with a normal component. The disseminated-style deposit (Luizao), situated at the boundary between the South and North facies of the Novo Mundo Granite, displays high K counts and F-Parameter anomalies (F = K.U/Th) suggests the extension of the potassium rich alteration. The Luizão region exhibits low magnetic interconnectivity of lineaments, major lineament of the region and magnetic anomaly is emplaced in lithologic contact and east-west-oriented deep magmatic bodies. In contrast, the vein-style deposit (Aguinaldo) and vicinity feature a high interconnectivity of lineaments that control the location of the associated magnetic anomaly and the geometry of the deposit. Our work provides contrasting key factors in different styles of mineralization, providing further tools for exploration.

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Induced Polarization Forward Modeling Using Spectral-Infinite-Element Method

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Investigating the electrical characteristics of the subsurface is possible through the use of the induced polarization (IP) method. It is extensively utilized in engineering geophysics, groundwater research, environmental investigations, and mineral exploration. The IP approach is especially helpful in places with significant clay content or in the presence of conductive minerals, where standard resistivity surveys might be less successful. To create a successful IP survey and analyze

data obtained from the IP method, a quick and effective numerical simulation methodology is needed. We have created a flexible open-source numerical tool to simulate IP in a homogeneous medium, based on the spectral-infinite-element method. The spectral-infinite-element method (SIEM) is a numerical methodology used to address unbounded geophysical problems such as magnetic anomalies and gravity perturbations. It combines the spectral-element method with the mapped infinite-element method. To replicate the infinite boundary conditions, the SIEM discretizes the unbounded domain into the infinite elements in the outer domain and the spectral elements within the finite domain.

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Comparison between 3D surface geometry inversion and artificial intelligence inversion of magnetic data for dipping prism model

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Artificial Intelligence (AI) in geological and geophysical applications has become increasingly popular and beneficial. Compared to traditional inversion methods, AI algorithms can potentially solve geophysical inverse problems much more efficiently. Here we present an investigation of the capabilities of some AI algorithms at solving an archetypal geophysical inverse problem. We consider the inverse problem of constructing the shape and size of a dipping, uniformly magnetized prism from surface magnetic data. We consider Random Forests, Support Vector Machines, and Deep Learning algorithms. Training datasets were generated by randomly generating prisms of different shapes. Noisy as well as noise-free data were considered. The ability of the different AI algorithms to construct the correctly shaped prism for a given dataset were assessed, as well as the computational resources required. The total computational resources required, i.e., for training and for constructing a model from a given dataset, are also compared with those required for a more traditional surface geometry inversion approach.

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Investigating the Relationship Between In Situ Geophysical and Geochemical Measurements and Mineralization in Southwestern New Brunswick

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In this research, the petrophysical characteristics of different rock types in southwestern New Brunswick were examined to explore the potential relationships of various geological features from airborne geophysics to a variety of mineralized areas in the region, which will feed into mineral prospectivity mapping (AI MPM). The handheld RS125 instrument was utilized to gather Gamma Ray Spectrometer (GRS) measurements throughout the region, while the KT9 instrument was also employed for magnetic susceptibility measurements. Approximately 200 readings were taken on outcrops and mineralized rocks within the study area. Additionally, 70 samples were

collected from outcrops and mineralized zones in the study area, and portable X-ray fluorescence (pXRF) analyses were conducted to determine the chemical composition of the samples and evaluate the types of mineralization.

Southwestern New Brunswick has a long and complex tectonic history that has given rise to a great variety of mineralized systems. Precambrian and Silurian stratiform base-metal sulfide deposits were intensely deformed, and in part remobilized, from Early to late Devonian (Acadian orogeny) and/or Early Carboniferous deformation events. Numerous deposits formed as a result of late- to post-Acadian tectonic activity and include both epigenetic and stratiform deposits.

The concentrations of the radioelements, K (%), eU (ppm), and eTh (ppm), were measured and also magnetic susceptibility (SI * 10-3) measurements were mapped within the study area using kriging method as it can better address the spatial variability of the regional variables. Also, the radioelement ratio maps, such as eTh/K, eU/K, and eU/eTh, were calculated as they can better distinguish the areas related to various types of hydrothermal alteration and mineralization. In addition, the anomaly maps of the metallic and pathfinder elements, such as Cu, Pb, Zn, Sb, As, were also produced using the pXRF results of the collected samples. According to the Anomaly maps, the mineralization is more probable in the Mascarene Peninsula, Pocologan Metamorphic Suite, Lorneville, Beaver Harbour, and Lepreau areas. For the final step, the geophysical interpolated maps were correlated to the geochemical maps in order to investigate the relationships between the geophysical properties of the rock types with the mineralized zones. The results showed that the mineralized areas correlate with zones of higher potassium, and lower concentrations of eTh. However, eUranium shows similar behavior in mineralized and non-mineralized zones. There is no specific correlation between magnetic susceptibility and the mineralized zones, but mineralization seems to occur in areas with relatively lower values of magnetic susceptibility.

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Deciphering Geophysical Data Distortions and Computational Modeling of Magnetic Anomalies: A Concise Review Emphasizing Fundamental Factors for Ensuring Robust Interpretations in Subsurface Mapping

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The accurate interpretation of magnetic maps derived from locally measured magnetic data, aimed at discovering regional magnetic anomalies, faces several inherent challenges. This study endeavors to underscore the paramount importance of meticulously accounting for fundamental factors during calculation processes. The inadvertent neglect of these factors can lead to substantial distortions in the informational integrity of outcomes resulting from mathematical operations applied throughout data processing and interpretation phases.

