GEOSCIENCE CANADA
JOURNAL OF THE GEOLOGICAL ASSOCIATION OF CANADA
JOURNAL DE L'ASSOCIATION GÉOLOGIQUE DU CANADA

At the Heart of the Continent — Au Coeur du Continent

Abstracts from the Brandon 2024 GAC–MAC–PEG Conference

2024 VOLUME 51

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Print Edition: ISSN 0315-0941
Online Edition: ISSN 1911-4850

Volume 51

A journal published quarterly by the Geological Association of Canada, incorporating the Proceedings.
Une revue trimestrielle publiée par l'Association géologique du Canada et qui en diffuse les actes.

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Cover Image: The Bernic Lake mine in Manitoba, located on the world-famous Tanco pegmatite, which now produces lithium, tantalum and cesium. Image courtesy of Tantalum Mining Corporation of Canada.

ABSTRACTS

GAC-MAC-PEG 2024 Brandon Meeting: Abstracts, Volume 47

Introduction

The 2024 Geological Association of Canada - Mineralogical Association of Canada Meeting, held jointly with the 10th International Symposium on Granitic Pegmatites, was hosted by Brandon University, Manitoba, between May 19 and 22, 2024. Under the banner of *At The Heart Of The Continent*, GAC-MAC-PEG 2024 offered a wide and diverse scientific program, with a strong critical minerals component, and several workshops and fieldtrips, as well as extensive outreach and Indigenous engagement programs. It also featured several social events and formal functions that contributed to bringing geoscientists together. The meeting was strongly supported by industry, academia, and government sponsors and hosted numerous exhibitors.

This year's meeting was smaller than some previous GAC-MAC events, with 260 abstracts (190 oral and 70 poster presentations) and 350 attendees, perhaps due to the remoteness and perceived lack of appeal of Brandon. Nevertheless, the meeting attracted many international delegates from 25 countries located on almost every continent - indeed, approximately a fifth of the delegates came from beyond Canada. Our diverse attendees were able to learn about the strong and successful Geology Department at Brandon University and about Brandon, the Wheat City, the largest equestrian centre in Canada, and home to a surprisingly successful hockey team, the Wheat Kings.

Readers will be able to appreciate the breadth and diversity of the scientific program at the GAC-MAC-PEG 2024 meeting by perusing this issue of Geoscience Canada, which includes all the abstracts. Please note that some limited additional editing was applied as part of the publishing process, so for some there may be small differences from versions distributed at the meeting or available at the conference website. In most cases, these are just format-related matters, but there were a few cases where minor adjustments to grammar, spelling, and continuity of text were resolved to the best of the Geoscience Canada editors' abilities. A very small number of abstracts originally included references, funding acknowledgments or other material that is normally excluded from abstracts, and these were removed from the final layout. Readers who have specific questions about a given contribution or who are interested in clarification should contact the author(s). Registered users can access all abstracts on the conference website (event.fourwaves.com/gacmac2024/, under Presentations).

On behalf of the GAC-MAC-PEG 2024 Local Organizing Committee, I thank all the contributors to its success, and hope that this published record will have long-term value in addition to interesting reading!

Paul Alexandre, PhD, PGeo
Chair, Local Organizing Committee
GAC-MAC-PEG Brandon 2024

Introduction

La réunion de l'Association géologique du Canada et de l'Association minéralogique du Canada de 2024, tenue conjointement avec le 10e Symposium international sur les pegmatites granitiques, a été organisée par l'Université de Brandon, au Manitoba, du 19 au 22 mai 2024. Sous la bannière « Au cœur du continent », la réunion AGC-AMC-PEG 2024 a offert un programme scientifique vaste et diversifié, avec une forte composante sur les minéraux critiques, plusieurs ateliers et excur-

Geoscience Canada, v. 51, https://doi.org/10.12789/geocanj.2024.51.211 pages 63–128 © 2024 GAC/AGC®

sions sur le terrain, ainsi que d'importants programmes de sensibilisation et d'engagement autochtone. Elle a également comporté plusieurs événements sociaux et réceptions officielles qui ont contribué à rassembler les géoscientifiques. La réunion a été fortement soutenue par l'industrie, le milieu universitaire et les sponsors gouvernementaux et a accueilli de nombreux exposants.

La réunion de cette année était plus petite que certains événements AGC-AMC précédents, avec 260 résumés (190 présentations orales et 70 affiches) et 350 participants, peut-être en raison de l'éloignement et du manque d'attrait perçu de Brandon. Néanmoins, la réunion a attiré de nombreux délégués internationaux de 25 pays situés sur presque tous les continents - en fait, environ un cinquième des délégués venaient de l'extérieur du Canada. Nos divers participants ont pu en apprendre davantage sur le solide et performant département de géologie de l'Université de Brandon ainsi que sur la ville de Brandon, surnommée « Wheat City », qui accueille le plus grand centre équestre du Canada et une équipe de hockey étonnamment performante, les Wheat Kings.

Les lecteurs pourront apprécier l'étendue et la diversité du programme scientifique de la réunion AGC-AMC-PEG 2024 en parcourant ce numéro de Géoscience Canada, qui comprend tous les résumés. Veuillez noter que quelques modifications supplémentaires limitées ont été apportées dans le cadre du processus de publication, de sorte que pour certains, il peut y avoir de petites différences par rapport aux versions distribuées lors de la réunion ou celles disponibles sur le site Web de la conférence. Dans la plupart des cas, il s'agit simplement de questions liées au format, mais dans quelques cas, des corrections mineures ont été apportées à la grammaire, à l'orthographe et à la continuité du texte, au mieux des capacités des rédacteurs de Géoscience Canada. Un très petit nombre de résumés comprenaient à l'origine des références, des remerciements financiers ou d'autres éléments qui sont normalement exclus des résumés, et ceux-ci ont été supprimés de la mise en page finale. Les lecteurs qui ont des questions spécifiques sur une contribution donnée ou qui souhaitent obtenir des éclaircissements sont priés de contacter le, la ou les auteurs. Les utilisateurs enregistrés peuvent accéder à tous les résumés sur le site Web de la conférence (event.fourwaves.com/fr/gac-mac2024/, sous l'onglet Présentations).

Au nom du comité d'organisation local de la AGC-AMC-PEG 2024, je remercie tous les contributeurs pour son succès et j'espère que la publication de ce compte rendu aura une valeur à long terme en plus d'être une lecture intéressante !

Paul Alexandre, PhD, PGeo
Président, comité d'organisation local
AGC-AMC-PEG Brandon 2024

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PEG 2024
Brandon, Manitoba, Canada
May 19-22, 2024
10th International Symposium on Granitic Pegmatites

BRANDON UNIVERSITY
DEPARTMENT OF GEOLOGY

NMMA
NORTHERN MANITOBA MINING ACADEMY

ALPHABETICAL LISTING OF ABSTRACTS

U–Pb DETRITAL ZIRCON GEOCHRONOLOGICAL STUDY OF THE UNGAVA OROGENY: NEW PALEOGEOGRAPHIC INTERPRETATION OF THE NORTHERN DOMAIN

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Paleogeographic reconstructions of ancient orogenic belts, such as the Paleoproterozoic Trans-Hudson orogen (THO), are crucial for understanding of their tectonic evolution and the recognition of potentially different terranes juxtaposed during convergence. The foreland of the Ungava Orogen (Nunavik, Quebec), a branch of the THO, is characterized by the metavolcanic-sedimentary Southern (SD) and Northern (ND) domains. The SD is para-autochthonous and formed along the Superior Craton rifted margin, whereas the ND has been interpreted as an exotic assemblage of arc/ophiolitic/accretionary wedge material that would have formed in the now subducted Manikewan Ocean. The Bergeron fault, separating the two domains, would thus represent a suture zone, although recent research questioned these previous interpretations. In our study, U–Pb geochronological analyses on detrital zircon grains were conducted to unveil sedimentary sources in Paleoproterozoic metasedimentary rocks of the SD and ND, refining their paleogeographic positions. Preliminary detrital zircon U–Pb geochronology reveals the presence of two main age distributions: (i) samples from the SD that recorded only Archean ages (> 2.6 Ga); and (ii) samples from the ND exhibiting Archean-Paleoproterozoic ages, with peaks around 2.4–2.3 Ga. Our results highlight a significant differentiation among sedimentary sources recorded in the SD and ND and support previous interpretations of the SD being part of the Paleoproterozoic rifted margin of the Superior Craton. In contrast, it appears zircon grains of the ND have a Churchill Province affinity, placing it in a more northern position (e.g. Meta Incognita terrane) compared to what was previously interpreted, and likely separated from the SD by either an intracratonic, marginal, or oceanic basin. In this context, U–Pb detrital zircon geochronology is fundamental to redefine the paleogeographic interpretation of the SD and ND, reshaping previous understandings of the region and triggering new debates on the tectonic evolution of this segment of the THO.

HIGH-RESOLUTION ELEMENTAL MAPPING AND QUANTIFICATION OF LITHIUM-RICH MINERALS IN LITHIUM-CESIUM-TANTALUM TYPE PEGMATITES WITH LIBS AND LA-ICP-MS

Jolan Acke[1,2], Simon Nachtergaele[3], Christian Burlet[4], Renata Barros[5], Stijn Dewaele[2], Anouk Borst[1,6]

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Laser induced breakdown spectroscopy (LIBS) is a highly effective and straightforward technique to semi-quantify the distribution of light elements, such as lithium, in a variety of geological samples. Here, we use thin and thick sections (3 × 2 cm, 30 or 200 μm) and quarter core samples (8 × 2 cm) from the Musha–Ntunga area in Rwanda to study the distribution of lithium in fresh/unweathered and locally deformed lithium-cesium-tantalum (LCT) type pegmatites. We use two distinct LIBS laser setups to evaluate the optimal resolution within the lithium-bearing minerals (spodumene, montebrasite, lithiophilite and eucryptite) and to visualize lithium distribution on a bigger scale (core level). The lasers are equipped with a compact pulsed diode-pumped Nd:YAG laser with pulse energy of 50 mJ at 1064 nm. Laser spot and step size is 50 μm for the thick/thin sections and 100 μm for the core samples for the first laser, while the second laser has a spot size of 10 μm. Two spectrometers are mounted: a 4-channel Avantes Avaspec EVO 4096CL covering a wavelength range of 200–572 nm and 0.07–0.09 nm spectral resolution, and a single channel Avantes Avaspec EVO 2048CL, with a wavelength range of 570–686 nm and 0.18 nm spectral resolution. A series of minerals from an internal collection is routinely used for comparison with free atomic emission tables to ensure peak intensities/positions are within 0.1 nm of standard values. To process the LIBS data, the Python based Hyperspy software package is used. To quantify the obtained LIBS pixel intensities, LA-ICP-MS spot analysis is carried out with an Analyte Excite Laser Ablation system coupled to an Agilent 8900 triple quadrupole ICP-MS. Standardization occurs with EPMA quantified spodumene samples (based on Al and Si apfu) and the NIST 610 standard (LA-ICP-MS).

PETROGRAPHY, MICROTEXTURES AND LITHIUM DISTRIBUTION OF DEFORMED LITHIUM-CESIUM-TANTALUM TYPE PEGMATITES FROM THE MUSHA-NTUNGA AREA (RWANDA)

Jolan Acke[1,2], Justin Uwiringiyimana[3], Stijn Dewaele[2], Anouk Borst[1,4]

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Lithium-cesium-tantalum type pegmatites in the Mesoproterozoic Karagwe-Ankole Belt of central Africa are associated with widespread granitic intrusive complexes which were emplaced around 1 Ga. This study presents the first detailed petrographic study of spodumene-albite pegmatite drill core samples from the Musha–Ntunga area in East Rwanda, which show evidence of localized deformation after emplacement. Petrographic and cathodoluminescence microscopy combined with elemental geochemistry (EPMA and LA-ICP-MS) are used to study the mineral assemblages and microtextures, and the (re-)distribution of lithium during the main paragenetic stages, i.e. magmatic, magmatic-hydrothermal and sub-solidus deformation. We identify five types of spodumene (spd) textures. Coarse-grained subhedral spd type 1, with narrow rims of symplectitic spodumene-quartz intergrowth (spd type 2) reflect primary magmatic crystallization, while spd types 3 and 4 suggest magmatic-hydrothermal to hydrothermal recrystallization. In some samples, spodumene has been intensely deformed, both in a brittle and a ductile manner. Under localized shear stress, large spd type 1 crystals have been deformed to sigma clasts surrounded by bands of fine-grained spd laths (spd type 5), with interstitial apatite and quartz ribbons. Additionally, large spd (type 1) grains can be fractured with microcline, albite, micas and Li-phosphates (lithiophilite and montebrasite) filling the space. Book-shelf rotation and sliding along fracture or cleavage planes is also common, evidenced by offset twins in spodumene. Montebrasite occurs both as a late primary magmatic phase with spodumene, and as a secondary/late phase, recrystallizing during magmatic-hydrothermal alteration and deformation. Eucryptite and lithiophilite are only observed as secondary minerals, replacing primary mineral assemblages. The occurrence of lithium in metasomatic tourmaline within the metasedimentary host rock indicates significant dispersion of lithium into the host rock during pegmatite crystallization. Lithium appears to be retained within the recrystallized spo-

https://doi.org/10.12789/geocanj.2024.51.211

dumene during post-magmatic deformation. However, a decrease in spodumene grain size may have an effect on the ease of extraction.

THE START OF THE URANIUM CYCLE IN THE WESTERN CHURCHILL PROVINCE

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Prior to 2.5 Ga, hydrothermal uranium deposits are largely absent in the geological record and most uranium deposits occur as primary magmatic deposits or detrital grains preserved in placer deposits. The Western Churchill Province (WCP) is prolific in various uranium deposits; however, the earliest deposits are dated at ~2.3 Ga and the source of uranium for economic Paleoproterozoic hydrothermal deposits is largely debated. Here we provide petrographic, compositional, and geochronological data for Mesoarchean detrital uraninite preserved in Paleoproterozoic quartzofeldspathic gneisses below the Nonacho Basin, Northwest Territories, Canada. These data record the start of the uranium cycle in the WCP and its tectonic evolution until the end of the Paleoproterozoic during the Trans-Hudson orogeny (THO). Detrital uraninite grains (~500 mm), intergrown with metamict zircon, occur as clasts in a hydrothermally altered quartz-biotite-breccia. The Th (< 18.7 wt.% ThO_2) and REE-rich (1.7–2.33 wt.% $\Sigma[REE+Y]_2O_3$) nature of the uraninite suggests a magmatic provenance and uraninite U–Pb ages record primary crystallization at ~2787 ± 16 Ma. Geochronological uraninite data reveal three isotopic resetting and alteration events related to crustal reworking of the Rae Craton: (i) 2614 ± 11 Ma during emplacement of the Snow Island Suite magmatic rocks, (ii) 2531 ± 17 Ma corresponding to widespread magmatism throughout the western Rae, and (iii) 1778 ± 14 Ma recording alteration by hydrothermal fluids, which also produced molybdenite (1794 ± 28 Ma; Re–Os) and chloritized earlier biotite (1834 ± 1.17 Ma; Ar/Ar). This late hydrothermal event is coincident with sinistral movement of the adjacent King Shear Zone, related to broader extensional collapse of the THO, and likely provided uranium for the formation of deposits within Nonacho Basin. The results of this work suggest rocks of the WCP were enriched in uranium during the Archean and may have supplied a soluble uranium source for the giant hydrothermal uranium deposits that formed during the Paleoproterozoic.

REMOTELY PILOTED AIRCRAFT SYSTEMS MISSION PLANNING ON NATURAL HAZARDS WITH THE DEVELOPMENT OF A NATURAL DISASTER INFORMATION SYSTEM

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This study outlines the development of a natural disaster information system (NDIS) which focuses on optimizing remotely piloted aircraft systems (RPAS) mission planning. The NDIS provides a system facilitating rapid deployment of geophysical sensors using RPAS, also known as drones, as a platform for monitoring natural hazards before, during, and after the hazard occurrence. The primary goal of this research is to generate a workflow for acquiring geohazard data using the most suitable combination of RPAS and geophysical sensors. By this approach, NDIS aims to enhance data acquisition, specifically targeting improved accessibility, spatiotemporal resolution, and sensitivity. The strategy involves leveraging commonalities across natural hazards, RPAS, and geophysical fields, constructing a generalized workflow rather than tailoring solutions to specific hazards or sensors. A field campaign is currently planned to test the NDIS at Anak Krakatau volcano in the Sunda Strait of Indonesia. Two observation methods, optical imaging and a drop-off and pick-up of a seismometer using RPAS will be attempted. The campaign consists of three stages based on the level of difficulty in accessing the volcanic site. The stages include Merak Port, an easily accessible area with high population density and infrastructure; Sabesi Island, serving as a base for monitoring due to its proximity to Anak Krakatau; The third stage extends to Anak Krakatau volcano, indicating limited access that might be required beyond the visual line of sight for the RPAS operation, making this the most challenging mission. NDIS is expected to facilitate rapid RPAS mission deployment during natural disasters and not only contributes to technological advancements but also aligns with broader objectives defined in the United Nations' Sustainable Development Goals. These include Goal 11, focusing on establishing resilient urbanization, and Goal 17, emphasizing the use of technology for disseminating information on natural hazards and disaster management measures.

TWO TEMPORALLY DISTINCT EVENTS OF PEGMATITE FORMATION AT THE LAC JACQUES PEGMATITE SWARM IN CENTRAL GRENVILLE PROVINCE (LAC-SAINT-JEAN REGION, QUÉBEC)

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Numerous LREE-rich granitic pegmatites are hosted in the allochthonous Medium-Pressure Belt (aMP Belt) of the central Grenville Orogen. Previous dating (U–Pb zircon) of nine pegmatites hosted in the aMP Belt reveals two periods of LREE-rich pegmatite formation at 1060–1040 and 1015–990 Ma. The Lac Jacques pegmatite swarm, located in Lac-Saint-Jean region (Québec), is a typical example of LREE-rich pegmatites. It consists of > 100 undeformed granitic dykes intruding a deformed/migmatized metagabbro. Two main suites of pegmatites are recognized: syenogranitic and pink granitic dykes. Both are weakly peraluminous, but only the pink pegmatites are enriched in LREE, Nb, and Th, hosted by allanite, monazite, and pyrochlore. The leucosomes occur in situ along the foliation of the metagabbro and as mobilized melts crosscutting it. Laser ablation-ICP-MS U–Pb dating of zircon was conducted on the metagabbro, the mobilized melt, and on the two pegmatite types. The metagabbro has two chemically and texturally distinct zircon populations. One population yields a date of 1098 ± 24 Ma, interpreted as the age of peak metamorphism, whereas a second population yields a date of 1022 ± 2 Ma, interpreted as a younger thermal event. The mobilized melt yields a date of 1051 ± 7 Ma, which is coeval with a syenogranitic pegmatite that yields a crystallization age at 1048 ± 4 Ma. Two pink pegmatites yield crystallization ages at 1010 ± 7 and 1006 ± 2 Ma. Based on previous studies, pegmatites in the Grenville Province are interpreted to be sourced from anatectic melts. The obtained ages suggest that two crustal partial melting events associated with pegmatite formation may be recorded in the Lac Jacques swarm, at ~1050 and ~1010 Ma, which is coherent with regional data. These ages are significantly younger than the peak metamorphic age recorded by the metagabbro, suggesting that the central Grenville Orogen might have been affected by several distinct events of partial melting after peak metamorphism.

DEEP-SEATED, CRUSTAL STRUCTURAL CONTROLS ON REE-TH-U AND U-TH-REE MINERALIZATION IN ABYSSAL PEGMATITES AT ALCES LAKE AND FRASER LAKES, SASKATCHEWAN (CANADA): CHARACTERISTICS AND EXPLORATION IMPLICATIONS

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The Alces Lake and Fraser Lakes properties in northern Saskatchewan continue to emerge as low- to high-grade critical mineral (REE, Th, U, Ga) exploration plays. The Alces Lake area (part of the Beaverlodge Domain) is found ~28 km north of the Athabasca Basin margin and the Fraser Lakes area (part of the Wollaston Domain) is located ~22 km east of the Athabasca Basin margin. Both areas contain highly anomalous grades of critical minerals within abyssal (anatectic) pegmatites of felsic to mafic compositions, intruding Archean orthogneisses and Paleoproterozoic metasediments. In particular, the Alces Lake area contains the highest reported grades of REE in Canada, some of which (i.e. Nd-Pr) are required for the green technology industry. At both localities, the mineralization comprises both high-grade mineralization at/near surface and low- to medium-grade mineralization from surface to depth. The mineralization zones at Alces Lake and Fraser Lakes occur in large fold structures at the Archean/Paleoproterozoic transition zone and along / near an extensive large-scale structural corridor (i.e. the focus of the paper), possibly rooted to basal decollements of the Beaverlodge Domain and the Wollaston

Domain. Based on the extremely complex geological setting of both the Alces Lake and Fraser Lakes areas, some common field, geophysical, geochemical, and petrogenetic criteria for exploration purposes have been identified with respect to the location of the critical mineral system at both localities, in particular the large polyphase megafolds and the major deep-seated crustal structural controls from surface to depth. This contribution will provide geophysical, geological, and outcrop evidence for the major crustal structural controls that have been identified at various scales. Similarities and differences of both localities will be presented with respect to petrogenesis, timing of mineralization, and exploration vectoring tools.

DETRITAL ZIRCON GEOCHRONOLOGY FROM MISSI SUPRACRUSTAL SUITE ROCKS IN THE REINDEER ZONE, TRANS-HUDSON OROGEN: WHAT WE KNOW, AND WHAT WE DON'T

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The Reindeer Zone in the Manitoba–Saskatchewan segment of the Paleoproterozoic Trans-Hudson Orogen consists of volcanic, intrusive, and sedimentary rocks that developed in a variety of tectonic environments as the Manikewan Ocean opened, evolved, and closed. The deformational and metamorphic history of the rocks are linked to interaction between intraoceanic tectonic domains, and with the Archean Hearne, Sask, and Superior cratons, culminating in peak regional metamorphism at ca. 1.81 Ga. The intraoceanic accretionary events led to the initial thickening of the Reindeer Zone crust, and emergence above sea level, as highlighted by the development and local preservation of a paleoweathering profile at Flin Flon, and the subsequent deposition of fluvial-alluvial sedimentary rocks in many locations in the Reindeer Zone. These rocks form the Missi Supracrustal Suite (MSS), which were deposited between 1.85 and 1.83 Ga. Geochronological investigations over the last 30 years, utilizing Pb-evaporation, TIMS, SHRIMP, and LA-ICP-MS analyses of detrital zircon grains, and cross-cutting intrusions, from many basins containing MSS rocks, have provided tight constraints on the timing of sedimentation. The detritus was dominantly sourced from 1.89 to 1.85 Ga igneous rocks, but the presence of intrusive rocks coeval with and post-dating MSS rocks, emphasizes that the basins developed in active tectonic environments which allowed exposure of mid-crustal intrusions and subsequent rapid burial to similar depths. Older Paleoproterozoic or Archean detrital zircons are rare, and little work has been done to determine whether the older grains are derived from Archean crustal fragments in the Manikewan Ocean, or from the Sask, Superior, or Hearne cratons. Overall, even though the general age of MSS rocks is known, more comprehensive zircon data, including U–Pb, and Hf isotopes, are required to understand their provenance, and evolution of the Reindeer Zone during the final stages of the closure of the Manikewan Ocean.

ESTIMATED DETECTION LIMITS OF CARBOXYLATES IN PALAGONITE BY X-RAY DIFFRACTION AND REFLECTANCE SPECTROSCOPY

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Low molecular weight carboxylates (carbonates, oxalates, formates, and acetates) are either known or are expected to be present on the surface of Mars. Previous work has suggested these phases to be present in Gale Crater materials at nearly the expected limit of detection (LOD) for crystalline materials with the Mars Science Laboratory (MSL) Curiosity rover CheMin X-ray diffraction (XRD) instrument. Detection limits of these materials by CheMin-like XRD and reflectance spectroscopy are poorly constrained, thus leading to uncertainties in detectability with these types of instruments. We have filled this knowledge gap by making intimate mixtures of a variety of carboxylates with the JSC Mars-1a regolith analogue material and measured their XRD patterns with a CheMin-like breadboard and reflectance spectra with instruments analogous to the SuperCam instrument on the Mars Perseverance rover. We used simple linear regression to create calibration curves to estimate LODs and compared and contrasted ten different LOD calculations previously used for XRD. Application of these data to CheMin observations shows the method could accurately detect low concentrations of siderite at nearly the same values determined from previous CheMin data processing within error and within an average of 0.5–1.0 wt.% where siderite was detected. We did not find strong evidence for other carboxylate detection in any of the CheMin data. We applied the measured reflectance spectra from 350 to 4000 nm to some data collected by the SuperCam instrument at Jezero crater. We did not find evidence for carboxylates in the reflectance spectra except for Mg-rich anhydrous carbonates, and we determined the concentration to be between roughly 5.0 and 20.0 wt.%, which is broadly consistent with the previous analyses of these samples by radiative transfer modeling.

THE KRAKEN LITHIUM-CESIUM-TANTALUM PEGMATITES IN SOUTHERN NEWFOUNDLAND

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Canada's efforts to develop low-carbon technologies has increased the demand for critical minerals. For example, demand for lithium is driving global exploration for difficult-to-locate lithium pegmatites. Southern Newfoundland is a region displaying favourable geological conditions to host lithium pegmatites including metasedimentary host rocks (Bay du Nord Group), a major crustal-scale shear zone (Bay d'Est shear zone), and voluminous, geochemically evolved, two-mica granitic plutonic rocks (Peter Snout and Rose Blanche plutons). The present research is focussed on the Kraken pegmatites, a swarm of lithium-cesium-tantalum (LCT) pegmatites discovered in 2021 in southern Newfoundland. Preliminary fieldwork focussed on mapping and sampling multiple spodumene-bearing pegmatite dykes. Both the LCT pegmatite dykes and granitic plutons intruded the metasedimentary rocks. The mineralogy of the pegmatites is spodumene, quartz, K-feldspar, albite, muscovite, and garnet, with minor apatite, columbite-tantalite, white beryl, and schorl tourmaline. Some of the spodumene dykes exhibit discernible internal zoning patterns, characterized by layered aplite in the footwall, a lower intermediate pegmatite zone, a core zone that contains the coarsest spodumene, and a hanging wall zone with abundant tourmaline. However, some of the exposed dykes are unzoned. This research aims to provide a better understanding of the age and mineralogy of the Kraken spodumene pegmatites and contribute to an enhanced understanding of processes that resulted in emplacement of spodumene pegmatites in southern Newfoundland and the broader Ganderia in the northern Appalachian orogen.

GEOCHEMICAL EVIDENCE OF A MAFIC CONTRIBUTION TO IOCG STYLE HYDROTHERMAL SYSTEMS: EVIDENCE FROM THE K2 SYSTEM, GREAT BEAR MAGMATIC ZONE, NORTHWEST TERRITORIES

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The K2 deposit is a partially explored iron oxide-copper-gold (IOCG) system in the northern Great Bear Magmatic Zone of the Northwest Territories, Canada. Diorite-monzodiorite intrusions into andesitic volcanic rocks have caused widespread hydrothermal alteration and mineralization that progress from magnetite-actinolite-apatite at depth to potassic (K-feldspar-hematite-tourmaline-quartz-chlorite) at intermediate levels, and an upper phyllic assemblage (quartz-sericite-pyrite). This alteration is superimposed on an early propylitic (chlorite-epidote-sericite-calcite) alteration that characterizes all andesitic host-rocks in the district. The main economic metals added to the system during potassic alteration are Cu, Co, Au, Ag with arsenopyrite, pyrite and chalcopyrite. Enrichments also occur for U, K, P, Mn, Mo, Bi, W, As, La, and Ce. Depleted elements include Sr, Na, Rb, Ba, Ti, Ta, Nb, Cr, Ni, Sc, V, Zn, Mg and Li. Silver and Bi have a positive association with copper. Silver also exhibits a strong correlation with Sb, S, and Ni. Cobalt, Ni, V, P, Y, and Fe have a relatively strong correlation with the magnetite-actinolite-apatite assemblage. Phosphorus, Y and REEs occur in apatite. The components that are least mobile are Al, Zr, and Hf. The hydrothermal elemental enrichments in the K2 system may be separated into two groups: i) felsic affinity elements (incompatible) (e.g. Zr, Hf, K, Na,

https://doi.org/10.12789/geocanj.2024.51.211

Rb, U, Th and REEs), and ii) mafic-affinity elements (compatible) (e.g. Fe, V, Cr, Co, Ni, Cu and P). The elemental correlation and association may be an indication of mixing of a mafic magma with diorite as suggested by the presence of gabbro and basalt in the Echo Bay stratovolcano complex. It may also indicate mixing during melting-assimilation-storage-homogenization (MASH) processes near the crust-mantle interface with an unusually efficient fractionation of mafic affinity metals into the hybrid intermediate magma.

APPLYING MULTIVARIATE STATISTICAL ANALYSES AND 3-D INTERPOLATIVE MODELLING TO DELINEATE TEMPORO-SPATIAL RELATIONSHIPS OF ORE BODY ARCHITECTURE AND DEPOSIT-SCALE STRUCTURAL CONTROLS IN AN ANCIENT VOLCANOGENIC MASSIVE SULPHIDE DEPOSIT

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This study is part of a PhD project examining the processes, geochemical signatures, and resulting architecture of metal remobilization in metamorphosed and deformed volcanogenic massive sulphide (VMS) deposits. It seeks to better understand controls on grade and tonnage of mineralization, including primary mineralization and subsequent modifications superimposed by metamorphic and tectonic events. The Snow Lake district VMS deposits in Manitoba, Canada, owned and operated by Hudbay Minerals, are the primary case-study sites for this project. This poster presents preliminary results. Large geological databases for the Snow Lake camp exist, complete with geochemical and assay results. Applying multivariate statistical analyses to these databases and modelling the results in 3-D with deposit-scale faults and folds may reveal novel patterns and spatial associations. Published multivariate data set analyses algorithms have successfully been applied to geological data to characterize and detect patterns in complex settings, including cluster analyses, random forest ensemble method, and gradient tree boosting algorithms. These algorithms can be used to analyze multiple variables simultaneously, out-performing traditional statistical or graphical interpretations. This study will employ the "outside-in" approach to deposit-scale modelling developed in Leapfrog Geo™, adding multivariate statical analyses and ioGAS™. We hypothesize that the ore body architecture and metal grades are strongly controlled by deposit scale structures. Many of the structures at the Snow Lake camp are inferred or underdefined. These structures can be identified using multivariate analyses on existing geological databases and point data from drill core data when integrated into 3-D interpolative modelling and validated during on-site visits. Understanding major structural contacts and syn-to-late-D_2 normal shear zones spatially associated with mineralization may better define the geometry of the ore bodies and predict the structural controls of undiscovered mineralized zones.

EMBEDDING SKILLS DEVELOPMENT IN UNDERGRADUATE COURSES - A TRIBUTE TO THE LATE DR. ANNE MARIE RYAN

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The practice of geoscience typically includes work in the field, in the lab, and from the desk, and requires interaction between various stakeholders. To get ready for this challenging work environment our students need to know concepts of Earth science and practice a range of skills. Such skills include quantitative reasoning, ethical thinking, the ability to effectively work in teams, finding the information they need, and communicate effectively in writing and speaking. Thus, it is necessary to allow students to develop and practice skills in their geoscience courses. In this tribute to my friend Anne Marie, I want to share insights I learned from her mentorship and reflect on how I try to incorporate these into my work as educator.

THE KINEMATICS AND GEOCHEMICAL FOOTPRINT OF THE EAGLE RIVER GOLD DEPOSIT IN NORTHWESTERN ONTARIO

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The Eagle River deformation zone hosts Wesdome Gold's 2.7 Ga Neoarchean orogenic gold deposit in the Mishibishu greenstone belt of the Wawa subprovince in northwestern Ontario. 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. Whole rock geochemistry suggests the Eagle River deposit and host rocks formed in a supra-subduction environment and have subsequently underwent a regional D_2, N-S directed, shortening event that produced a well-defined, E-W trending, S_2 regional foliation that dips at 75° to the NE. The deposit is associated with a simple shear-dominated, transpressional, high-angle reverse shear zone. Gold mineralization occurs in sub-vertical to steeply dipping, east-west striking, lenticular, dynamically recrystallized quartz veins. Recrystallization occurred through grain boundary migration, indicating a high-temperature and low-stress environment. The quartz veins have a pervasive mineral stretching lineation that plunges 75° to the NE (down-dip). The deposits' host rock, a rigid diorite pluton, combined with the localized shearing, created conditions optimal for gold endowment.

STUDIES OF THE NORTHERN APPALACHIAN OROGEN - PAST, PRESENT, AND FUTURE

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The northern Appalachian orogen played a pivotal role in early geological studies of mountain belts. Its 100-year global influence as the "type area" for the Hall-Dana geosynclinal theory aptly changed focus with Tuzo Wilson's classic 1966 paper that posed (and answered) the question "Did the Atlantic Close and Then Reopen" and led to the modern view of global tectonics based on the "Wilson cycle". In retrospect, these early ideas about mountain-building were hindered by lack of factual details. Although the 1978 map of the Appalachian orogen compiled and hand-drawn by Harold Williams remains an outstanding example of geological artwork, the actual complexity of the orogen that it depicts was barely imagined. The map includes no absolute ages - the abundant plutons are all pink and collectively described as "granitic intrusions, mainly Mid-Paleozoic but ranging in age from Precambrian to Mesozoic". That lack of data has changed dramatically in subsequent decades with the development of methods that could be only wished for in the 1970s. The list includes accurate and precise absolute dating techniques, the GPS for field work, methods of chemical analyses of rocks and minerals that leave almost no naturally occurring element or isotope unmeasured, and geophysical techniques that image crust and mantle in ever-increasing detail. Appalachian studies now cover a spectrum from small areas investigated in detail to orogen-wide and global-scale interpretations that track Appalachian components back to their origins. We now know orders of magnitude more about the orogen than anyone could have imagined in 1978. Not surprisingly all that new knowledge has resolved many of the questions that were being asked in the 1970s but also not surprisingly, just as many more questions have arisen. Every new map, new interpretation, and new model challenges us with new questions - one hopes that geoscience will always be that way!