The research predominantly concentrates on elucidating the impact of variables such as sampling distance, measurement grid characteristics, and parameters associated with both the geomagnetic field and remanent magnetism. Given the prevalent use of the Discrete Fourier Transform (DFT) for frequency domain filtering, an in-depth investigation into its behavior under diverse conditions has been conducted to delineate potential drawbacks and adverse phenomena.

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Integrated Analysis Geophysical, Geochemical, and Geological Data to Define Gold Exploration Targets in the Simpson Field Area, Northern NB

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Northern New Brunswick contains a variety of gold mineralization types that originated at different times during the Appalachian orogeny. The prominent Acadian dextral transcurrent regional structures, such as the Restigouche, Rocky Brook-Millstream, McCormack-Ramsay Brook, and McKenzie Gulch faults, played a critical role in controlling the geological features and mineral deposits of the region. Simpson field occurs within the Chaleur Bay Synclinorium of the Middle Paleozoic Matapédia Cover Sequence of northern and western New Brunswick. Here, the Simpsons Field Formation (clastic sedimentary rocks) is cut by a series of northeast-trending mafic dykes that have been carbonatized and have hematite, chalcopyrite and gold mineralization associated with narrow quartz veins. The strongest gold mineralization occurs in highly carbonatized and silicified pyritic zones. Sulphide mineralogy accompanying alteration is dominated by pyrite with minor arsenopyrite and chalcopyrite. Crosscutting gold-bearing fracture sets and gouge zones suggest that gold mineralization is structurally controlled.
The purpose of this research is to narrow down the exploration area for gold mineralization by progressively integrating soil geochemical, airborne regional geophysical, mineralogical analysis and geological data be it directly, or indirectly associated with gold mineralization. Compositional-based multivariate techniques were utilized to examine the various geochemical datasets from Simpson Field. The resulting biplots indicated a strong correlation among Au, As, S, and Sb. The study also explored the relationship among lithology, mineralogy, and magnetic susceptibility. Magnetic susceptibility measurements from drill cores clearly indicated that the highest average value (95.3×10^{-3} SI) is associated with mafic intrusive rock (gabbro). Subsequently, pXRF and microXRF spectrometry analyses were utilized to establish the connection between magnetic susceptibility and bulk chemical composition and mineralogy of the rocks. Using airborne geophysical mapping, magnetic anomalies were assigned primarily to gabbroic intrusions, and a magnetic anomaly was detected along the primary mineralized zone. Following this, the mineralization-related characteristics identified through the interpretation of geophysical data can be integrated with the geochemical signature of mineralization to establish reliable exploration targets.

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Joint gravity and magnetic inversion of the Cornwall Peninsula (South-West UK)

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Gravity and magnetic fields joint inversion is an efficient method to detect and identify concealed crustal bodies, testified by numerous literatures. Positive and negative anomalies in the gravity and magnetic fields were detectable with appropriate instrumentation, and the associated variations in density and susceptibility can be defined through inversion techniques. For this reason, grav-mag method is a powerful tool in mineral exploration. Combination of magnetic and gravity datasets also guarantees reliability to the inversion results and increases the probability that the detected bodies are realistic geological elements, resolving the ambiguity problem of the single field inversion result.

The present study is focused on the Cornwall Peninsula, in the southwest of the Great Britain. Area is characterized by the presence of an early Permian granitic body, the Cornubian Batholith, resulting from the Variscan orogeny. The batholith has a rich mining history dating back to the Prehistoric period, with ore fields associated with different stages of its emplacement. Active mines, primarily focused on kaolin extraction, also show potential for Tin, Lithium, and Tungsten production, as well as geothermal energy exploitation.

The inversion process utilizes the jif3d framework, a collection of scripts for joint inversion of gravity and magnetic fields developed by Max Moorkamp from LMU in Munich. The inversion method incorporates the variation of information, seeking a one-to-one relation between investigated properties. This minimizes misfits between observed and calculated fields, resulting in a model with density and susceptibility values that align with observations and demonstrate correspondence between the two properties.

We present initial results of the new model for the Cornwall Peninsula, highlighting not only the body's edges but also the distribution of density and susceptibility along the investigated area. The Cornubian ore field is identified as an ideal territory for studying granite-related hydrothermal mineralization. Understanding the physical properties distribution provides a valuable case study for analyzing areas with similar geological histories, of relevant importance considering its future exploitation regarding the mining industry and the green material transition.

808 **Neeraj Nainwal - PhD**
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Spectral-infinite-element simulation of Gravity and Magnetic data

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In potential field geophysics, imaging techniques are crucial in estimating source property distributions within two- and three-dimensional spaces. Central to this field are the gravity and magnetic methods, which are governed by the unbounded Poisson/Laplace equations. Traditional approaches for solving these equations are based on direct integral methods, where the

computational cost is proportional to the number of observational data points. This dependency poses significant challenges in simulating complex models that require higher data points.

This study introduces the Spectral-Infinite-Element Method (SIEM) as a potential solution to address these challenges. SIEM uses nodal quadrature to integrate the spectral element method with the mapped infinite element method. Poisson's equation is solved within the domain of interest using spectral elements in conjunction with the Gauss-Legendre-Lobatto (GLL) quadrature. For areas outside the domain, the Gauss-Radau quadrature effectively captures the infinite elements in outer space.

A distinct advantage of SIEM over traditional integral methods lies in its higher-order discretization capability, which allows for a more accurate representation of complex models. Furthermore, SIEM is independent of the number of observational data points, making it an efficient method for simulating large-scale complex models.

The efficacy of SIEM was tested through synthetic simulations of gravity and magnetic methods and compared with analytical solutions. The results demonstrate that SIEM offers a higher accuracy and efficiency over traditional methods. This method provides a robust and scalable solution to complex 3D models with computational ease.

809 **Victoria Susin - PhD**
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Subsurface characterization of the SW Limerick Syncline in the Irish Zn-Pb Orefield using seismic reflection and petrophysics

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The zinc-lead mineralization in the Limerick Syncline, southwest Ireland, is hosted in the Mississippian and Viséan carbonate rocks. Several Zn-Pb massive sulphide bodies have been discovered in the area, e.g., Pallas Green and Stonepark, making the Limerick Syncline emerge as an important subdistrict of the Irish Zn-Pb Orefield. The sulphide mineralogy and stratigraphic setting in the Syncline have many similarities to other Irish-type deposits, the main difference is that the mineralization shows a close spatial and temporal association with the igneous rocks, the exact nature of which is still poorly understood. Major gaps remain regarding (i) the existence of deep faults, which appear to have some control on ore deposit location, and (ii) the relationship between base metal mineralization and the Lower Carboniferous magmatism, which is likely to have contributed heat to drive fluid circulation, thereby bringing ore-forming components to the system. To address these issues and fill in the gaps, we reprocessed legacy 2D seismic profiles to extract new information from the data and map major structures and main lithological boundaries. The main challenges for previous seismic imaging in the area were the lack of information about the velocity field and the presence of thick volcanic sequences overlying the host rocks, causing strong signal absorption and transmission loss. Recent downhole petrophysical data campaigns and laboratory petrophysical data measurements of core samples from multiple drill holes along the seismic profiles give insights into sonic velocities and rock density. This information has enabled the reprocessing of the 2D seismic lines leveraging new petrophysics-guided velocity model building. The updated velocity models

are used for new migrations resulting in improved seismic profiles with better signal recovery, displaying more interpretable reflectors and new insights on the structural setting of the Limerick Syncline, which is a key knowledge for the better understanding of the mineralization system.

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OreLog®: Downhole Assay Measurements Beyond Iron Ore

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Borehole pulsed-neutron tools have been providing reliable downhole assays in iron ore resources for the last decade. The in-situ assay measurements not only provide high (~20 cm) vertical resolution and large (>30 cm) rock volumes but eliminate the numerous handling issues associated with cores, assays, and blast cone samples. International operators such as BHP and Rio Tinto integrate these non-destructive in-situ pulsed-neutron downhole assay measurements into production workflows at numerous mine sites. The time is ripe to expand downhole assay technology to other resources, such as Copper, Lithium, and Nickel.

A new 76 mm diameter pulsed-neutron logging tool which relies on time-resolved neutron detection and gamma-ray spectroscopy, OreLog®, has been introduced. It consists of a powerful Deuterium-Tritium neutron accelerator source along with a high- resolution gamma- ray spectrometer and an array of neutron detectors. Field trials using a combination of the gamma-ray and neutron have shown that combining multiple measurements can unlock a wider range of elements and better detection levels than with gamma spectroscopy alone. In order to further enhance the results, an advanced library of spectral gamma templates has been developed using a combination of Monte Carlo N-Particle Transport (MCNP) simulations, lab experiments, and field trials. These templates allow the spectral measurements to be "unfolded" into their constituent elements and are particularly useful for recognising mineralogy.

The integration of multiple measurements coupled with the advanced spectral gamma template matching techniques have shown promise in field trials in a variety of deposits including iron ore and e-metals. Examples will be shown to illustrate the benefits of the new measurement and processing techniques.

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Petrophysical characterization of the Lisheen Zn – Pb deposit in Ireland

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The project focuses on investigating the petrophysical response, mainly electrical conductivity, of the mineralization of the classic Irish-type Lisheen Zn-Pb deposit. The EM data from Lisheen deposit is used as a textbook example for a higher conductivity anomaly associated with the Zn-Pb mineralization. However, although the feeder zones contain elevated concentrations of more conductive Cu and Ni sulphides, most of the Irish Fe-Zn-Pb mineralisation is not very conductive,

possibly due to the lack of chalcopyrite, pyrrhotite and graphite. One possibility is that the anomaly is associated with the pyrite/marcasite cap around the Zn-Pb ore, although the pyrite/marcasite in this cap is not a continuous body all over the deposit. The continuity of conductive sulphides is the main premiss behind the application of the electromagnetic (EM) method.

Given this puzzle and the lack of a clear understanding of the relationship between mineralogy and geophysical data, this project proposes a comprehensive petrophysical characterization of the different geologic units at Lisheen. In this project, we measured density, velocity, conductivity, susceptibility, and resistivity of 253 spatially distributed samples from the Lisheen deposit and host rocks, aiming to connect between the three-dimensional distribution of minerals and EM anomalies. These samples are categorized into 11 groups, group 1 is composed of samples of different combinations of massive sulphide (galena, sphalerite and pyrite), group 2-6 of different types of host rocks (clean carbonates and argillaceous carbonates), group 7-11 of different types of host rocks with sulphides. The geological classification of the samples using pXRF is allowing to understand the variations in the type of sulphides and correlate with the physical properties.

The preliminary results show that, in comparison to the host rock (groups 2-6), the mineralization shows significantly higher density and conductivity, along with relatively lower resistivity and susceptibility. Additionally, its average velocity is a bit higher than the velocity of the argillaceous carbonates and lower than of the clean carbonates. Considering the presence of three types of sulphides, further subdivision is essential to identify which sulphide type is exerting influence on the observed high conductivity in the measurement results. Simultaneously, mapping out the spatial continuity of sulphides is conducted to assess whether the specific sulphide meets the prerequisite for the application of EM method.