A POTENTIAL CHROMITE DEPOSIT IN HYBRID FELDSPATHIC PERIDOTITES FROM THE BAY OF ISLANDS OPHIOLITIC LOWER CRUST?

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Almost a third of the world's chromite comes from ophiolites. The Bay of Islands Ophiolite Complex (Newfoundland) lower crust records emplacement of a laterally discontinuous boninite sill complex. Centimetre-scale high-Cr/Al chromitite reaction rims separate intrusive dunite from lowermost crustal pyroxenites and formed through incongruent dissolution of Cr-rich pyroxene into chromite-saturated melts. The reaction rims are stripped from their substrates during magmatic flow and attain metre-scale thickness in fold noses, but volumes are small. High-Cr/Al chromitites are concentrated along the top of the lowermost crustal pyroxenite band. The mafic-ultramafic zone is constituted of peridotitic sills nearly identical to those of the underlying ultramafic zone that were injected synkinematically into gabbronorites, ferro-gabbros and olivine gabbros belonging (originally) to the older tholeiitic gabbro unit above. Field evidence shows feldspathic peridotites are hybrids generated by mixing primitive replenishments with host gabbros. Feldspar occurs within gabbroic schlieren and is often amoeboid and decorated by low-Cr/Al spinel, which formed by incongruent dissolution. Olivine is forsteritic ($Fo_{84–90}$), but each sample has a distinct population of plagioclase (An_{96} to An_{52}). The more sodic feldspars overlap with plagioclase compositions from distal tholeiitic gabbros, representing cases where the feldspar did not reequilibrate after mixing. Hybrid feldspathic peridotites generally contain 3–5% chromite (0.2–0.4 Cr_2O_3 wt.%) but there are centimetre-scale chromitite schlieren, which likely represent disaggregated reaction rims. The chromite grains are relatively coarse (0.5–3 mm), and our beneficiation and carbothermic reduction tests indicate that it represents a potential source for ferrochrome production. Spinel formation is locally inhibited by the presence of sulphides in host gabbros, as this lowers the oxygen fugacity and can remove chromite from the liquidus. Conversely, addition of sulphur to the melt locally triggered formation of sulphide in the boninitic magma (present as small globules), and we have detected fine-grained Pt and Pd sulphides during the processing test.

DEEP SEATED PEGMATITE EMPLACEMENT MECHANISMS

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Deep-seated pegmatite emplacement is driven by replacement and not any significant dilation. This is accomplished through fluid/rock interaction and assimilation. The process is enhanced by the inherent strain energy in the microstructure of the protolith due to deformation. As a rock such as a gabbro is under stress the internal strain of individual plagioclase grains increases as seen by undulose extinction and then the formation of mechanical twins which host the greatest number of defects. The grains with more defects provide a higher Gibbs Free Energy which helps drive the replacement process because strain energy is released during a chemical reaction. With increasing strain, recrystallization begins, and the grains lose their defects becoming strain free and less susceptible to reaction with the pegmatite. This paper will give an example of the Madawaska Mine pegmatites from Bancroft Ontario emplaced into the Faraday Metagabbro Complex (FMC) under upper amphibolite facies metamorphism during the Grenville orogeny. Here the microstructures are demonstrated and the effects of assimilation of the metagabbro are shown. This process of assimilation of the reduced iron-rich protolith also induced U-precipitation by fixing the uranium. Therefore, the emplacement mechanism provided the precipitation mechanism for ore mineralization. There are no known economic U-pegmatites outside of the metagabbro complex. Intrusion of a granitic pegmatite into metagabbro has a strong geochemical gradient from felsic to mafic, also redox reactions between the higher oxygen fugacity in the felsic pegmatite versus the reduced composition of the metagabbro assist in the reactions for replacement and assimilation. Evidence of this assimilation can be seen macroscopically but is also evident in the pegmatite mineralogy whereby the incongruent melting creates a peritectic documented by the occurrence of albite (granitic) and oligoclase due to assimilation of the Ca bearing gabbro. Emplacement of deep pegmatites is largely accomplished by strain enhanced reactivity.

GEOLOGY OF THE SPARK LITHIUM-CESIUM-TANTALUM PEGMATITE, NORTHWESTERN ONTARIO

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The Spark pegmatite, located ~180 km north of Red Lake (Canada), occurs with a group of pegmatites near the Bear Head fault zone, a dextral transcurrent structure within the North Caribou terrane of the Superior Craton. The Spark pegmatite, along with the Pakeagama Lake pegmatite 2 km to the south, are petalite subtype, LCT (lithium-cesium-tantalum) pegmatites that are a significant lithium reserve together containing more than 22 million tonnes grading 1.55% Li_2O. The Spark pegmatite is bounded to the south by an east-west-trending, steeply dipping fault that is oblique to the regional northwest-southeast-oriented structural trend. South of the fault, and in intrusive contact with the Spark pegmatite to the west, north, and east, are mafic metavolcanic rocks of the Favourable Lake greenstone belt. These host rocks consist of foliated to non-foliated amphibolite and phyllite. Lithological contacts within the Spark pegmatite are subvertical to vertical, and local open to close folds with vertical axial planes are observed. The Spark pegmatite consists of two predominant lithologies, which are aplite and felsic pegmatite, based on lithogeochemistry and outcrop and drill core observations. Aplite consists of fine-grained albite and quartz with variable muscovite (including lithian muscovite), tourmaline, and garnet. The felsic pegmatite contains megacrystic potassium feldspar, quartz, plagioclase, and muscovite with variable tourmaline. Spodumene is common to abundant in both lithologies with textures ranging from fine-grained scattered laths to coarse ubiquitous blades, to fine- to coarse spodumene-quartz intergrowth. Accessory Li-phosphate and lollingite occur in both lithologies. Contacts between host rocks and both lithologies commonly display centimetres to decimetres of biotite-tourmaline-holmquistite-lollingite wall zone, and holmquistite, epidote, carbonate, and actinolite altered host rocks metres away from the contact with pegmatite lithologies. The age of the pegmatite and host rocks, and chemistry of framework to accessory minerals, are virtually unknown and are the focus of future research.

AN INSIGHT INTO THE NATURE OF REE MINERALIZATION IN THE EASTERN PART OF THE ICE RIVER COMPLEX, BRITISH COLUMBIA

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In a developing world, an increased interest has been placed by governments on identifying a domestic source of critical metals, which include the rare earth elements (REE). From a geochemical standpoint, the REE include the lanthanide series (La-Lu) plus yttrium (Y). Light rare-earth elements (LREE) comprise lanthanum (La) to europium (Eu), which are enriched in alkaline igneous rocks and carbonatites. Carbonatites are notable to exploration companies for elevated LREE and other incompatible element concentrations. To form economic concentrations of REE-bearing minerals in carbonatites, a combination of evolutionary processes are required to raise REE concentrations to economically viable levels. In order to understand this, a detailed understanding of mineralogical and microtextural characteristics of any given carbonatite are essential. One example of a carbonatite associated REE exploration prospect is located on the eastern aspect of the Ice River Complex (IRC). The IRC is a late Devonian to early Carboniferous alkaline intrusion hosted in weakly metasomatised Cambrian–Ordovician deepwater country rocks. The oldest parts of the intrusion comprise a feldspar-poor jacupirangite to urtite series, which is crosscut by carbonatites and feldspathoid syenites, and in turn crosscut by lamprophyre dykes. As previous work on the Ice River carbonatites is limited, further analytical work is required to understand the source(s) of these rocks, their

https://doi.org/10.12789/geocanj.2024.51.211

relationship to the other intrusive units, and the character and distribution of associated REE mineralization. The focus of this presentation will be the mineralogical, textural, and paragenetic characteristics of the eastern Ice River carbonatites, with special attention being paid to REE-bearing phases.

PETROGENESIS, GEOCHRONOLOGY, AND CRITICAL MINERAL POTENTIAL OF HALL PENINSULA PEGMATITES, BAFFIN ISLAND, NUNAVUT

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Late-tectonic, unzoned granitic pegmatite bodies locally discordantly to concordantly intrude the Archean basement and Paleoproterozoic country rocks of Baffin Island's Hall Peninsula. The pegmatites are undeformed to moderately deformed, have widths of up to tens of metres and lengths up to hundreds of metres, and are well exposed at surface in the poorly vegetated tundra region. This research examines their melt source, relative timing of emplacement during the Trans-Hudson Orogen (THO), absolute crystallization age, and critical mineral potential. Uranium-lead dating on zircon and monazite collected from seven pegmatites provided three concordant ages and four non-concordant ages. The oldest concordant age, of 1870 ± 17 Ma, correlates with the intrusion of the Cumberland Batholith, whereas the younger concordant ages, of 1765 ± 9 Ma, and 1782 ± 10 Ma, correlate with the late- to post-tectonic phases of the THO. Mineralogically, these are simple pegmatites with a mineral assemblage of quartz-K-feldspar-biotite ± muscovite, tourmaline, garnet, and/or apatite, and are considered abyssal lithium-cesium-tantalum pegmatites. Whole-rock geochemical analysis of the pegmatites indicates a metasedimentary source for the original partial melts, and the pegmatites with the strongest fractionated geochemical anomalies, including Li, Sn, Nb, Ta, and Ce, are found in proximity to Paleoproterozoic Lake Harbour Group metasedimentary rocks. A group of eight pegmatites from the study area were identified as potential targets for further investigation of their critical mineral potential. Five of this group were both contemporaneous with the terminal stages of the Trans-Hudson orogeny, and geochemically anomalous when compared with regional geochemical trace-element concentrations. Several of the Hall Peninsula pegmatites merit further investigation of their critical mineral potential, and in general, exploration companies interested in pegmatites on Baffin Island should focus on prospecting activities along surface exposures of contacts between Archean tonalite gneisses and Paleoproterozoic metasedimentary rocks.

INVESTIGATING THE NORTHERN CACHE CREEK TERRANE OF ALFRED BUTTE MOUNTAIN - PRELIMINARY RESULTS FROM THE 2023 FIELDWORK SEASON

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Upper Paleozoic shallow platform carbonate rocks dominate the northern Cache Creek terrane in the Canadian Cordillera. Previous studies utilized warm-water fossils to advocate for an exotic origin of this terrane in the Panthalassa Ocean, far outboard of Laurentia. Recent re-evaluation of the terrane framework indicates that some terranes, including the historic Cache Creek terrane, were incorrectly defined, resulting in unreliable tectonic reconstructions and potentially incorrect provenances of these terranes. Fieldwork in 2023 focussed on the Cache Creek terrane at three locations on Alfred Butte Mountain, southern Yukon, to improve the constraints on the Paleozoic provenance of this terrane. Detailed stratigraphic sections were logged and sampled for petrographic, geochemical, and biostratigraphical (conodonts and palynology) analyses. Specifically, analyses focus on proxies for continental margin proximity such as the presence/absence of pollen spores, the occurrence of terrestrially-sourced red beds, and the concentrations of terrigenous trace metals. Based on in-the-field observations, the Horsefeed Formation on Alfred Butte is imbricated, with a at least five thrust sheets exposed in the immediate area. The base of each thrust sheet is characterized by cataclastites, basalts, red beds, and fossiliferous packstones to grainstones. The remainder of each thrust sheet is predominantly composed of massive lime mudstones with rare macrofossils and laminations. Evidence of alteration is prevalent in the forms of numerous stylolites, veins, and microfracturing. This presentation will provide an overview of the results of the field investigation and present preliminary findings from the ongoing analyses.

MACHINE LEARNING TO ASSIST IN IDENTIFYING NEW CRITICAL METAL TARGETS IN SEDIMENTARY BASINS

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The transition to a net-zero economy will necessitate a significant increase in the production of metals required in clean energy technologies which will require mineral exploration in previously unexplored environments. This will require new methods of analyzing and optimizing data in exploration, such as machine learning-based approaches. Such tools are being increasingly applied in the Earth sciences due to the increasing volume of available data. Non-traditional sources of critical metals, including those from sedimentary basins such as coal and coal combustion by-products (CCBs), phosphorites, and formation waters, are emerging as potential targets for addressing the increased mineral demands associated with the energy transition. While these sources have been historically under characterized with respect to their critical metal potential, a significant amount of data is available through historical industrial and research activities. Such large datasets are amenable to analysis through the application of machine learning approaches. Here, unsupervised and supervised machine learning algorithms are used to identify indicators and predict metal enrichment for REE in sedimentary strata and CCBs, as well as Li in formation waters. Results indicate that REE are commonly associated with incompatible elements (i.e. Th, Nd, and Hf) while Th and P are most important for predicting REE abundances. Conversely, geochemical associations with Li in formation waters are more difficult to ascertain, implying basin or depositional specific controls may control Li concentrations. Collectively, these findings can be incorporated into broader frameworks that include additional geochemical, spatial, historical, fluid flow, or drill core data as parts of an exploration strategy. Such an approach may be used to identify novel targets with potential for critical metal enrichments in previously underexplored environments. Recovering critical metals from non-traditional environments can be advantageous compared to traditional ore deposits due to lower production costs and less environmentally taxing extraction processes.

THE EFFECT OF SIZE AND SHAPE OF BRITTLE CLASTS ON DEFORMATION DYNAMICS WITHIN A SEMI-BRITTLE MATERIAL: A FIELD AND EXPERIMENTAL APPROACH

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Deformation styles change along a subduction zone interface from shallow earthquake-generating brittle deformation to viscous aseismic creep at depth. In the transition zone from brittle deformation to viscous creep, strain transients such as slow slip, tremor, and low-frequency earthquakes can be recorded. One explanation for the occurrence of these strain transients is coeval brittle and viscous (semi-brittle) deformation. Excellent examples of semi-brittle deformation are well-preserved within clast-in-matrix structures of exhumed subduction mélange deposits. These deposits form along the subduction interface when clasts are plucked from the under- or over-riding plates and incorporated into a seafloor sediment matrix. Field observations of the Franciscan Mélange outcropping near San Simeon, CA, reveal distinct semi-brittle behaviour. The clasts vary significantly in size following a power law distribution within the observation window. Furthermore, regardless of lithology, clasts display brittle failure terminating at clast boundaries. The encompassing fine-grained shale matrix is intensely foliated and fills fractures and voids within the clasts. Combining field observations with analog laboratory experiments, we investigate how grain size distribution and shape impact the deformation dynamics of brittle clasts embedded in a viscous matrix. For the brittle phase, we use

HydroCubes or Orbs that, when failing, follow a similar size distribution to the clasts at San Simeon. Carbopol® gel, a non-linear yield stress fluid, is used as the viscous phase. Both materials are deformed together inside a ring shear apparatus where we can observe and quantify how stress is transferred between the two phases. Experiments reveal larger and more angular clasts (cubes) undergo the highest degree of brittle failure. Understanding how clast size and shape can impact the degree of brittle failure has implications for subduction zone deformation dynamics.

INTERNATIONAL GEOLOGICAL CONGRESS 2028, AN EFFECTIVE CONDUIT FOR ADDRESSING OBSTACLES ASSOCIATED WITH GEOSCIENCE EDUCATION AND OUTREACH ACROSS CANADA

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International Geological Congresses (IGC) are the Olympics for geosciences. The Congress occurs once every four years, moving to different locations worldwide through a competitive bidding process. Typically, North American IGCs attract over 10,000 delegates. With the enthusiastic support of the Canadian Federation of Earth Sciences Members, Canada is submitting a bid to host IGC 2028 in Calgary, with the intention of returning an IGC to Canadian soil for the first time since 1972 (Montreal). The geosciences currently face the significant challenge of low student enrolment in Canadian undergraduate programs (decrease of over 40% since 2017). The Canadian IGC 2028 bid includes several strategies to address this issue and to promote geoscience education and outreach across Canada including: (i) Two years of national geosciences for 2027 (Geological Society of America will be in Montreal in 2027) and 2028, (ii) Creation of place- and curriculum-based geosciences modules for K-12 classes (across a wide range of subjects), (iii) Teacher workshops, (iv) Nation-wide GeoPromotion competition where K-12 students can promote any aspect of the geosciences with any deliverable (e.g. artwork, music, podcasts, blogs, videos, etc.), (v) Use of geoscience discoveries and events through social media to create a buzz across multiple platforms, (vi) Fostering of positive working relationships with federal, provincial, territorial, and municipal government partners (e.g. promote the geosciences through all levels of government), (vii) Development of a two week dual credit (grade 12 and first year university) summer geoscience course to be held in cities across Canada (geosciences as a standalone course in all provinces and territories), and (viii) A major media and marketing plan developed in collaboration with American Geophysical Union and Prospectors and Developers Association of Canada. It is our intention to use IGC 2028 as a platform for promoting the geosciences across Canada.