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Machine Learning-based Mineral Prospectivity Mapping: Exploring the Role of Negative Training Labels to Enhance Predictive Models

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Mineral Prospectivity Mapping (MPM) is an important tool to identify areas with significant potential to host mineral deposits. Recent advancements in computational sciences, especially the advent of Machine Learning (ML), have enhanced MPM's capabilities. ML techniques enable a higher degree of data integration and extraction compared to traditional statistical methods such as Weights of Evidence, enhancing the accuracy and efficiency of identifying mineral exploration zones. When using ML techniques for MPM, the influence of negative training labels (ie. barren areas with no mineralization) remains a neglected research area, and this study investigates the influence of such label selection to optimize predictive models for Canadian critical mineral exploration.

Previous approaches to ML-based MPM often adopted a random assignment of negative training labels wherever positive training labels were absent. This study aims to refine this method, striving for a more systematic approach in negative label selection. The evolution of MPM, transitioning from traditional statistical methods to modern ML algorithms, signifies a shift towards heightened accuracy and efficiency. Prior research underscores the importance of balanced representation between mineralized and non-mineralized labels in ML models. Techniques such as Synthetic Minority Over-Sampling (SMOTE) and Positive and Unlabelled Learning (PUL) have been highlighted in previous studies, emphasizing the necessity of effectively handling negative training labels to prevent biases and enhance model performance. While SMOTE and PUL synthetically balance datasets by either oversampling minority classes or considering only positive and unlabeled instances, this study focuses on leveraging public exploration data to identify real negative training labels and provide a more authentic representation of non-mineralized areas without synthetic augmentation.

Using datasets compiled by the Geological Survey of Canada containing discoveries & occurrences of magmatic Ni (±Cu ±Co ±PGE), this research incorporates geological, geochemical, and geophysical data from established sources. Public exploration data will be used to identify areas devoid of magmatic Ni (±Cu ±Co ±PGE). These locations will serve as negative training labels for this study. Our particular choice of ML model is a Gradient Boosting Machine (GBM), and validation involves comprehensive evaluation techniques such as confusion matrices and receiver operating characteristic curves to assess model performance.

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DrillDown: an open-source Python package for the visualization and analysis of ore deposits datasets

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The metal intensity of the global energy transition demands higher ore deposit discovery rates. To address this challenge, members of industry and academia are collecting ore deposits datasets of increasing size, dimensionality, and diversity, particularly along drillholes, the only direct sampling

of deposits at depth. However, there are limited tools to integrate these datasets for visualization and analysis, and existing ones exhibit shortfalls, not least of which is their commonly high licensing fees. They are also typically closed-source and GUI-driven — characteristics that inhibit reproducibility and silo them both from one another and from the many tools developed as part of the broader Scientific Python ecosystem.

DrillDown is a Python toolkit for visualization and data analysis involving drillhole datasets. It is built on PyVista (for 3D visualization through VTK), Plotly (for 2D visualization), the web framework Trame (for constructing interactive applications), and the broader data science Python stack (e.g., NumPy and pandas). DrillDown provides classes for constructing drillholes from collar and survey data and interrogating datasets collected along them (e.g., assay, lithology, or core photos). Such drillhole datasets can be visualized in 3D together with other meshes (e.g., ore shells, structural geology models, or topography). DrillDown provides both manual and programmatic means to analyze these datasets, including sophisticated mouse-based selection in 3D, cross-filtering with 2D plots, and boolean filtering. Together, this functionality enables construction of reproducible data analysis workflows, both in jupyter notebooks and in traditional scripting environments.

DrillDown is free, open-source, and hosted on GitHub (https://github.com/cardinalgeo/drilldown), promoting community contribution, transparency, and extensibility. As an open-source Python package, DrillDown can be readily paired with other Python packages. In this way, it both serves as a jumping off point for bringing the Scientific Python ecosystem to bear on ore deposits problems and as a springboard for the geoscientist-turned-novice-programmer.

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Leveraging Multi-sensor Remote Sensing and Machine Learning for Enhanced Critical Mineral Exploration

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Geological mapping is pivotal in mineral exploration, discerning lithological units, alterations, and diverse mineral types. Traditional methods rely on fieldwork, geochemical sampling, and ground surveys, often limited by accessibility, costs, and weather. In this study, we addressed these constraints, focusing on the Mountain Pass District in the eastern Mojave Desert, California, aiming to identify potential areas for rare earth mineral host rocks associated with various hydrothermally altered rocks.

To overcome limitations, we employed advanced remote sensing and machine learning techniques, incorporating ASTER, Landsat-9, and Sentinel-2 satellite imagery. Applying specialized band ratios and principal component analysis generated thematic layers, while fuzzy logic machine learning integrated these layers into mineral prospectivity maps. Results detailed spatial distribution patterns of iron oxides, hydroxides, hydroxyl-bearing and carbonate minerals, kaolinite minerals, dolomite, and phyllosilicates. The prospectivity maps highlighted zones with the highest potential for hydrothermal ore mineralization.

To validate remote sensing outcomes, field surveys were conducted, verifying alteration zone occurrences and identifying highly prospective hydrothermal alteration locations. The findings contribute foundational knowledge for future research in the eastern Mojave Desert, fostering scientific innovation and a deeper understanding of carbonatite-hosted Rare Earth Element (REE) deposits.

This study signifies a paradigm shift in mineral exploration methodology, leveraging cutting-edge technology to overcome conventional challenges. The integration of remote sensing and machine learning not only provided detailed mineralogical insights but also enhanced the efficiency of prospectivity mapping. The spatial patterns revealed through this approach enable precise targeting of exploration efforts, reducing costs and increasing the likelihood of discovery.

Moreover, the validation through field surveys adds robustness to the findings, bridging the gap between remote sensing data and on-the-ground reality. The identified prospective zones for hydrothermal ore mineralization serve as valuable guides for future exploration endeavors. The broader implications of this research extend beyond the specific study area, contributing to the understanding of REE deposits in carbonatite-hosted environments and offering a template for innovative mineral exploration strategies in diverse geological settings.

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Volcanic evolution and differential base metal endowment of the Swayze area, Abitibi greenstone belt, Ontario – An update

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The Swayze area of the western Abitibi greenstone belt (AGB) contains most of the chronostratigraphic metavolcanic episodes present in the metal-endowed eastern AGB; however, fewer ore deposits have been discovered. New mapping, lithogeochemical and geochronological data, in conjunction with Metal Earth geophysical surveys, have resulted in a new interpretation of the crustal architecture for the Swayze area. Although the Swayze area contains the oldest and youngest AGB volcanic episodes, significant differences include: 1) an absence of Tisdale (2710-2704 Ma) volcanic rocks, 2) an abundance of Pacaud (2750-2735 Ma) and Blake River (2704-2695 Ma) volcanic rocks, with the latter lacking volcanic centres containing subvolcanic plutons 3) an absence of ultramafic rocks in all volcanic episodes except for the Blake River; 4) anomalously thick (up to 200m) and extensive (up to 20 km) intra-volcanic episode iron formations which contain the known base metal mineralization, and 5) significant inherited zircons compared to volcanic rocks of the eastern AGB. These differences, together with the thicker crust of the Swayze area compared to the eastern AGB, suggest that a volcanic evolution characterized by fewer and intermittent volcanic episodes and punctuated by long volcanic hiatuses during which iron formations containing the known base metal prospects (e.g. Shunsby and Jefferson) are deposited, are less favourable for VMS formation.

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Using Hyperspectral Imaging of Drill Core to Classify the Mineralogy of the Walton Barite Deposit, Nova Scotia

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The historic Walton mine in Nova Scotia was operational from 1941 to 1978 and saw extensive mineral exploration and production of valuable commodities such as barite, copper, zinc, lead, and silver. This mine is located within the Windsor-Kennetcook subbasin of the Maritimes Basin, a vast, structurally, and stratigraphically complex sedimentary basin extending from the Gulf of Maine to the Grand Banks of Newfoundland. The Walton deposit is hosted in the Visean Windsor Group and is characterized by a barite orebody with a mineralized sulphide deposit below it. Drill core from around this deposit was logged by private and provincial geologists. Visual analysis of core is a complex, time-consuming process that can be subjective and prone to error. Hyperspectral imaging is a non-destructive, typically quick, logging tool that can be used to characterize the composition of rocks based on their spectral signatures. Approximately 3000 m of Walton mine drill core is housed at the Nova Scotia Department of Natural Resources and Renewables core facility in Stellarton. For this project, ca. 300 m of drill cores, both proximal and distal to the main deposit, were digitized using Scient Analytics' LithoScan mobile platform for high-resolution RGB and hyperspectral scanning. The scanners give reflectance spectroscopic images of core in the ultraviolet to shortwave infrared range which encompasses the optical absorptions of many different rocks and minerals of interest including barite, siderite, dolomite, and gypsum. These can then be classified based on the location, depth, and shape of absorption features in their spectra. Minerals of economic interest, including barite, are shown on false-colour images, resulting in a more objective tool for logging core. For example, barite has unique absorption features at approximately 600 and 620 nm. Hyperspectral scans from proximal and distal to the Walton orebody at similar stratigraphic levels show significant differences in the apparent volume of barite and level of alteration.

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Enhancing drift exploration strategies and interpretation by establishing till provenance from regional surveys. An example from South-Central Northwest Territories

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A common practice for mineral exploration in glaciated terrain is to use selected indicator minerals (e.g., gold grains, kimberlite indicators) retrieved from subglacial sediments to reveal surficial dispersal trains from an up-ice buried mineral source. However, mapping dispersal trains in their entirety to circumscribe and reveal a new source of interest remains challenging. Here, we make the case that bedrock provenance analysis from regional government till sampling surveys can provide new and useful knowledge about regional subglacial dynamics, including improved understanding of sediment erosion, transport, and deposition. This can lead to

identification of different tills at the surface or of contrasting transport histories, which would be difficult to achieve using only indicator minerals from yet to be discovered sources. Using glacial sediment composition (i.e., till matrix geochemistry and pebble lithology), and bedrock geological maps of an area just west of Great Slave Lake in south-central Northwest Territories, we were able to discriminate the surficial till into a dominantly locally derived and a more distally derived till. We also used the Arctic DEM to establish a spatial relationship between regional topography, subglacial bedforms, and our till provenance interpretation. Specifically, principal component analysis (PCA) was applied to assemblages of major and selected trace elements of surficial samples, and through k-means clustering of PC scores, samples were grouped based on compositional makeup to determine bedrock provenance. Results point to relatively local bedrock for the surficial till at higher elevation (~260 m asl), where till may be thinner and subglacial bedforms are sparse or lacking. In contrast, till from within a corridor-like lower-elevation (210-230 m asl) area characterized by abundant W/SW-trending streamlined subglacial bedforms appear to have a more distal provenance with dispersal patterns aligned with the landform and corridor orientation. Pebble lithology counts are broadly consistent with this. This provides evidence for enhanced transport of subglacial traction till during the formation of streamlined bedforms like drumlins and Mega-Scale Glacial Lineations (MSGL), and more limited transport outside of the drumlin corridor. This case study shows how regional till compositional data can be used alongside other publicly available data (e.g., bedrock maps, DEM) to get key insights into bedrock source regions of surficial till, and the potential relationship between surficial till provenance and glacial bedforms. This is a relatively low-cost approach that can help design more detailed till sampling grids for exploration, and support interpretation of indicator minerals and geochemical pathfinders from industry surveys.