INCREMENTAL EMPLACEMENT OF THE GIANT MANONO-KITOTOLO SPODUMENE PEGMATITES, DEMOCRATIC REPUBLIC OF THE CONGO

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The Manono–Kitotolo pegmatites in the Democratic Republic of the Congo represent the worlds largest known LCT pegmatite system, stretching NE-SW over 13.5 km with a thickness of 250–300 m and unknown extent at depth. They consist of flat lying to steeply dipping subparallel sheets, and include the Roches Dures, Kyoni, Mpete and Tempete pegmatites in the southwestern Kitotolo sector, and the Carriere De L'Est and Malata pegmatites in the northeastern Manono sector. The alluvial and eluvial parts of the pegmatite were industrially mined for cassiterite and columbite-tantalite between 1915 and 1985. As of January 2024, exploration has led to a resource estimate of 842 million tonnes at 1.61 wt.% Li_2O, 709 ppm Sn, and 37 ppm Ta. Here, we present new geological and mineralogical findings from field work and drill core samples that present a full cross-section through the pegmatite occurrences. Spodumene forms the dominant Li phase, occurring as white tabular or prismatic crystals reaching 40 cm in length, and typically showing unidirectional growth textures perpendicular to the pegmatite contacts. Prismatic spodumene exhibits thin rims or crosscutting intervals of spodumene-quartz intergrowths (SQUI). Spodumene also occurs as fine-grained needle-shaped masses. Accessory phases include apatite, triphylite, garnet, and tourmaline. Metre-scale layering (or zoning) is visible in outcrop, whereas drill cores reveal zones of greisen, aplite, and alternating quartz-rich, albite-rich and spodumene-rich zones. Although a well-defined internal zonation pattern is lacking, zoning instead appears to be repeated at a metre to decimetre scale. Geochemical assays of the core reveal multiple 'high grade' zones, where Li_2O contents exceed 2%. These high-grade bodies appear to dip parallel to the overall pegmatite orientation and may represent core zones of individual pegmatite sheets. Consequently, we propose that the giant Manono–Kitotolo system formed through incremental emplacement of many smaller pegmatite bodies.

PROTRACTED (> 100 Myr) DEEP CRUSTAL OROGENESIS REVEALED BY IN SITU MONAZITE PETROCHRONOLOGY IN THE SHUSWAP METAMORPHIC COMPLEX, BRITISH COLUMBIA

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The Shuswap Metamorphic Complex (SMC) in the southern Canadian Cordillera exposes penetratively deformed, high grade metamorphic rocks exhumed from deep crustal levels (~25–30 km depth). We focus on a panel of SMC rocks ~12 km in structural thickness between Sicamous and Revelstoke, British Columbia. Here, the SMC is bounded by a Mesozoic to Paleogene northeast-directed thrust-sense shear zone (Monashee décollement) at its structural base, and the early Eocene west-directed Okanagan Valley fault system at its structural top. Previous models describing the tectonometamorphic evolution of the SMC lacked in situ absolute ages that could be directly tied to deformation and metamorphism. As a result, questions remain regarding when and for how long did the SMC rocks undergo penetrative ductile flow and high grade metamorphism, and how long were the bounding shear zones active. To address these questions and test the previous models, we apply U–Th–Pb monazite petrochronology, metamorphic phase modeling and microstructural analysis to quantify the pressure-temperature-time-deformation (P-T-t-d) paths along our transect of the SMC. The results demonstrate that peak metamorphism youngs with increased structural depth, and in early Eocene time there is progressive localization of opposite-sense shearing along the bounding shear zones. The petrochronology provides a robust record of protracted downward-migrating northeast-directed compression accompanied by metamorphism from ca. 167 to ca. 58 Ma, after which west-directed extension along the uppermost structural levels continued until at least ca. 49 Ma. Our constructed P-T-t-d paths are consistent with basal accretion in front of a downward and foreland-propagating ductile thrust system, followed by exhumation of the SMC via normal faulting.

MINERALOGY AND PETROLOGY OF THE PETALITE-SUBTYPE PROF PEGMATITE, REVELSTOKE, BRITISH COLUMBIA, CANADA

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The Prof pegmatite is ~70 × 5 m dyke located NW of Revelstoke, British Columbia, Canada on Boulder Mountain. Due to the abundance of petalite within it, the Prof pegmatite is classified as a petalite subtype Li-Cs-Ta pegmatite or a Group 1 pegmatite. The pegmatite contains a suite of minerals indicative of a highly evolved

https://doi.org/10.12789/geocanj.2024.51.211

pegmatitic melt including petalite, elbaite, lepidolite, and Nb-Ta oxides. It can be divided into four textural zones: (1) border, (2) intermediate including, (2.1) graphic texture dominant and (2.2) overgrowth dominant, where multiple minerals form rims around one another, (3) central, and (4) a quartz core. The border zone has a similar mineralogy to the intermediate zone and is interpreted to represent a chilled margin. The intermediate zone has a feldspar, mica, garnet and dravite-schorl dominant composition. The central zone hosts an evolved pegmatite core, which contains the main lithium mineralization composed of petalite, elbaite, and lepidolite. The tourmalines, Nb-Ta oxides, and micas within the pegmatite record the geochemical evolution of the melt from more primitive Fe and Mg-rich minerals to a Li, Mn, and Nb-rich assemblage indicative of an evolved geochemical system. The textures and geochemical composition of the pegmatite indicate that the melt was undercooled, highly geochemically evolved and crystallized rapidly. Three phases of metasomatism are recognized in the Prof pegmatite: an albitization event, a Na-Li-F rich event, and a sericitization event. Comparison to other pegmatites regionally shows that the Prof pegmatite is most likely linked to known pegmatites on Mount Begbie 15 km to the south, which have a similar mineralogy (in particular the notable presence of the rare qitianlingite, petalite, lepidolite and elbaite). The Prof pegmatite forms part of an extensive unmapped pegmatite field. Additional work is required to assess the extent and nature of mineralization within this field.

GOLD REMOBILIZATION THROUGH DEFORMATION AND METAMORPHISM: A CASE STUDY FROM THE GOLIATH GOLD DEPOSIT, DRYDEN, ONTARIO

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Archean gold deposits account for a major proportion of the world's gold resources. These deposits are generally associated with shear zones, have significant vertical extent, and are associated with carbonate alteration and elevated Au/Ag ratios. Although Archean gold deposits are associated with localized shear zones, the role of deformation in remobilizing gold remains poorly understood. The Goliath Gold deposit in Dryden, Ontario serves as a natural laboratory for studying gold remobilization during deformation because it is hypothesized to be a remobilized volcanogenic massive sulphide deposit. In this contribution, we examine the metamorphic history of the Goliath Gold deposit using Ti-in-quartz geothermometry, metamorphic pseudosections, and petrographic observations. The distribution of the ore zone at the Goliath gold deposit is the result of two main deformation events. The first event was a N-S compressional event producing tight, isoclinal folds and the second event was a E-W transpressive event producing open folds. The second deformation event is believed to be, in part, responsible for the remobilization of gold at the Goliath Gold deposit. Gold occurs along grain boundaries within quartz veins which display evidence for dislocation creep through grain boundary migration, including lobate and sutured grain boundaries. Grain boundary migration dynamic recrystallization is a deformation mechanism that occurs under low stress conditions. Ti-in-quartz analyses of gold bearing veins indicate that dynamic recrystallization occurred at ~580–606°C. These values are in general agreement with pseudosections and garnet isopleths which suggest peak temperatures of 550–600°C and pressures of 500–600 MPa. At the Goliath Gold deposit, gold appears to be remobilized to grain boundaries during dynamic recrystallization, potentially concentrating gold. We hypothesize that dynamic recrystallization of quartz at amphibolite facies, low stress conditions may have contributed to gold remobilization at the Goliath Gold deposit and may be a mechanism for local remobilization of gold in Archean gold deposits.

UNRAVELING THE ORIGIN OF NICKEL MINERALIZATION 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 is 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 remobilization of the sulphides during serpentinization. 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.

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 km east of Cochrane. These pegmatite units 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 (Cs-aluminosilicate) and columbite-tantalite (Ta-Nb oxides). Cesium mineralization in particular is rare in Ontario with five known occurrences: one of which is the Case Lake LCT pegmatite swarm. 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.

GREENPEG PROJECT'S GEOCHEMICAL EXPLORATION FOR LI-Cs-Ta (LCT) PEGMATITES IN NORTHERN PORTUGAL

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This research presents the preliminary results of the GREEPEG project stream sediment campaign to complement legacy data that did not cover the entire Barroso–Alvão pegmatite field (northern Portugal), where the largest spodumene reserves in Europe are located. The campaign took place in June 2022 during the dry season, with 20 samples collected (one sample per 1.85 km^2). The samples were sieved in situ (150–500 microns), riffled and 1/4 was sent for bulk geochemical analysis at Actlabs. Descriptive statistics and multivariate analysis were employed (correlation analysis, principal component analysis, exploratory factor analysis, and hierarchical clustering). Spatial analysis considered the mapped pegmatites within the field, as well as the distribution of known mineralized pegmatites. Anomaly definition was made through the percentile method (97.5%). Considering known pathfinders for LCT pegmatites (Li, Cs, Rb, Sn, Ta, Nb), Li, Sn, and Rb are closer to a normal distribution. All elements are positively correlated. The lowest correlation was Ta-Li. High correlations include Ta-Nb, Sn-Nb, Sn-Ta, and Cs-Rb. Both PCA and factor analysis show positive contributions of all elements in the first component. The second component highlights a correlation between Li and Cs (weaker for Rb), antipathetic with Sn, Ta and Nb. This is confirmed by hierarchical clustering. Spatial analysis showed that the highest Sn content does not match the highest Li values. Cesium,

Ta and Nb showed the most similar spatial patterns for high contents. Several mapped pegmatites can contribute to anomalous values, but none of the anomalies are justified by the mineralized pegmatites, indicating mineralized pegmatites were overlooked in the past and classified as barren. Unknown pegmatites in the region cannot be discarded. This needs to be checked in the field. Future studies will test other methods and incorporate the lithological background, and the results will be merged with the legacy data.

LITHIUM-BEARING PEGMATITES IN THE MONASHEE COMPLEX, BRITISH COLUMBIA: DIRECT FROM ANATEXIS TO EMPLACEMENT DURING SUDDEN BRITTLE FAILURE

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The study of lithium-bearing pegmatites is enlivened by ongoing debates and unanswered questions. One pertains to their genesis: can pegmatites containing distinct lithium-rich minerals form directly from metasediments by low degrees of partial melting, or can sufficiently high lithium concentrations only be achieved by extreme fractionation (or re-melting) of large volumes of granitic magma? Another relates to their emplacement: if the pegmatite-forming melts are typically significantly undercooled, what finally triggers crystallization? Observations from the Monashee Complex may provide answers. Firstly, a single anastomosing pegmatite dyke can be traced along strike, from a zone of complex mineralogy including lepidolite and elbaite, through simple quartz-feldspar-schorl, to diatexite migmatite. The contacts between these zones are gradational, indicating they formed from coeval melt, and suggesting a direct, traceable link between partial melting of metasediments and lithium-mineralized pegmatites. It remains unclear what processes allowed sufficiently high lithium concentrations to develop in this melt, but the composition of the calc-silicate, pelitic, and semi-pelitic source rocks may have been important. Secondly, several of the pegmatites occur as subvertical dykes with sharp contacts, emplaced into steep ~E-W trending shear zones developed in the generally gently dipping, locally migmatitic host rock. These shear zones resemble metre-scale extensional shear bands that accommodated ~N-S extension. Where they host pegmatites, there is a sharp contact between the gently dipping wall rocks and the steeply dipping internal units, suggesting sudden brittle failure. Where pegmatites are absent, the wall rocks curve into parallelism with the steep internal units, indicating ductile shear. This suggests that the pegmatites were selectively emplaced into those portions of the structure that experienced sudden brittle failure during extension, creating low-pressure spaces into which pegmatitic melts were sucked from the surrounding migmatites. These pegmatites were thus emplaced suddenly, potentially during seismic ruptures, and the pressure drop may have triggered their crystallization.

NITROGEN ISOTOPIC INSIGHT INTO THE GENESIS OF ARCHEAN CONTINENTAL CRUST

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Earth's earliest continental crust is dominated by a unique rock series of tonalite-trondhjemite-granodiorite (TTG). Despite the consensus on the source of TTGs (i.e. hydrous mafic crust), the origin of its internal geochemical diversity is widely debated. Conventionally, the distinguishing trace element concentration patterns (e.g. La/Yb versus Sr/Y ratios) of TTGs are linked to melting of altered basalts at various depths, which implicitly assumes that melt was completely crystallized after generation. However, recent studies advocate that mineral crystallization (plagioclase and/or hornblende) drives the compositional variability of TTGs. Here, we present a large nitrogen isotopic variation from the Neoarchean (ca. 2720 Ma) granitoids in the western Superior Province, southeast Manitoba. Modeling shows that N isotopes are insensitive to fractional crystallization. Instead, the large isotopic discriminations of the Manitoba TTGs track melting of altered oceanic crust at various depths.

PHOSPHORUS SPECIATION IN MAJORITIC GARNET: A DENSITY FUNCTIONAL THEORY INVESTIGATION OF PHOSPHORUS INCORPORATION MECHANISMS UNDER HIGH PRESSURE

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Garnets, including majorite (tetragonal $Mg_3(MgSi)Si_3O_{12}$), are important constituents in the upper mantle and the transition zone, and have long been suggested to incorporate significant amounts of phosphorus at pressures > 3 GPa. Therefore, the ability of majorite to accommodate and transport phosphorus is instrumental in understanding the phosphorus geochemical cycle within the deep Earth. The charge-coupled substitution mechanism involving phosphorus (P^{5+}) and aluminum (Al^{3+}) simultaneously replacing silicon (Si^{4+}) at tetrahedral sites is well-established for silicate minerals under crustal conditions. The documentation of six-coordinated P in berlinite ($AlPO_4$) and synthetic stishovite under elevated pressures at < 20 GPa points to the possible P substitution for Si octahedral sites in majorite, probably responsible for the increased incorporation of P in majoritic garnets at high pressures. This study conducted Density Functional Theory-based first-principles calculations to investigate various $P^{5+} + Al^{3+} = 2Si^{4+}$ substitution configurations in the ideal $MgSiO_3$ system, at static pressure up to 22.5 GPa. Preliminary results showed that configurations with tetrahedral P have lower energies than those with octahedral P under the investigated pressure ranges. Among the 25 configurations calculated thus far, one with an isolated P tetrahedron and an isolated Al octahedron is the most energetically favourable. Further calculations investigate P substitutions in the $MgSiO_3$ system upon phase transition from majorite to bridgmanite. These findings are anticipated to advance our comprehension of P behaviour in the Earth's mantle, offering insights into the roles of majoritic garnet and bridgmanite in phosphorus storage.

RELATIONSHIPS BETWEEN Co-Ni-As AND U MINERALIZATION IN THE ATHABASCA BASIN

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The Proterozoic Athabasca Basin in central Canada hosts numerous world-class uranium deposits, many of which contain elevated concentrations of Ni-Co-As and other metals, referred to as polymetallic unconformity-related uranium (URU) deposits. The relationship between Co-Ni-As and U mineralization in these deposits is a subject of debate regarding whether these deposits formed by two distinct mineralization events, i.e. U mineralization superimposed by a separate Co-Ni-As mineralization event, or by one unified U-Ni-Co-As mineralization event. This problem is complicated by the possibility of multiple stages of ore precipitation in one mineralization event, and multiple remobilization events that make accurate dating of the primary mineralization challenging. Petrographic studies of polymetallic URU deposits reveal multiple stages of mineralization, each showing a paragenetic sequence with precipitation of uraninite followed by Ni-Co arsenides and sulphoarsenides, which is consistent with geochemical modeling of progressive reaction of oxidizing ore-forming fluids with reducing fluids or lithologies. The repetition of the same paragenetic sequence argues against the notion that U was precipitated in one mineralization event and Co-Ni-As by a separate one. The primary mineralization age extrapolated from chemical ages of the most intact uraninite is consistent with that inferred for both polymetallic and monometallic URU deposits across the Athabasca Basin. The ore-forming fluids of both polymetallic and monometallic URU deposits and diagenetic fluids in the basin, recorded by fluid inclusions, are all within the H_2O-NaCl-$CaCl_2$-KCl-$MgCl_2$ system, including NaCl-dominated and $CaCl_2$-dominated varieties, with overlapping U-Co-Ni concentrations and Na/(Na + Ca) ratios. The L-shaped relationship between Ni + Co and U concentrations in fluid inclusions suggest that these metals were derived from different sources, with U being most likely from the basin and Ni + Co from the basement. Whether polymetallic U-Ni-Co deposits were formed depends on the avail-

https://doi.org/10.12789/geocanj.2024.51.211

ability of these elements as well as As and S in the various fluids involved in the mineralization.