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Rock Till You Drop: Following Groupies of Indicator Minerals in a Tour around Sturgeon Lake, Ontario

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Utilization of till mineralogy and grain counts are known successful exploration tools. Across Canada's Superior Province, the Laurentide Ice Sheet has deposited dm-thick sequences of till and glaciolacustrine material. Ice flowing across the Neoarchean Western Wabigoon Terrain was toward ~200° based on LiDAR analysis of glacial depositional features. The greenstone belt contains many Cu-Zn volcanogenic massive sulphide deposits, and a few visible gold showings. Till samples (n: 800) were collected perpendicular to the ice flow to ascertain locations of buried gold mineralization across the Sturgeon Lake greenstone belt. The least magnetic heavy mineral concentrate (HMC; >3.2g/cm^3) was assessed within the 0.25-0.50 mm size fraction. In general, the metamorphic (kyanite, sillimanite, staurolite) components represent ~23% of the HMC. Rock forming accessory minerals (monazite, rutile, spinel, titanite, xenotime, zircon) constitute ~26% of the HMC, and ore forming minerals (hematite, pyrite) are ~17%. Most pyrite and kyanite was euhedral indicating a proximal origin. Less than half of the titanite, rutile, and zircon, common refractory phases, was euhedral, possibly suggesting a more distal source for these components. Garnet, hematite, monazite, and staurolite were almost always anhedral. Rare earth minerals (xenotime, monazite) are found down-ice of the region containing a high gold grain count. The aluminosilicates and the ore forming minerals are present in greater quantities where the

gold grain count is highest, and most often with higher proportions of accessory minerals. We also examined the concentration and distribution of magnetic minerals in the till samples due to apparent relationships with mineralized quartz veins in the field. The magnetic minerals are inversely correlated to the appearance of mineralized bedrock except for the two southern most samples. Although the greenstone belt has been mapped as possessing greenschist facies assemblages, the identification of amphibolite facies index minerals is indicative of a local higher metamorphic grade possibly correlated to mineralization. Furthermore, the presence of zircons, rutile, and titanite in nearly every sample strongly suggests a compelling link between the surrounding granodioritic plutons of the area and the glacial dynamics transporting our collected till samples.

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Structural geology, timing of deformation and boundary relationships of the Martyn Lake Formation of the Waugh Lake group, southern Taltson Orogen

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Supracrustal rocks unveil crucial insights into superposed orogenesis, yet the Paleoproterozoic sequences in the western Rae craton remain enigmatic. One such sequence is the 2.02-1.97 Ga Waugh Lake group (WLg) in extreme NE Alberta, bordering Saskatchewan. Initially hypothesised as an intra-arc/back-arc basin to the 1.99-1.96 Ga Taltson arc, the WLg reveals a complex stratigraphy. As originally mapped, the WLg consists of a package of turbidites, the Martyn Lake formation (MLfm), overlain by conglomerates and local mafic and intermediate-felsic volcanic rocks (Doze, Sederholm, Johnson Lake formations), and topped by the Niggli formation. This study delves into the MLfm's age, deformational history, and boundary relationships. Structural analysis exposes the intricate nature of MLfm turbidites, displaying abundant younging reversals indicative of an earlier set of isoclinal (F_1) folds. Early folding led to a sub-vertical, broadly SW-striking composite S_0/S_1 foliation with locally preserved rootless F_1 isoclines. Subsequent refolding about NE-trending axes resulted in type 3 'hook-style' fold interference patterns, confirming co-axial refolding through the near coincidence of hinge lines of F_2 and F_1 folds. Progressive D_1-D_2 deformation coincided with the emplacement of a meta-diorite unit cutting F_1 folds but carrying the S_2 foliation. The meta-diorite's age, coupled with detrital zircon geochronology, may provide an upper limit for deposition/early deformation. While MLfm bedded turbidites record two phases of folding, the overlying rocks of the upper WLg seemingly document only the secondary phase, suggesting the MLfm's potential antiquity and prompting a re-evaluation of stratigraphic relationships and the back-arc model. The WLg, locally intruded by 1.97 Ga granitoids, introduces uncertainties in contact relationships (autochthonous, allochthonous). Examination of the eastern belt uncovers MLfm turbidites in sheared/faulted contact with mylonitic pink and grey gneiss. The oldest tonalitic gneiss component raises questions about whether it represents basement material or a strongly deformed marginal Taltson arc pluton. The economic significance of the Waugh Lake shear zone lies in distinctive N-S trending gold-bearing shear zones unique to the MLfm. A secondary goal is to investigate factors influencing mineralization. The MLfm's northward extension into the Northwest Territories, merging with the Hill Island Lake assemblage (HILA) turbidites, unfolds promising exploration opportunities. HILA exhibits similar N-S trending, gossanous shear zones, suggesting potential mineralization patterns. The upcoming research phase, leveraging U-Pb dating on key units like the meta-diorite and tonalite, aims to unravel the MLfm's deposition and deformation timing, providing enhanced insights into the broader geological context.

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Preliminary metamorphic observations and garnet isotopic ages in metasedimentary domains of the western Superior Province, NW Ontario, Canada

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The western Superior Province represents an amalgamation of Mesoarchean (3200-2800 Ma) to Neoarchean (2800-2600 Ma) continental crust. The three main crustal components between the Sydney Lake / St-Joseph Lake and the Quetico deformation zones include, from north to south: i) supracrustal assemblages of the English River subprovince, ii) gneissic rocks of the Marmion / Winnipeg River subprovince, and iii) supracrustal assemblages of the western Wabigoon subprovince. Several critical metal-bearing pegmatite occurrences and a developing lithium prospect near Mavis Lake (Dryden, ON) are spatially located proximal to faulted contacts between the supracrustal rocks and basement gneisses, and possibly genetically related to metamorphic (temperature) gradients across these contacts, formation of gneisses, and emplacement of granitic plutons. Characterizing the metamorphic evolution of these components using petrography, phase equilibria modeling, and geochronology of metamorphic minerals is key to understanding the evolution of the area, including the formation of pegmatites. A preliminary isotopic study of garnets hosted in iron-rich metasedimentary rocks of the Thunder Lake group, located between the western Wabigoon greenstones and the Winnipeg River gneisses, yields a Lu-Hf age of 2638.2 ± 14.3 Ma (on 3 concordant garnet fractions) and a Sm-Nd age of 2610.0 ± 32.4 Ma (on 5 concordant garnet fractions). Those garnet ages are consistent with previously published U-Pb monazite ages on pegmatitic granites (ca. 2650-2646 Ma). Similar isotopic analyses along with phase equilibria modeling will be performed on metasedimentary rocks of the Winnipeg River and English River subprovinces to determine the temporal and spatial variations of the Neoarchean metamorphism, providing new perspectives on the crustal geodynamic processes leading to the formation of late orogenic granites and pegmatites in the western Superior Province.

910 **Djelika Sogoba - BSc**
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Formation mechanisms of native silver in a selected mineral paragenesis of the Cobalt ore deposit, Ontario, Canada

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In this study, I will use reflected light microscopy, and scanning electron microscopy -energy dispersive spectroscopy (SEM-EDS) to determine various silver-bearing phases, their composition and texture. Further, studies at the nanoscale using transmission electron microscopy (TEM) on selected samples will determine if Ag nanoparticles were present and whether the aggregation of the nanoparticles led to the formation of native Ag. The results of the study will help to constrain how silver phases form in silver vein deposits and can be applied to other five-element vein deposits. The study will specifically focus on the cause of the dendritic texture for native

silver and its relationship to other Ag-bearing ore phases such as Ag-bearing aresenide and sulfarsenide. It precisely tries to understand whether (a) the enrichment of silver occurred either via fluid transport or mineral replacement reaction, (b) other Ag-bearing minerals play a role in the enrichment of silver, (c) the formation of native silver occurred through the attachment of Ag ions or Ag nanoparticles on a growing mineral surface. Hence, this study will add information on the genesis of ore forming minerals in five-element (Ni, Co, Bi, As, Ag) vein deposits. A comparison with nano-scale features of dendritic Ag from a different location will help us to determine whether the observed features at the five-element vein deposit in the Cobalt District are unique or represent general mechanisms for the formation of native silver.

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Structural and Morphotectonic Mapping in the North New Hebrides Subduction Zone Reveals the Spatio-temporal Patterns of Volcanism in a Nascent Backarc Basin

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In intra-oceanic convergent settings, backarc basin opening occurs when rollback of the subducting slab or migration of the overriding plate away from the trench induces extension in the overriding plate. Most backarc basins feature stable spreading centers that accommodate crustal accretion and basin opening. Little is known about the early tectonic processes and patterns of volcanism prior to the establishment of axial spreading centers sustained by passive mantle upwelling. To address this gap in knowledge, this study investigates the tectonic evolution and changes in the patterns of volcanism in the North New Hebrides Backarc - 360 km long and 70 to 135 km wide nascent backarc basin, absent an axial spreading center and featuring variably oriented lineament fabric and spatially distinct seafloor morphologies. Utilizing available high-resolution ship-track bathymetry data and satellite altimetry data, a remote predictive mapping approach is employed to produce a structural map and a morphotectonic map of the North New Hebrides Backarc, both mapped at a 1:100 000 scale. Visualization of the seafloor is accomplished via the import of raster datasets into GIS software and modification of these data using geoprocessing tools, allowing for lineament and morphologic classification. In seismically active areas, fault kinematics are resolved using shallow centroid moment tensor data. Lineament orientation analysis and morphological distinctions reveal three spatio-temporal domains of backarc basin opening, younging from east to west: 1) initial arc breakup associated with clockwise arc rotation, 2) extensional basin opening, and 3) transtensional basin opening associated with counterclockwise arc rotation. Morphotectonic mapping reveals a variety of volcanic features including large volcanic edifices (>2 km diameter), small volcanic cones (<2 km diameter), rifted volcanoes, and volcanic fissures. The distribution of volcanism is not random and interpreted within the framework of the three spatio-temporal domains, volcanism in the backarc migrates from east to west, trailing behind migrating arc volcanoes. This pattern of volcanism is revealed along four to five separate volcanic tracts.

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Gold geochemistry as a vectoring tool: A neural network approach at your fingertips

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Gold serves as a crucial indicator for the presence of mineral deposits, either as a primary or secondary ore. Despite its significance, direct analysis of gold itself is not commonly utilized as a tool in ore deposit exploration, with most exploration efforts focusing on other minerals within the deposit. Recently, there has been a growing interest in understanding the relationship between gold and the elements it hosts in its structure. This interest has led to an increase in publicly and available data on gold geochemistry, resulting in the development of an Artificial Neural Network (ANN) model that can predict the type of deposit that a gold grain formed in with an accuracy exceeding 80%. The model is introduced as an application (APP) with a user-friendly interface, enabling individuals or companies to evaluate their own data. Combining this information with traditional exploration data results in a powerful tool for advanced exploration campaigns.