LI-BEARING PEGMATITES FROM CAT LAKE, MANITOBA, CANADA

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Metasomatism influences lithium content in lithium-bearing pegmatites. Understanding the evolution of the magmatic stages during the formation of these pegmatites, the magmatic-hydrothermal transition, and the origins of metasomatizing fluids are crucial. These processes are important for identifying lithium depletion mechanisms and pathways to optimize exploration efforts. This project aims to develop a paragenesis for the magmatic-metasomatic stages, examine the impact of metasomatic fluids on lithium content, and lithium remobilization with respect to lithium-bearing pegmatites. The Cat Lake area (southeastern Manitoba) was the focus of sampling for lithium-bearing pegmatites exhibiting metasomatic alteration. These Archean-age pegmatites intrude mafic volcanic and metasedimentary rocks from the Bird River Greenstone Belt. The focus of this study is a zoned pegmatite, with fine-grained texture close to the contact, followed by a relatively unaltered and an altered spodumene zone, and a zone with quartz and feldspar. Drill core samples cover the complete sequence of the pegmatite and country rock. Petrographic analysis identified two stages of mineral growth - magmatic (quartz + feldspar, then spodumene, as suggested by relative cross-cutting relationships between the crystals) and metasomatic (evidenced by spodumene breakdown and intergrowths with albite or quartz, albitization, and feldspar alteration). Future work includes further petrographic studies to reconstruct pegmatite paragenesis. Understanding the more complex textures will enable us to characterize the extent of metasomatism, identifying chemical variations and the breakdown path of spodumene. Stable isotope analyses (O, B, and Li) will be employed to determine the origins of metasomatizing fluids (e.g. meteoric, magmatic, or metamorphic) and assess potential magmatic influences and crustal assimilation in pegmatitic melt sources.

CRITICAL MINERAL POTENTIAL OF NORTHEASTERN ALBERTA'S CANADIAN SHIELD: ANOMALY DETECTION USING WORLDVIEW-3 VNIR AND SWIR BANDS AND TERRASPEC HALO SPECTRA

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Northeastern Alberta's Canadian Shield is underexplored for metallic minerals, despite many known occurrences. Its mineral potential is poorly understood due to complex lithologies and structural-metamorphic features, including prominent shear zones, unspecified protoliths and orogenic contexts, and inadequately documented pegmatites. The region also presents opportunities for discovering critical minerals alongside primary, non-critical economic minerals. By utilizing WorldView-3 multispectral imagery, this study identifies mineral anomalies through field spectra analysis, predominantly in narrow belts near major shear zones. These anomalies are associated with alteration features: weathered sulphide horizons, quartz-tourmaline metasediments, and pegmatites. In this study, we isolated pure pixels of rock outcrop in the imagery by masking non-rock features such as vegetation, wetland, and shadows. This was crucial for accurately identifying mineralogical anomalies. Out of 629 TerraSpec Halo mineral spectra collected in the summer of 2023, 13 unique endmember spectra were selected using Spectral Feature Fitting (SFF) and Spectral Angle Mapper (SAM) with a combination of more than two absorption features: AlFeMg, AlOH, CSM, Fe3i, Fe3t, ISM, and MgOH. The endmember spectra were then resampled to WorldView-3 visible to near infrared (VNIR; 425 to 950 nm) and short-wave infrared (SWIR; 1210 to 2330 nm) bands. These resampled endmembers facilitated the generation of a spectral similarity map using SAM and OH indices. Ninety-three percent of endmembers within a 20-m radius of rocks with elevated concentrations of Ce, Nd, Pr, Li, U, and Th (as measured by whole-rock geochemical analysis of field samples) exhibit four or more absorption features. The primary lithologies linked with these findings are gneiss, granitoid, mylonite, and diatexite. Future initiatives will extend this methodology to mineral spectra of the original geochemical samples in different geological settings. The spectral similarity endmember map has been instrumental in identifying targets for enhanced field investigation and mineral exploration.

SPECTROSCOPIC ANALYSIS OF PLANETARY REGOLITH ANALOGUES

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Numerous space agencies and public and private organizations have produced simulants (or analogues) of regolith present on multiple bodies, such as the Moon, Mars, asteroids, and comets. The design and fabrication of regolith simulants can be a complex undertaking and can be driven by multiple considerations. These include the intended use, such as reproducing geotechnical properties for assessing factors such as trafficability, exploitation for in situ resource utilization, reproducing the mineralogy of planetary regoliths, or reproducing the spectroscopic properties of a planetary surface. These are not always mutually exclusive. The fidelity of simulants can also be affected by the availability of "raw materials" that go into their production, as well as desired quantities. In addition, it is not possible to produce a "universal" simulant for a solar system body, as geological diversity (both physical and compositional) is the norm on planetary surfaces. For instance, the lunar surface can be broadly subdivided into two major lithologies, mare and highlands, but within these broad groups, there are variations in terms of mineralogy, and physical properties (e.g. grain size, particle size distribution). Another factor that impacts the production of high-quality regolith simulants relates to the conditions present on different planetary surfaces. For instance, the surface of Mars has a thin atmosphere with little protection from solar UV irradiation. This can lead to changes in the composition of various minerals, particularly water-bearing ones. In the case of the Moon, its lack of atmosphere and bombardment by solar wind, galactic cosmic rays, and micrometeorite bombardment (often collectively referred to as space weathering) leads to a unique surface environment that is difficult to reproduce on Earth. We have undertaken a wide-ranging spectral reflectance study of various planetary regolith simulants that can serve as a guide to identifying appropriate simulants for specific applications.

DISENTANGLING STRATABOUND COBALT MINERALIZATION AT KINSEVERE, DEMOCRATIC REPUBLIC OF THE CONGO

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The Central African Copperbelt (CACB), which spans the frontier between Zambia and the Democratic Republic of the Congo, is the world's largest repository of copper and cobalt. Both metals are critical to the Green Energy Transition, and demand for cobalt is increasing most rapidly, because of its use in the cathode of lithium ion electric vehicle batteries. The CACB has shouldered much of the increased cobalt production needed to meet this demand, with production rates increasing > 9% from 2022 to 2023, thereby accounting for more than two thirds of the global supply of cobalt. Despite the importance of the CACB to the global cobalt supply, the key processes that control the distribution of cobalt, especially with respect to that of copper, are poorly constrained. To improve our understanding of the distribution of these metals and the associated ore-forming processes, we have undertaken field and petrographic studies at Kinsevere, a collection of three deposits that constitutes the largest copper-cobalt resource in the Southern Congolese Copperbelt. The copper and cobalt at Kinsevere occur both as vein-hosted and disseminated mineralization hosted predominately in the Mines Subgroup. A distinct style of cobalt-rich mineralization is present at the base of the Mines Subgroup, extending ~< 5 m above and below the contact with the Roches Argileuses Talqueuses (R.A.T.) Subgroup. A textural evaluation of the constituent sulphides indicates that they overprint (post-)diagenetic features, suggesting the formation of this stratabound, cobalt-rich mineralization by the late- or post-diagenetic infiltration of a hydrothermal fluid along the Mines-R.A.T. contact. This highlights the important contribution

of late- or post-diagenetic processes to the metal endowment of the CACB, as well as the challenges that attend the genetic interpretation of its disseminated, stratabound cobalt mineralization.

THE USE OF BERYLS AS PETROGENETIC INDICATORS OF PEGMATITES, A CASE STUDY IN THE ARAÇUAÍ OROGEN

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Beryl occurs in a wide range of rare-element pegmatites and has provided important insights into their evolution. Studies on the pegmatites of the state of Espírito Santo are scarce. This region is in southeastern Brazil, in the context of the Araçuaí Orogen and the Eastern Brazilian Pegmatite Province. This contribution aims to characterize the chemistry of the major and trace elements found in beryls and to classify the pegmatites related to them. In this study, beryl crystals from pegmatite were examined using electron microprobe analysis, ICP-MS (inductively coupled plasma-mass spectrometry), XRD, Fourier transform infrared spectrometer, and Raman analyses. Beryls' affinity for the dominant normal substitution is reflected in cell dimensions and the c/a ratio. Based on Raman and infrared spectroscopy, samples have a similar position and intensity of water, indicating the presence of both water types in the channels. In terms of classification based on petrogenetic families, the Itarana (I) and Varzea Alegre (VA) pegmatites belong to the niobium-yttrium-fluorine family, while the pegmatites of Afonso Cláudio (AC), Vargem Alegre (VA), São Gabriel da Palha (SGP), Nova Venécia (NV), Castelo (C) and Mimoso do Sul (MS) belong to the lithium-cesium-tantalum family. Pegmatites with genesis related to residual melts from granitic magmatism are AC, VA, I, VA, C and MS. The SGP and NV pegmatites have anatexis-related genesis. According to the new classification, these pegmatites belong to group 1 (AC, VA, I, SGP, NV, VZA, C - with beryl assembly without evidence of Li, Nb, Ta or Sn mineralization) and group 2 (MS - pegmatite characterized by high Be and F contents expressed mainly in the form of beryl, topaz and fluorite).

COMPARISON BETWEEN SUPERVISED AND UNSUPERVISED METHODS FOR PROSPECTING PEGMATITES USING LOW DENSITY CURRENT SEDIMENT DATA - CASE STUDY IN THE STATE OF ESPÍRITO SANTO - ARAÇUAÍ OROGEN, BRAZIL

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The state of Espírito Santo is in the southeast of Brazil, in the context of the Araçuaí Orogen and the Eastern Brazilian Pegmatite Province, one of the most important pegmatite provinces in the world. Lithium is on the European Union's list of critical raw materials, due to its importance for the green energy transition, as well as its significant role in the production of lithium-ion batteries. Against this backdrop, the search for new deposits is in full swing in the region, as is the development of new tools to make Li exploration more accessible and effective. Despite having a geological framework marked by numerous granitic intrusions of the same origin as those that host the mineralized pegmatites of Minas Gerais. Espírito Santo has not yet been recognized as a potential pegmatite area. Two methodologies were applied: one supervised, in which the operator defines weights and combinations of elements, and the other unsupervised, based on principal component analysis (PCA). The concentration-area fractal method was used to distinguish normal concentrations from anomalies. As a result, the geochemical maps were interpolated by inverse distance weighting, with target areas detected based on anomalous concentrations. In the supervised method, the data was separated into five principal components (PC), comprising 75.75%. PC1 corresponded to the elements Rb, Cs, Li, Ba, Zn, Be and Sc. The areas with large anomalous points were delimited by the association of elements that may indicate areas with potential for pegmatites (PC1 anomalies) and regions with favourable lithology for pegmatites. Validation was carried out using a prediction area graph, which provides a reliable method for analyzing the performance of spatial evidence maps and prospecting models.

THE TOWER VOLCANOGENIC MASSIVE SULPHIDE DEPOSIT: A JUVENILE ARC-HOSTED SYSTEM WITHIN THE SUPERIOR BOUNDARY ZONE

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The Tower Cu-Zn-Ag-Au deposit is a bimodal, likely mafic dominated, volcanogenic massive sulphide (VMS) system located within the Superior Boundary Zone of Manitoba. The deposit is situated along the eastern margin of the Thompson Nickel Belt (TNB), close to the boundary with the Winnipegosis Komatiite Belt, and subcrops under Paleozoic limestone and sandstone of the Western Canadian Sedimentary Basin. The deposit is hosted by a variety of amphibolite, gneiss, and schist, which were metamorphosed to middle amphibolite-facies conditions during the Trans-Hudson orogeny. The host rocks were initially correlated with the Ospwagan Group stratigraphy of the TNB; however, this was found to be inconsistent with whole-rock isotopic and lithogeochemical data. The data suggests the Tower stratigraphy represents variably altered mafic and felsic rocks of juvenile arc-affinity. The juvenile, arc-like geochemistry of the Tower stratigraphy contrasts with our current understanding of the Winnipegosis belt, which is characterized by komatiitic and tholeiitic MORB-like magmatism along the rifted margin of the Superior craton. Juvenile arc-affinity magmatism is associated with several VMS deposits identified in the Kisseynew Domain in the adjacent Reindeer Zone of the Trans-Hudson Orogen. However, the rocks at Tower appear isotopically and geochemically distinct from those associated with the Kisseynew Domain deposits. The rocks hosting the Tower deposit appear to share the greatest isotopic and geochemical similarity with rocks from the Snow Lake assemblage of the Flin Flon Domain. It has been suggested that the Snow Lake assemblage might have developed as a pericratonic-arc outboard of the Superior craton. It is proposed that the rocks that host the Tower deposit represent a slice of juvenile crust from the Reindeer Zone that was thrust onto the Superior craton margin. The juvenile crust was preserved as an erosional remnant, or klippe, that now resides approximately 30 km east (inboard) of the present-day Superior craton margin.

STRUCTURAL STUDY OF THE TAZIN RIVER SHEAR ZONE IN THE HILL ISLAND LAKE AREA, SOUTHERN TALTSON OROGEN, NORTHWEST TERRITORIES

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The Tazin River shear zone (TRsz) is a major north-striking ductile-brittle fault zone separating the Taltson basement complex from the Nonacho basement complex in the southern Taltson orogen of the western Canadian Shield. At Hill Island Lake, low-grade supracrustal rocks of the Hill Island Lake assemblage (HILa) are localized along and span this fault zone. Fieldwork carried out in conjunction with the Northwest Territories Geological Survey focused on an E-W transect of the fault, emphasizing lakeshore lithostructural mapping and sampling. Across this transect, pelitic rocks of the HILa show a significant increase in metamorphic grade from middle greenschist facies (biotite zone) in the west, to strongly foliated, middle amphibolite facies (garnet-staurolite-andalusite-bearing) schists within the fault zone. Basement orthogneisses within and east of the shear zone contain older amphibolite-upper amphibolite facies assemblages. Three main episodes of deformation affect the HILa rocks along the transect. D_1 is mainly expressed as an axial planar cleavage preserved in the HILa rocks. D_2 is manifested as a set of northwest-trending, mainly Z-asymmetric folds in the HILa and basement rocks. Associated shearing indicates a dextral shear regime. D_3 is represented by a set of northeast-trending S-folds concentrated within HILa schists marking the TRsz along the eastern shore of Hill

https://doi.org/10.12789/geocanj.2024.51.211

Island Lake; similarly oriented S-folds are present within basement gneisses. Shear sense was determined using rotated porphyroclasts, shear bands, rotated quartz veins, and S-C' fabric. The high degree of strain in the TRsz basement rocks suggest that older basement structures have helped localize younger deformation/reactivation. Petrographic-microstructural study will characterize the mineral assemblages and further evaluate the timing of mineral growth in relation to deformation with absolute ages to be constrained by in situ U–Pb dating. This approach will help determine the relationship between the three locally observed deformational phases and more regionally recognized events.

TRACE ELEMENT GEOCHEMISTRY OF LI-RICH PEGMATITES IN THE CAROLINA TIN-SPODUMENE BELT, NORTH CAROLINA, USA

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Granitic pegmatites are an important Li source necessary for the transition to a green economy less reliant on fossil fuels. Lithium-rich pegmatites in the historically mined Carolina Tin-Spodumene Belt (CTSB), North Carolina, USA, are one of the largest known Li sources in the USA, with future mining in the planning stages, yet their geochemical evolution and petrogenesis remain poorly understood. We used whole-rock and mineral trace element geochemistry to place the CTSB pegmatites in the context of Li-rich pegmatites worldwide and evaluate petrogenetic hypotheses for the CTSB. The low Li content (44 ppm) of the potential parental granite for the CTSB pegmatites, the Cherryville Granite, is insufficient to reach Li saturation through fractional crystallization based on trace element modelling, suggesting an anatectic origin for the pegmatites rather than evolution via extreme fractional crystallization. Other evidence for an anatectic origin includes low Rb and Al contents in quartz and lower REE contents in garnet and apatite in spodumene-bearing samples compared to spodumene-free samples. Large positive Eu anomalies and REE patterns with marked tetrad effects in apatite indicate crystallization during oxidizing conditions with fluid involvement. Trace element chemistry of muscovite, K-feldspar, garnet, and spodumene indicate that Li-rich pegmatites of the CSTB are moderately fractionated, but not as evolved as many Li-rich pegmatites worldwide. In addition to the well-known muscovite K/Rb-Li systematics, this study points to several other useful indicators to aid in Li-pegmatite ore exploration efforts. These include K/Rb and Li in K-feldspar; K/Rb, Li, Al, Rb, and Ge in quartz; Sn and REEs in garnet; and Sr and Y in apatite. These geochemical indices can individually or collectively be helpful in distinguishing samples with and without Li mineralization.