913 **Lianna Vice - PhD**
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The Easey Lake deformation zone: a Porcupine-Destor analogue in the eastern Michipicoten Greenstone Belt, Wawa Subprovince, Ontario

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The Michipicoten greenstone belt is the largest greenstone belt of the Wawa subprovince in the southern Superior Province of Ontario and consists primarily of typical supracrustal successions of Neoarchean metavolcanic and metasedimentary rocks intruded by multiple igneous suites. Gold endowment in the Michipicoten greenstone belt is present as both early intrusion-hosted/related (Renabie and Magino mines) and late orogenic (Island Gold, Magino and Renabie mines). Although these gold deposits have been relatively well studied, the broader tectono-stratigraphy of the belt remains poorly documented. Recent mapping has defined a previously unrecognized deformation zone in the eastern Michipicoten greenstone belt, the Easey Lake deformation zone, which represents a boundary between metavolcanic rocks to the south and clastic metasedimentary rocks to the north, a setting comparable to the gold-rich Porcupine-Destor deformation zone in the southern Abitibi greenstone belt. Two metasedimentary facies are observed including isolated patches of polymictic metaconglomeratic rocks near the deformation zone, as well as isoclinally folded metaturbiditic rocks that define the northern Lochalsh basin. In this basin, metamorphism increases northward from greenschist facies (Chl-Ms) to amphibolite facies (Amp-Bt-Gt). The east-west deformation zone contains shear sense indicators with primarily dextral offset; however, both sinistral and dextral deformation is observed along the structure, as well as a subvertical stretching lineation. Preliminary timing constraints for the bulk of deformation includes the deposition of the metaconglomeratic rocks (possibly as young as the <2680 Ma Doré metasedimentary rocks in the western part of the belt) and the intrusion of spatially associated undeformed granitic to quartz-syenitic bodies (approximately 2670 Ma in the

northern part of the belt). The Easey Lake deformation zone presents all structural, sedimentary, and magmatic characteristics of major crustal structures commonly observed in Archean cratons. It is therefore a key component of the Michipicoten greenstone belt regional tectonic and metallogenic evolution and a possible link with the Abitibi greenstone belt to the east, the Shebandowan greenstone belt to the west and the Wabigoon greenstone belt to the northwest.

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Evaluating the Potential of Adirondack Graphite Deposits through Detailed Geological and Analytical Investigation

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The Adirondack Mountains of New York, US, host graphite deposits that have been intermittently exploited since the early 19th century. The last systematic study of the regional graphite deposits was conducted by Harold L. Alling in 1917. At that time, graphite was important for lubricants, pencils, and crucibles, and mines were exploited in the eastern Adirondacks by Lake George area and in the northwest Adirondacks around St. Lawrence County. Today, demand for graphite has expanded such that it is considered a critical mineral due to its importance in Lithium-ion battery production. This study undertakes an updated investigation of the geology and mineralization characteristics of Adirondack graphite deposits using multiple analytical techniques: Raman spectroscopy, C isotopic analysis, hyperspectral analysis, and LA-ICP mass spectrometry. The regional geology comprises amphibolite-grade metamorphic crystalline and metasedimentary rocks, including graphite-bearing gneisses, marbles, calcsilicates, and schists formed during the 1.3-1.0 Ga Grenville orogeny. Samples were collected during field mapping of historical mining sites and surrounding locations. Petrographic analysis reveals graphite mainly occurs as discrete flakes in quartzofeldspathic gneiss, schist, and pegmatitic rocks. The textural relationships of graphite to surrounding paragenesis are critical: graphite also occurs in small, connected veinlets, graphite cross-cutting all other minerals, anastomosis graphite, and sillimanite showing alteration to micaceous minerals. Raman spectroscopy demonstrates graphite crystallized at temperatures consistent with amphibolite to granulite facies regional metamorphism of 650-800°C. $\delta^{13}C$ values can be used to fingerprint organic vs. igneous carbon sources. Lab hyperspectral analysis of graphite-bearing rocks detected alteration minerals that are helpful for petrographic studies and provides guidance for future remote sensing exploration. LA-ICP-MS analysis of graphite flakes and trace elements compositions provide insights into crystallization history and compositional variability. The multifaceted analytical approach improves understanding of graphite genesis and demonstrates the utility of combining field observations with petrography, textures, Raman, isotopic, hyperspectral, and micro-analytical techniques for resource genesis and exploration targeting. In addition, the full characterization approach is critical in understanding important geometallurgical attributes of these deposits which may improve processing and extraction of diverse ore types. This study provides critical geological and geochemical data to understand Adirondack graphite deposits, highlighting their potential as a strategic source of natural graphite. Further work should focus on additional lithologic characterization, and geophysical prospecting to delineate exploration targets.

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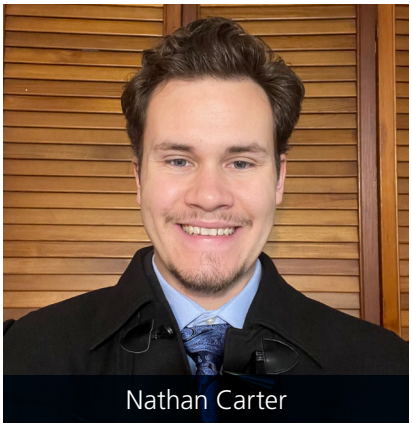
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