ARE WE TEACHING OUR STUDENTS ABOUT GEOTHERMAL ENERGY? AN EXAMINATION OF POST-SECONDARY GEOSCIENCE CURRICULA ACROSS CANADA

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Geoscientists have a critical role to play in many aspects of the current energy transition, as our global society moves away from fossil fuels and towards renewable energy sources. Energy from the heat of the Earth can be utilized for electricity generation in high enthalpy systems, or for district heating and other direct uses in low enthalpy systems. Exploration and development of geothermal systems requires geoscientists who can interpret the subsurface based on geological, geochemical, and geophysical data. But are post-secondary geoscience departments across Canada teaching students about geothermal systems at the same frequency as more traditional subsurface energy sources such as oil, natural gas, and coal? A preliminary examination of geoscience curricula shows that only a few departments offer courses dedicated to geothermal energy, while most offer courses focusing on fossil fuels. At several universities, geoscience students are actually not allowed to enroll in geothermal energy courses; they are reserved for energy engineering or petroleum engineering students. In fact, it is much more common for courses on geothermal energy to be found either in engineering departments or as a sub-topic in business or sustainability courses, rather than in geoscience departments. This situation needs to change. Departments need to start offering courses that will prepare students for work in emerging renewable energy sectors such as geothermal. This industry needs more than engineers and policymakers, it needs geologists, geochemists, and geophysicists who understand mineralogy, petrology, and the 3-D geometry of complex subsurface structures. Even though we have a different geological setting than somewhere like Iceland, geothermal energy is relevant for Canada and we need skilled geoscientists to be involved in the development of this renewable resource.

TESTING GENETIC MODELS FOR LITHIUM-CESIUM-TANTALUM PEGMATITE FORMATION USING MULTI-METHOD GEOCHRONOLOGY: WESTERN SUPERIOR PROVINCE, DRYDEN, ONTARIO

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Three main genetic models have been established for the formation of lithium-cesium-tantalum (LCT) pegmatites: (1) extreme fractionation of S-type granitic magma, (2) low-degree partial melting of metasediments, and (3) partial melting of S-type granites. Each model has predictable and testable temporal relationships between the pegmatites and the surrounding geology. The pegmatites in the Dryden area of the western Superior Province are ideal for testing these genetic models as they are hosted in locally migmatitic sedimentary and metavolcanic rocks and occur in proximity to several granitoid bodies, including the Ghost Lake Batholith. However, limited geochronological data exists for the region. To address this, we are conducting a geochronological study on the LCT pegmatites and spatially associated rocks in the Dryden area. LCT pegmatites crystallize from highly evolved melts. As such, conventional geochronologic minerals such as zircon may not be present, or if so, may be extremely U-rich, resulting in a metamict crystal unsuitable for geochronology. Furthermore, depending on the pressure-temperature history of the region, U–Pb zircon geochronology may only record a discrete phase in the formation of an LCT pegmatite system. To constrain a complete history of the region and of LCT pegmatite mineralization, we plan to use a combination of U–Pb cassiterite/columbite/tantalite/microlite, in-situ Rb/Sr mica (biotite/muscovite), and Re–Os molybdenite geochronology, together with conventional U–Pb dating of zircon and monazite where possible. The resulting ages will be used to test which genetic model is consistent with the Dryden LCT pegmatites. Model 1 would be supported by similar crystallization ages for both the pegmatites and the Ghost Lake Batholith; Model 2 would be favoured if the pegmatites and migmatitic sediments are of a similar age; while Model 3 would be indicated by similar ages for the pegmatite and the remelting of the nearby granites (potentially evidenced by magmatic zircon rims).

SPATIAL AND TEMPORAL TRACE-ELEMENT AND O AND Hf ISOTOPE HETEROGENEITIES IN THE ARCHEAN RAE PROVINCE RECORD

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The Archean crust of the Rae Province was mainly formed at 2.75–2.58 Ga, but its primary characteristics have been reworked and obscured by at least five tectonometamorphic events between 2.6 and 1.8 Ga. To characterize the lithospheric architecture of the Rae Province and identify tectonic controls contributing to its crustal growth, we use trace-element and hafnium (Hf) and oxygen (O) isotopic analysis of zircon from 115 Archean magmatic rocks. The samples are representative of the spatial and temporal breadth of the Rae Province. Two magmatic intervals (2.75–2.68 Ga and 2.63–2.58 Ga) are dominant across the Rae Province and are the focus herein. Circa 2.75–2.68 Ga rocks have correlated O and Hf isotopic signatures. Samples from southern Melville Peninsula (Repulse Bay block) and Baffin Island record elevated $\delta^{18}O$ (up to 7.5‰) and low εHf (-5 to +1), requiring interaction of their source with Mesoarchean sediment or crust. In contrast, samples from Woodburn Lake, Committee Bay, northern Melville Peninsula, South Rae, and Chesterfield block show mantle $\delta^{18}O$ (< 6‰) and juvenile εHf (+3 to +5) compositions, consis-

tent with derivation from juvenile crust as preserved in nearby, coeval greenstone belts. These contrasting isotopic signatures indicate that Baffin Island and the Repulse Bay block may have a shared history distinct from the rest of the Rae Province prior to 2.68 Ga. Circa 2.63–2.58 Ga plutonic rocks (Snow Island suite) are dominant throughout most of the Rae but are absent from areas influenced (Baffin Island, the Repulse Bay block), or dominated (Queen Maud block, Taltson basement complex) by Mesoarchean crust. Crystallization ages and εHf decrease westward towards the Mesoarchean Queen Maud block and Taltson Basement Complex from εHf of +2 at 2.63–2.60 Ga to -2 at 2.60–2.58 Ga. O isotope compositions and trace-element ratios do not correlate with Hf and instead reflect local crustal heterogeneities.

GEOCHEMISTRY OF METABASITES FROM THE GRENVILLE FRONT TECTONIC ZONE IN WESTERN QUÉBEC

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Part of the parautochthonous belt of the Grenville Orogen, the polymetamorphic Grenville Front Tectonic Zone (GFTZ) exposes high grade rocks of various ages, variably reworked during the Grenvillian orogenesis, for which the nature, timing, and P-T conditions remain poorly constrained despite being key to decipher fluid generation episodes and tectonic styles of the region. In western Québec, the GFTZ is composed of migmatitic parageneiss locally hosting metabasite pods and lenses of uncertain origin and age. To address these unknowns, we present new field relationships, petrography, and whole rock chemistry data from 48 metabasite samples from the GFTZ. Two groups are identified based on different mineral assemblages and trace elements signatures. A first group includes massive plagioclase + clinopyroxene + garnet + biotite + ilmenite ± olivine ± hornblende ± hercynite mafic rocks with preserved igneous sub-ophitic texture. They are characterized by the absence of a negative Nb-Ta anomaly, Nb/Yb (13.1) and Th/Yb (1.7) ratios typical of an OIB signature and a high TiO_2/Yb (1.2) ratio consistent with a deep mantle source. They are interpreted as Paleo- to Mesoproterozoic mafic dykes metamorphosed during the Grenvillian orogenesis. A second group includes granoblastic, strongly foliated, and folded metabasites composed of hornblende + plagioclase + clinopyroxene + garnet ± orthopyroxene ± quartz ± ilmenite ± titanite containing up to 5 vol.% leucosome. These rocks are characterized by a negative Nb-Ta anomaly, Nb/Yb (2.1) and Th/Yb (0.7) ratios reflecting a contaminated MORB signature and a low TiO_2/Yb (0.5) ratio attributed to a shallow mantle source. This second group is interpreted as syndeposition gabbroic sills, metamorphosed at the granulite facies during the Neoarchean. Our results suggest two distinct high-grade metamorphic episodes, with a first Kenoran event recorded by mafic granulites and a second Grenvillian event recorded by monocyclic Proterozoic mafic dykes. Quantitative P-T-t-D data are being produced and will provide the basis of our understanding of the metamorphic conditions and styles during both events in this complex polymetamorphic region.

THE MINERALOGY OF METEORITES - AN INDEPENDENT SURVEY

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A detailed review of the mineralogy of meteorites (and other extraterrestrial materials) has been under construction since 2015. For each mineral, there is an abstract in a set format, with basic chemical and structural data, systematic data such as name, type locality and type material (where known), and notable physical properties as they relate to meteorites. There follows a note of each class of meteorite in which the mineral is known. A "comments" section may add miscellaneous data, including notes of occurrences in Moon rocks and/or asteroidal or cometary sample returns. There are currently some 155 "off-world" minerals first described in Moon rocks and meteorites, and some 277 species previously described on Earth, for approximately 432 minerals (7.2% of 6006 IMA-approved species as of January 2024). The "heavenly bodies index" follows an LPI tradition and will list all the meteorites mentioned in the abstracts: 500-plus are cited for the first 150 "Earth" minerals. The authors have contrasting fields of expertise that include systematic mineralogy (JdF), meteorite petrology (RKH) and Earth-science literature (GCW). The latter's MINLIB bibliographic database has been mined extensively for the circa 64% of species first described on Earth, with > 12,000 records relevant to meteorites and nucleosynthesis, planetary science, Moon rocks and impact events (some 8400 — 9% of the database — are relevant to meteorites and their payloads of cosmic clues). The multidisciplinary field of meteoritics has spawned a vast trove of books and journal articles. The new volume's structure will be akin to several systematic and topographic mineralogy texts. Although it is compiled from the literature and is thus something of an homage to the small but active meteoritics community, the structure of the work separates it from the many existing reviews.

EARTHQUAKE EARLY WARNING EDUCATION CHALLENGES WITH MAGNITUDE AND INTENSITY: EARTHQUAKE SCIENCE DISCOVERY, DATA COLLECTION, AND DATA PREPARATION

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Tasked with examining misconceptions of the terms magnitude and intensity, the Earthquake Early Warning Education (E3) sociocultural research analytics process involved four distinct steps: data discovery, collection, preparation, and analysis. To complete the work to support the Government of Canada earthquake early warning (EEW) system, the terms earthquake magnitude and earthquake intensity were examined in a broader framework of disaster studies and science communication studies. Empirical evidence from a Pan-Canadian E3 bilingual survey, a Pan-Canadian review of textbooks used in undergraduate natural hazard university courses, and content from Facebook Ads, Google Trends and Open Knowledge Map was collated. Interdisciplinary analysis of the term earthquake magnitude and earthquake intensity was completed. Based on empirical evidence collected from several different sources, 6 general misconceptions were identified. Misconception 1: earthquake magnitude can be compared to earthquake intensity; Misconception 2: earthquake magnitude is the same as earthquake intensity; Misconception 3: the estimation of earthquake magnitude will determine the amount of shaking in a specific location; Misconception 4: earthquake magnitude estimations provide my team with a situation awareness update for a specific geographic region; Misconception 5: earthquake magnitude estimations forecast the impact on buildings, people and the environment; Misconception 6: building standards/critical infrastructure design that use magnitude calculations as a design feature confirm that the construction is earthquake proof. Revisions to stereotypical definitions and perceptions of earthquake science occurred because the analysis was grounded in disaster research and science communication research. The findings are used to extend an existing framework on earthquake science analytics. Researchers and practitioners who wish to examine the challenges and potential of using earthquake science in EEW messaging to support decision making during disasters and emergencies will find this presentation helpful.

EARTHQUAKE INTENSITY AND EARTHQUAKE MAGNITUDE: THE E3 RESEARCH-BASED CHECKLIST FOR CRITIQUE OF VISUAL CONTENT

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Research investigating earthquake early warning (EEW) systems reveals many challenges in EEW messaging to support decision making during disasters and emergencies. The consequences of misunderstanding the concept earthquake magnitude in this forum may mean lives are saved, or more deaths have been caused. Visual content may allow disaster response teams to receive valuable earthquake science education products from the Government of Canada prior to and during a crisis event. However, misinformation about earthquake science is circulating the globe, due to the architecture of internet, smart phones and computers. Research indicates that

https://doi.org/10.12789/geocanj.2024.51.211

many online EEW teaching tools contain visuals that are scientifically incorrect. Nevertheless, these teaching tools are picked up by professional networks who uncritically use them to teach children, youth and adults. To overcome these issues, this paper presents a checklist built from a broad research base on how people learn in emergency situations. This checklist helps to: (1) critique visuals to deliver training during an earthquake event which will provide the correct interpretation of EEW messaging, thereby promote the appropriate actions; (2) evaluate visual EEW content good enough to train those for first deployment during an earthquake event; and (3) classify EEW visual training materials for personnel to support situational awareness for decision making and coordination efforts. Vetted visuals can be used in training to ensure correct tasks follow from EEW alerts. Using this approach, a global inventory of online visuals has been classified as off topic (irrelevant to situation awareness) or on topic. This step provides transparency, presenting specific content that will create pedagogical myths about the terms earthquake magnitude and earthquake intensity. Stated simply, if used in emergency management training, they will increase learner's confusion about these concepts. Despite the use of the preliminary checklist on the visual dataset, further improvement would be welcomed.

EARTH SCIENCE COMMUNICATION: CONNECTING EARTHQUAKE SCIENCE, GEOHAZARD RISK AND CRISIS eLEARNING INFORMATION NEEDS

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Research initiatives that focus and promote consistent and scientific application of existing geophysics and seismology in current public safety crisis communication interventions are rare and uncommon. International agreement on geohazards classification was developed through the ISC/UNDRR scientific/technical process. Yet these geohazards could become disasters dependent upon specific risk contexts (e.g. social, economic, political) within each nation. Currently, there is no technical overview available in Canada that provides a comprehensive picture of the legislation, disaster management models and information management to help inform the policy, practice (teaching) and reporting of geohazard risk for disaster risk management. This paper provides the basis for geoscientists to review and connect their work to the politico-legal framework required for national, provincial and municipal initiatives. This paper presents two frameworks: (1) A system for earth science communication analysis that includes abstract and precise science communication criteria that drives policy, and practice (including education), and (2) A framework that divided the learning context into four groups. They are in person learning, distance learning/eLearning, emergency eLearning and crisis eLearning. The case study of Earthquake Early Warning Education (E3) Crisis eLearning for Canadians puts these efforts in sharp focus. Crisis eLearning means that disaster risk managers are learning about the terms earthquake magnitude and earthquake intensity during the response to an earthquake event, with content delivered online with no support from an instructor. They need to adequately grasp these concepts to support decisions made in a crisis situation. This is a forum of life or death: there are immediate consequences if misunderstanding science concepts during an earthquake event. The aim is to connect national drivers such as legislation, conceptual models, information and outputs that shape science communication in daily practice in order to facilitate useful earthquake science training tools during a natural hazard event.

TECTONIC EVOLUTION OF THE SOUTH TAZIN LAKE SHEAR ZONE; A MAJOR ARROWSMITH-AGE (ca. 2.36 Ga) STRUCTURE IN THE SW RAE CRATON, LAURENTIA

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The Rae Province records the effects of multiple, staggered orogenies along both margins, leaving a complex record of tectonism within major shear zones. Although the recently recognized 2.5–2.3 Ga Arrowsmith orogeny is now known to have affected a large tract of the western Rae, few related structures have been described. Here we present the first detailed investigation of such a structure, the 'South Tazin Lake shear zone' (STLsz), localized along the boundary between the Nolan and Zemlak domains in the SW Rae. Multi-scale structural analysis documents the progression of strain across this structure and evaluates its context in the regional tectonic evolution. Strain intensity increases dramatically from north to south, with onset of thick, continuous intervals of protomylonite to ultramylonite. This high level of strain continues across a 3–5 km wide corridor that straddles the Nolan–Zemlak domain boundary and constitutes the core of the shear zone. $^{40}Ar/^{39}Ar$ thermochronology of hornblende and biotite provides temporal constraints on deformation and thermal evolution. An $^{40}Ar/^{39}Ar$ date of 2361 ± 12 Ma for hornblende overgrowing the sheared and recrystallized matrix in blastomylonitic rocks places a minimum age on D_2 mylonitization. This, together with similar ages throughout the shear zone, definitively links ductile shearing along the STLsz with Arrowsmith orogenesis. Cooling rates suggest an initial accelerated phase (~2360–2350 Ma) of post-Arrowsmith exhumation, but the absence of extensional shear-sense indicators implies control by structures outside of the immediate area; or masking by younger structures. Hence, the STLsz represents a significant Arrowsmith-age tectonic front that was subsequently reactivated only along its southern margin under ductile-brittle conditions during the ca. 1.93 Ga Taltson orogeny. These dual fronts were later transposed to a northeast orientation in concert with deformation along the Black Bay fault during the ca. 1.90 Ga Snowbird orogeny.

A NEW U–Pb TIMS AGE AND UPDATED TECTONIC HISTORY FOR THE WAUGH LAKE GROUP, SOUTHERN TALTSON OROGEN

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The Waugh Lake group (WLg) is a Paleoproterozoic greenschist-facies supracrustal succession, previously interpreted as the remnant of a back-arc basin, or alternatively an intra-arc, which formed on the SW margin of the Rae craton during the 2.0–1.93 Ga Taltson orogeny. Its lower sequence comprises a spatially extensive turbiditic package with local younging reversals related to early F_1 folding, unconformably overlain by a thin unit of strongly foliated polymictic conglomerate. The upper sequence comprises two cycles of variably sheared pebbly arkosic subarenite units each overlain by units of intermediate-felsic volcanic-volcaniclastic rocks. The two paired siliciclastic-volcanic cycles are separated by a distinctive unit of mafic-intermediate tuff interbedded with siltstone. The upper sequence is capped by a unit of variably schistose mafic volcanic rocks. All WLg units are folded along NNE-trending F_2 axes. Geochemical analyses of upper sequence volcanic rocks indicate calc-alkaline affinity with compositions ranging from basalt to dacite and arc-like trace element patterns. A TIMS U–Pb zircon age of 1958.1 ± 0.7 Ma for one of the intermediate volcanic (dacite) horizons provides a new age for deposition of the upper sequence of the WLg, whereas the 1.97 Ga minimum age still holds true for the lower sequence. Sm–Nd isotopic analysis of WLg volcanic rocks yielded T_{DM} ages of 2.81–2.72 Ga, and εNd values of -4.9 to -5.7 when calculated at 1958 Ma; together with the predominance of continentally-derived detritus (i.e. arkosic rocks), this points to a continental setting. Based on the arc-like geochemical character of volcanic rocks combined with the new age, more in line with known Taltson arc plutonism, the interpretation of an intra- or fore-arc basin is preferred for the upper WLg. Further, the difference in lithology, structural style and ≥ 10 Myr age gap between the upper and lower sequences suggests different tectonic histories.

LITHIUM ALUMINOSILICATE TEXTURES AND LITHIUM DISTRIBUTION FROM THE APLITE-PEGMATITES OF NORTHERN PORTUGAL: OUTCROP AND DRILL CORE COMPARISONS

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The lithium (Li)-rich aplite-pegmatites of the Barroso-Alvão (BA) field in northern Portugal present a complex structure, texture and mineral distribution. It is common to find aplite-pegmatites divided in several small branches (from a few centimetres

up to several metres wide). Textures observed are: parts of the bodies are strongly deformed (with Li remobilization); alternations of aplite and pegmatite that result in Li-barren and Li-rich zones; and a later Li- and Si-rich fluid that seems to replace several of the previous textures creating enriched Li zones. Since the Li-mineralization in these bodies is not continuous, a thorough examination was carried out to characterize the Li-distribution in thin sections from outcrops and drill core. The drill core observations were: (1) the layered aplite parts are usually Li-barren or only contain small amounts of spodumene + quartz, preserving the cone shape of the previous small petalite crystals (around 2 × 1 cm); (2) the pegmatitic parts contain more Li, usually in the center of the branches (after at least the initial 10% of the thickness of the branch counting from the edges towards the inside), occurring as very rich-zones of millimetric spodumene and quartz, usually around megacrystals of light pinkish feldspar; (3) similarly to the outcrops, shear-zones of micrometric to millimetric spodumene and quartz were also found on the drill core crosscutting previous textures, but at 100 m in depth. These shear-zones have an important role in concentrating Li. However, a later Li- and Si-rich fluid seems to form fronts of quartz and spodumene that replace the previous textures and are not related to deformation. The origin of this fluid is not yet completely understood but could be resultant from the final phases of a highly efficient fractional crystallization that formed an extremely Si and Li-rich fluid and is responsible for the observed textures.

PALEONTOLOGY IN PUBLIC: CHALLENGES AND ADVANTAGES OF IN-SITU EDUCATION

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With a wide variety of attention-grabbing material readily available, publicly accessible paleontological sites offer a unique and exciting means of educating the public on key geoscientific concepts. With these distinct advantages comes several challenges, including the difficulty associated with protecting these important sites from vandalism and/or excessive fossil collecting. Here I discuss several best practices for incorporating publicly accessible paleontological sites into field-based educational materials (e.g. GeoTrails). I use the Devonian coral reef preserved at Wainfleet Wetlands (southern Ontario) as a case study. I argue that by framing visits to these sites as a form of "citizen science", researchers and educators can better inculcate a sense of stewardship over these important areas in members of the general public. Furthermore, by encouraging members of the public to report interesting finds, researchers gain access to a potentially crucial source of additional data. I highlight some exceptional examples of citizen scientist-led paleontological discoveries worldwide, to demonstrate the value of this approach.

CONSTRAINTS ON MINERALIZATION AT THE PORKY MAIN AND PORKY WEST GOLD DEPOSITS, SEABEE GOLD OPERATION, NORTHERN SASKATCHEWAN FROM PARAGENETIC AND LA-ICP-MS STUDIES

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The Seabee gold operation (SGO) within the Pine Lake greenstone belt of the Paleoproterozoic Glennie Domain represents an ideal location for understanding gold mineralization in the Trans-Hudson Orogen because it contains past-producing and active mines and several exploration targets. Most deposits thus far are hosted within mafic volcanic rocks of Assemblage A, or similar age plutons. Recent discoveries of mineralization at the Porky West and Porky Main deposits occur within calc-silicate altered mafic volcanic rocks of Assemblage A and arkosic rocks of the Porky Lake Group. Little is known about the nature of mineralization at the Porky deposits, including mineral paragenesis, the relationship between gold and sulphide minerals, and how they compare to the better-understood Seabee, Santoy, and Fisher areas of the SGO. To address these questions, drillcore samples were analyzed by electron microprobe analysis, and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) of sulphide minerals. A mineral paragenesis chart was constructed and shows numerous sulphide generations, with Po1/Py1 forming during peak metamorphism. Py2 is an early colloform pyrite that was overprinted by Py3, Po2, Ccp1, Apy1, and native Au1 is associated with a calc-silicate alteration assemblage of Di, Ser, Pl, Bt, Ms, Kfs, Cal, Aug, Ttn, Ap ± Chl. Later smoky quartz veins contain Apy2, Py4, Po3, Ccp2, and native Au2 with bismuth and tellurium. Lastly, remobilization resulted in the growth of Py5, and Au3, where gold occurs in fractured older sulphide grains. Laser ablation-ICP-MS analyses show that Py3 are arsenic, silver, thallium, and lead enriched relative to Py4, which exhibits cobalt and nickel zoning. These findings along with metamorphic and deformational relationships, alteration types, and gold-sulphide mineral paragenesis support a regional system for gold mineralization across the SGO and support similar fluid conditions and element mobility in an orogenic setting.

ALTERATION OF SEKANINAITE-CORDIERITE AND ILMENITE IN THE GOVERNOR LAKE PEGMATITE, HALIFAX, NOVA SCOTIA

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Governor Lake Pegmatite (GLP) is located within Halifax Regional Municipality, Nova Scotia, Canada. It is hosted in the Sandy Lake Monzogranite at the most eastern edge of the post tectonic S-type granites of the South Mountain Batholith (SMB) of the Devonian Acadian orogeny. GLP outcrops on a hill above Governor Lake and was exposed during feldspar mining circa 1920. The exposed area is 5–8 m wide and 3 m high. The pegmatite is zoned with a quartz core, core margin (K-feldspar, muscovite, sekaninaite-cordierite, tourmaline, apatite, ilmenite), an intermediate zone (blocky K-feldspar) and graphic wall zone (K-feldspar, muscovite, quartz). Recent, nearby excavation at Bayers Lake exposed many similar pegmatites. The GLP is the largest and most altered with secondary alteration of sekaninaite-cordierite and ilmenite. Euhedral crystals of sekaninaite-cordierite alter into 'pinite' composed principally of muscovite. In some cases, these have altered further to dravitic tourmaline and pyrite only roughly resembling the original sekaninaite-cordierite crystal. Anhedral plates of ilmenite alter to anatase (up to 2 wt.% Nb) with minor zircon (3.4 wt.% Hf), metatorbernite and a REE (Y > Ce, Nd) containing mineral species. Possible causes for alteration could include instability of sekaninaite-cordierite and ilmenite in the final crystallization of the melt, disequilibrium in a later hydrothermal stage or alteration by external hydrothermal fluids. A linear structure, in proximity to which these phases appear most altered, is seen only at GLP, and could indicate a source of later hydrothermal fluids. These minerals might suggest a more highly evolved pegmatite or be due to external fluids introduced later. The mineral and chemical signatures indicate enrichment in fluorine, yttrium, niobium, titanium, uranium and hafnon. Previously described rare-element pegmatites associated with the South Mountain Batholith, classified as "lithium-cesium-tantalum type", occur at Brazil Lake and around New Ross in southwestern Nova Scotia and are not hosted in the South Mountain Batholith, but are contemporaneous with the South Mountain Batholith.

DIGGING DEEPLY INTO THE METAPHORS STUDENTS USE WHEN TALKING ABOUT SCIENCE

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Conceptual metaphor theory (CMT) asserts that human mental conceptualizations are almost completely metaphorical. This is an important insight because the metaphors we use to represent other abstract concepts influence the way we perceive reality, unconsciously and automatically; like putting on a pair of rose-coloured classes makes us see everything in a rosy way. This talk will present data collected over 6 years from about 2000 undergraduate, introductory geology (for non-science majors) students who were asked to reflect on what they were doing the last time they believed they were doing science. The data came in the form of open-ended responses and were coded using CMT as a theoretical framework as part of the phenomenographic study. According to the data collected, students thought they were "doing science" if they were wearing scientific clothing (goggles, lab coat), working with scientific equipment (microscopes or test tubes), or doing routine activities

https://doi.org/10.12789/geocanj.2024.51.211

(titrations, dissections, following directions). From these descriptions, they were using a SCIENTISTS ARE TECHNICIANS metaphor. This is in opposition to scientists as problem solvers or knowledge creators. Other metaphors students invoked were SCIENTIFIC KNOWLEDGE IS AN EDIFICE (I was listening to my geology professor's lecture about the structure and foundations of science and geology), and IDEAS ARE OBJECTS (Scientific knowledge is always open for debate and inquiry to further extend our grasp on a certain subject matter.). In these metaphors, scientific knowledge gets objectified, leading students (and instructors) to think that teaching and learning are merely a transfer of knowledge. This metaphor influences how instructors understand teaching (delivering a lecture) and how students understand learning (taking notes). Are there other metaphors that better reflect the nature of learning and knowledge development?

METASOMATIC ORIGIN OF THE HIMALAYAN BANDED TOURMALINE LEUCOGRANITE

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Leucogranite bodies are ubiquitous in the upper structural levels of the Himalayan metamorphic slab. Their formation has ramifications for myriad processes including the generation of crustal melts and orogenic heat budgets. One particularly enigmatic variety of the Himalayan leucogranites, abundant in the Langtang region of Nepal, are the banded tourmaline leucogranites; typified by centimetre-scale compositional banding between tourmaline-rich and quartzo-feldspathic domains. Here, we use in-situ Rb/Sr isotopic chemistry and microstructural analysis to show these banded tourmaline leucogranites do not represent a direct product of melt crystallization but instead were formed by the interaction between pegmatitic fluids and psammitic country-rock. This metasomatism was driven by the release of boron-rich fluids during the late crystallization stages of neighbouring muscovite-biotite leucogranite bodies. Rb/Sr isochrons based on biotite-plagioclase ± white mica and K-feldspar data define overlapping dates of ca. 17.5 Ma from both the banded tourmaline leucogranite and its paired muscovite-biotite leucogranite. The characteristic banding appearance of these rocks is a product of heteroepitaxial nucleation of tourmaline on biotite folia and the replacement of pre-existing biotite and plagioclase with tourmaline and K-feldspar. The heteroepitaxy relationship of tourmaline on biotite is characterized by the {10-10} face of tourmaline parallel to biotite (001), with the tourmaline c-axis parallel to either the biotite [110] or [010] direction. One broad implication of our findings is that field estimates based on the volume of coarse-grained leucocratic outcrop greatly overestimates the amount of melt generated at the top of the Himalayan slab.

PARENTAL CONTROL: THE ROLE OF EPITAXY IN METAMORPHIC ROCKS

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Epitaxy—the product of heterogenous nucleation of a daughter crystal on a parental grain boundary—is widespread in metamorphic rocks. In this talk we will demonstrate how epitaxy controls the crystal orientation and petrographic location of many, if not most, metamorphic phases. Using crystal orientation relationships derived from electron backscattered diffraction (EBSD) data, we will show examples of epitaxy formed between high symmetry (biotite-muscovite, plagioclase-orthoclase), moderately symmetrical (kyanite-staurolite, chalcopyrite-sphalerite, omphacite-actinolite, staurolite-chloritoid) and low symmetry mineral pairs (biotite-tourmaline, chlorite-tourmaline). Our preliminary data are consistent with high-symmetry epitaxial pairs forming close (polar-covalent bonded) phase boundaries with similar properties to low-angle subgrain boundaries in a single phase, whereas the boundaries between low-symmetry pairs are more akin to that of van der Waals attraction. We will discuss the implications of epitaxy on both the energetics of metamorphic reactions as well as the distribution of stresses in multiphase aggregates.

THE SIDI BOU-OTHMANE PEGMATITE FIELD (JEBILET MASSIF, MOROCCO): MINERAL ASSEMBLAGES AND REGIONAL ZONATION

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In the Jebilet Hercynian Massif (Moroccan Meseta), granitic pegmatites are widespread in the Sidi Bou–Othmane region where they form a subvertical dyke swarm intruding cordierite and andalusite-bearing micaschists. The thickness of the pegmatites ranges from a few centimetres to 4–5 m, and their extension can reach several hundreds of metres. The dykes display pegmatitic and aplitic textures, rhythmic layering, as well as abundant unidirectional solidification textures, including pseudographic intergrowths. The main minerals are quartz, feldspars and muscovite, whereas the accessory minerals include schorl, garnet, Nb-Ta oxides, lepidolite, elbaite, cassiterite, apatite, Fe-Mn and Li-Al phosphates. Based on the abundance of the accessory minerals, eight types of pegmatites are distinguished: (1) pegmatites that are poor in accessory minerals; (2) schorl-rich; (3) schorl-garnet-rich; (4) garnet-rich; (5) Fe-Mn phosphate-rich; (6) green tourmaline-rich; (7) Fe-Mn- + Li-Al-phosphates and Nb-Ta-oxide-rich, and (8) lepidolite-elbaite-rich pegmatites. Although the majority of the pegmatitic bodies are subvertical and regular in shape, the last two types have an irregular shape. Mapping of these different types of pegmatites shows a zonal distribution marked by an evolution from barren pegmatites, bearing schorl and garnet (Types 1 to 4) to intermediate pegmatites characterized by the abundance of Fe-Mn phosphates (Type 5 and 6) and then to fertile pegmatites that contain Li-rich minerals (Types 7 and 8). The phosphate minerals of the Sidi Bou-Othmane pegmatites form crystals and nodules up to 20 cm in diameter. The phosphate nodules are mainly composed of an intimate mixture of mineral species among which ferrisicklerite is the most abundant. Textural relationships indicate that the primary phosphates include montebrasite, graftonite, sarcopside, and ferrisicklerite. These minerals show various transformations into secondary phosphates including alluaudite, scorzalite, jahnsite, rockbridgeite, eosphorite, apatite, and heterosite.

CHEMICAL VARIATIONS IN APATITE AS RECORDER OF METASOMATIC PROCESSES ASSOCIATED WITH LITHIUM PEGMATITES IN THE GONÇALO PEGMATITE FIELD (CENTRAL PORTUGAL)

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In the Gonçalo pegmatite field (Central Iberian Zone of the Iberian Massif) Li-rich pegmatites occur as sub-horizontal dykes that display complex layering. During crystallization of these pegmatites the exsolution of immiscible fluids seems to have modified chemically the host rocks, generating a metasomatic mineral paragenesis close to the pegmatite contact. To better understand such chemical changes in the host rocks and shed light on mineral exploration through geochemical halos around pegmatites, apatite from the host granite of a lepidolite-bearing dyke has been analyzed. In situ EMPA and LA-ICP-MS analyses reveal compositional differences between apatite from the strongly metasomatized granite (SMG) and non-metasomatized granite (NMG), with apatite from the SMG displaying slightly higher Ca and P, and lower Mn, Fe and Na concentrations, without remarkable differences in F. Strontium concentration is higher in SMG's apatite, contrary to those of Y, U, Ta, As, Mo, Sc, and Sn. The sum of REE is lower also in apatite from the SMG, and Eu anomaly is less marked. It is thus suggested that during the crystallization of the selected lepidolite-bearing pegmatite, at least one episode of fluid exsolution took place. The aqueous fluids that exsolved from the pegmatitic melt most probably altered the main rock-forming minerals of the host granite and allowed formation of metasomatic apatite. The metasomatizing fluids were most likely rich in P and F from the source, and the origin of Ca for the newly formed apatite was probably in the primary plagioclase from the granite, which disappeared completely during greis-

enization of the host granite. The higher Sr concentration in the newly formed apatite, together with the less marked Eu anomalies, could also be explained by the dissolution of primary plagioclase. Therefore, apatite chemistry may be used to understand the magmatic-hydrothermal evolution of the studied pegmatite.

ZIRCON CHEMISTRY AND Hf ISOTOPES OF FELSIC SAMPLES FROM VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS OF THE VICTORIA LAKE SUPERGROUP, NEWFOUNDLAND

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Felsic volcanic and volcaniclastic rocks of the Cambrian–Ordovician Victoria Lake Supergroup in central Newfoundland, host volcanogenic massive sulphide (VMS) deposits with varying mineralization styles and base and precious metal content. Mineral and Hf isotope geochemistry of zircon from felsic samples from the replacement-style Cu-Zn-(Pb) Duck Pond/Boundary deposit, the barite-rich exhalative-style Zn-Pb-(Ag-Ag-Cu) Lemarchant and low-tonnage Zn-Cu-Pb-(Ag-Au) Long Lake deposits, are used to understand the composition and petrogenesis of host rocks to mineralization and the role of magmatism in the formation of VMS deposits. Zircon from all deposit samples have low Th/U (< 1) and Th/Nb (< 90) ratios. Zircon only from the Duck Pond/Boundary deposit have U/Yb ratios of > 0.3, and zircon in the Duck Pond/Boundary and Lemarchant deposit samples have Dy/Yb ratios of < 0.3. The Duck Pond/Boundary and Lemarchant deposits have εHf(t) values between +5.9 and +9.4 and depleted-mantle model (T_{DM}) ages between 1064 and 761 Ma, whereas zircons from the Long Lake deposit samples have εHf(t) values between +11.2 and +15.2, and T_{DM} ages between 730 and 489 Ma. Mean log fO_2 values in zircon from the Duck Pond/Boundary and Long Lake deposit samples are -14 to -14.9, whereas zircon from the Lemarchant deposit samples have more oxidized values of -11. The εHf(t) values, T_{DM} ages, and Dy/Yb ratios in zircon from the Duck Pond/Boundary and Lemarchant deposit samples suggest magmas derived from juvenile sources but with minor crustal contributions from Neoproterozoic basement, and that amphibole was co-crystallizing with zircon. Higher εHf(t) values, Dy/Yb ratios, and younger T_{DM} ages in zircon suggest more juvenile components and less interaction with the basement for the Long Lake deposit. Ongoing research is focused on the interpretation of this data coupled with previous whole-rock lithogeochemical information.

URANIUM MINERALS AS PROXIES FOR GLOBAL TECTONIC EVENTS: GLEANING THE BIG PICTURE FROM A SMALL SPOT

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Zoned minerals such as zircon and monazite have traditionally been used to determine the age of paleo-fluids associated with major tectonic and metamorphic events. Other minerals (e.g. micas) when combined with an appropriate geochronometer (e.g. Ar/Ar or Rb/Sr) have provided valuable information regarding the timing of large-scale fluid events that can be important to the formation of mineral deposits. Instruments such as SIMS and LA-ICP-MS offer the capability of measuring isotope ratios on a spatial resolution of 1–100 mm. These instruments have been used to measure radiogenic isotopes in cores and rims of these minerals, thus providing an unprecedented understanding of fluid evolution related to orogenic and metamorphic events. However, uraninite is one mineral that has been largely overlooked as a mineral proxy for large-scale fluid and tectonic events. Recent techniques and standards have improved precision and accuracy to a level that approaches those of conventional techniques for U–Pb isotopic analyses of U-bearing minerals. SIMS work suggests that on the microscale, U-deposits can provide a detailed record of continental-scale tectonic events at a single location, with a potential time-depth extending to before 2.0 Ga. For example, unconformity-related U deposits in Canada and the Oklo-Okélobondo natural fission reactors in Gabon record a nearly complete tectonic history of the continents over the past 2.0 Ga. Thus, if the chronologic detail suggested by these studies proves to be common to U-deposits in general, they will provide an important new approach to precisely dating tectonic and basinal fluid-flow events.

ADSORPTION MECHANISMS OF RARE EARTH ELEMENTS ON Mn-RICH OXIDES IN WEATHERED GRANITES: IMPLICATIONS FOR THE ORIGIN OF REGOLITH-HOSTED REE DEPOSITS AND THEIR SUSTAINABLE DEVELOPMENT

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Regolith-hosted REE deposits are the world's primary HREEs source. Most REE deposits occur in southern China hosted in the weathered crusts of granite bodies. Although many studies have shown that the REE patterns in regolith are inherited from the parent granites, the Gucheng HREE-dominated deposit occurs in the weathered crust of a LREE-enriched granite. This leads to a hypothesis that adsorption mechanisms play an important role in the formation of regolith-hosted HREE deposits. To test this hypothesis, we conducted a combined field-emission scanning electron microscope (FE-SEM), Raman, in situ composition analyses, microbeam X-ray fluorescence (μXRF) mapping, and microbeam X-ray absorption spectroscopy (μXAFS at Ce and Nd L3-edges and Y K-edge) study of selected samples to investigate the adsorption mechanisms of REEs in the weathering profiles of the Gucheng HREE deposit as well as the Shangyou HREE and Renju LREE deposits. The results show that birnessite in saprolites is only 0.82 and 0.22 vol.% in abundance but contributes 4.0 vol.% and 11.6 vol.% of total REE concentrations (excluding Ce) of the Gucheng and Renju saprolite samples, respectively, indicating its high REE capacity. Measured Ce L3-edge μXAFS data of birnessite confirm the presence of Ce^{4+}. The Nd (representing trivalent LREEs) L3-edge and Y (representing trivalent HREEs) K-edge μXAFS data of birnessite from the Gucheng, Shangyou, and Renju deposits suggest that REE are potentially adsorbed as 8- or 9-coordinated complexes. The Y μEXAFS fitting results further imply that HREE adsorbed on the Gucheng, Shangyou, and Renju birnessite all have a similar Y-O (CN = 8) polyhedral. This polyhedral was adsorbed onto the Gucheng and Shangyou birnessite via a monodentate vertex-sharing linkage but via a bidentate corner-sharing linkage onto the Renju birnessite. These EXAFS results support the view that adsorption mechanisms play an important role in REE fractionation for forming regolith-hosted HREE deposits.

AEROMAGNETIC DATA FROM THE ASSARAG AREA (OUZELLAGH-SIROUA SALIENT, CENTRAL ANTI-ATLAS, MOROCCO): IMPLICATIONS FOR THE IMOURKHSSEN Cu-Mo-Au-Ag PORPHYRY STYLE MINERALIZATION

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The Assarag region is located in the northern part of the Ouzellagh-Siroua salient, being a segment of the central Anti-Atlas basement bulging within the High-Atlas Belt of Morocco. It consists mainly of the late Ediacaran magmatic suites (LEMS) of the Ouarzazate Group (580–539 Ma) intruded in the volcanic rocks of the Saghro Group (620–600 Ma). The LEMS consist of high potassic calc-alkalic I-type granitoid rocks that host Cu-Mo-Au-Ag porphyry mineralizations in the Imourkhssen area. The aeromagnetic data from the Assarag region describe geological and structural features of the LEMS based on their magnetic footprints. The horizontal gradient filter performed on the N0° and N90° directions, outlines alongside the tilt angle transformation the NNE-SSW, NNW-SSE and NE-SW trending faults in addition to a curved magnetic halo in the SW part of the Assarag area. The upward continuation processing subdivides the area in two magnetic morpho-structural domains: the northern calmer portion with a non-magnetic feature, and the

https://doi.org/10.12789/geocanj.2024.51.211

south magnetic portion with positive curved E-W, NW-SE trends and deep concealed NE-SW lineament direction. The aeromagnetic data were also processed using the 2-D Spatio-spectral feature extraction and selection tool (SFES2D) to discriminate shallower and deep magnetic sources, to delineate the main tectonic structures and to locate concealed ones. The principal component analysis and independent component analysis corroborate the previous extracted magnetic lineaments. Further, the continuous wavelet transformation highlights two deep NE-SW and ENE-WSW tectonic structures in the southern part of the Assarag area. Hence, we nominate this new trend to consist of the southern High Atlas fault cutting cross the LEMS of the studied area. These newly identified tectonic features could constitute the path for the ore-bearing fluid circulation in the study area. Consequently, they present a valuable tool for guiding mineral exploration on a regional scale.

MARS ANALOGUE RESEARCH SAMPLE COLLECTION FOR TESTING AN IN SITU X-RAY DIFFRACTOMETER

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Rover-based instruments mainly provide elemental composition and spatial context for Mars surface materials, but do not typically provide mineralogical constraints on the conditions under which they formed. To better understand the evolution of Mars - its geologic history, paleoclimate, and habitability - we need to also study its mineralogical record. X-ray diffraction (XRD) is the primary technique to determine the mineralogy of geological materials. Although the Curiosity rover has a powder diffractometer (CheMin), it requires a fine-grained (powdered) sample, which destroys the original mineralogical context in the source rock and is complicated to obtain and deliver to the instrument. A miniaturized in situ XRD (ISXRD) instrument, which does not require powders or any sample preparation, is being developed in prototype by a multidisciplinary team of scientists and engineers from Western, Guelph, and Brock universities, and Proto Manufacturing (current specifications: XRT-32 source (25 kV, 5 mA), cobalt radiation, SPD detector). We summarize here our efforts to compile a suite of planetary analogue samples and their XRD patterns - the Mars analogue research sample (MARS) collection - comprised of rocks, minerals, and meteorites, which were used to compare lab-based measurements with results obtained from the ISXRD prototype. These analogue samples, from sedimentary, igneous and impact settings, were selected for their physical and/or compositional similarity to Martian materials. In October 2023, the ISXRD prototype was field tested in a simulated Mars mission scenario; this both tested the capabilities of the instrument and provided student trainees with a low-fidelity analogue mission experience. The prototype ISXRD outperformed expectations, acquiring data on seven Mars analogue samples which were 'seeded' around the analogue field location. This work lays the foundation for an in situ XRD instrument as a planetary exploration tool for future missions to Mars, or that could even be utilized for environmental science or resource prospecting at remote locations on Earth.

FLUID INCLUSION AND STABLE ISOTOPE STUDIES OF THE APATITE-MAGNETITE TYPE REE DEPOSIT AT KWYJIBO, QUÉBEC, CANADA

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Apatite-magnetite type rare earth element (REE) deposits are not well understood despite their economic importance for both light and heavy REE. The Kwyjibo deposit, which is located 120 km NE of Sept-Îles, Québec, has been reported to contain 6.92 million tons of ore with an average grade of 2.72% total rare earth oxides of which a third comprise the heavy REE. Hydrothermal processes led to the mobilization of the REE from fluorapatite and andradite to britholite and allanite, respectively. Microthermometric measurements identified three aqueous fluids that were associated with REE mobilization, namely a $FeCl_2$-NaCl-H_2O-dominated fluid ($FeCl_2$), NaCl-KCl-H_2O-dominated fluid (NaCl) and $CaCl_2$-NaCl-H_2O-dominated fluid ($CaCl_2$). REE was first mobilized by intermediate salinity (18–24 wt.% NaCl eqv.) $FeCl_2$ fluid at minimum temperatures of 185–290°C. This fluid records anhydrite solid in primary fluid inclusions hosted by fluorapatite, which implies a high sulphate ion activity. REE are preferentially mobilized by bonding with hard anions (i.e. sulphate). In a later metamorphic event, NaCl aqueous fluid, with a salinity of 9–16 wt.% NaCl eqv. was introduced and primary inclusions are recorded in andradite. These inclusions are dominantly multiphase (liquid-vapor-calcite/magnetite/hematite) liquid-rich, with liquid-vapor (L-V) homogenization temperature of 290–365°C. Lastly, two-phase (LV) liquid-rich inclusions of the three compositional types were found in fluorite, calcite and quartz. The L-V homogenization temperatures are much lower at 80–230°C, with a high salinity of 17–27 wt.% NaCl eqv. In addition, CO_2 was identified in some of these inclusions. $\delta^{13}C$ and $\delta^{18}O$ stable isotopes analysis was conducted on calcite in the mineralized zone. The $\delta^{13}C$ V-PDB value ranges between -4.67 and -7.74 ‰, and the $\delta^{18}O$ V-SMOW yield values of 8.86 to 17.32‰. These values suggest that fluids are of magmatic origin and have undergone low-temperature alteration, which is consistent with the low homogenization temperature documented.

CHARACTERIZATION OF ABADLA 002 CM2: OPTICAL, MINERALOGICAL, COMPOSITIONAL, AND SPATIAL CONSIDERATIONS

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CM chondrites, named after the first similarly classified chondrite, Mighei, are a type of carbonaceous chondrite meteorite distinguished by containing chondrules, hydrated minerals, and refractory inclusions. CMs are the most abundant of the carbonaceous chondrite groups; they typically show aqueous alteration, and sometimes thermal and/or shock metamorphism. The Abadla 002 meteorite is a relatively new find, discovered in December of 2021. This meteorite has not been well studied. Analysis of Abadla 002 is of interest as there are no publications regarding this meteorite, other than its entry in the Meteoritical Bulletin. Abadla 002 landed in Bechar, Algeria, and was typed by A. Ross, and C. Agee. They reported that Abadla 002 is a CM2, containing a dark fusion crust, and a relatively low (for CM chondrites) matrix volume of > 50%. The samples studied herein have masses of 5.0 g, and 0.92 g. The chondrule sizes range from < 100 µm to 750 µm, and calcium-aluminum-rich inclusions (CAIs) range from < 150 µm to 1.5 mm (longest dimension). We revisit its chemical group, petrologic type, with a focus on the most important parameters for determining the extent of alteration in CM chondrites: matrix volume and mineralogical alteration in CAIs and chondrules. We report analyses by polarizing and reflected light microscopy, micro-X-ray diffraction (µXRD), X-ray fluorescence (XRF), and micro-computed tomography (micro-CT). Further study of CMs is important in order to understand their origins, which could inform future exploration.

PROBING CHEMICAL TRANSPORT USING PORPHYROBLAST POPULATIONS: A MEANS TO DECIPHER THE MECHANISMS, CONDITIONS, AND DURATIONS OF METAMORPHIC CRYSTALLIZATION

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Published data on the geometry of compositional zoning of garnet populations in mica schists from the Sikkim Himalaya, the Grenville Province of SE Ontario, the Kalak Nappe Complex of northern Norway, and the Danba dome in the Eastern Tibetan Plateau indicate that the compositional gradients of the garnet-forming components in the rims of larger crystals are within error parallel to the core-to-rim gradients of smaller ones. Differences in the compositional zoning of differently

sized crystals are only developed in the cores of these crystals, with the core compositions of larger crystals reflecting their earlier nucleation, compared to smaller, later nucleated crystals. As suggested in the literature, this overall parallelism in the chemical gradients indicates the quasi-equilibration of the garnet-forming components during crystal growth across the rock volumes analyzed, as well as crystal growth kinetics controlled by interface reactions. However, systematic deviations from this compositional pattern in the crystals from Sikkim are interpreted to reflect the interfacial energy penalty to growth close to equilibrium. The patterns preserved in garnet from northern Norway, the Grenville Province, and the Danba dome lack such evidence, possibly due to diffusional overprint experienced dominantly by the smallest crystals of the garnet populations. We present a novel diffusion geospeedometry approach that utilizes the geometry of the compositional zoning of a garnet population, crystallized with rates limited by interface reactions, and subjected to partial diffusional alteration. This approach avoids the uncertainties inherent to thermodynamic data used to predict growth zoning, as it is solely based on the observed geometry of the compositional zoning of the garnet population. It significantly reduces the uncertainty on metamorphic durations commonly obtained via diffusion geospeedometry, and hence, contributes to our understanding of geological timescales and processes.

TRACE FOSSILS AS A PROXY FOR PALEOCLIMATIC AND PALEOCEANOGRAPHIC RECONSTRUCTION IN THE SOUTHERN ATLANTIC AT THE EOCENE–OLIGOCENE TRANSITION

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The Eocene–Oligocene Transition (EOT) marks the shift in global climate from the hothouse of the early Cenozoic to the icehouse conditions present today. Occurring approximately 34 Mya, the precise dates of the event are debatable due to a lack of continental sedimentary records. This study focuses on South Atlantic sediment cores obtained by the International Ocean Discovery Program (IODP) in 2020 and 2022 (Expeditions 390C, 395E, 390, and 393) across the western flank of the Mid-Atlantic Ridge. Through analysis of ichnofossils this study aims to further contribute to scientific understanding of the nature of the EOT, especially with regards to the paleoclimate at mid latitudes in the Southern Hemisphere. The results of this analysis are compared and contrasted with data on bulk stable isotope ratios, X-ray fluorescence scanning, stratigraphy, and paleocurrents. A total of 60 m of core were analyzed in each of the two core holes (U1558A and U1558F), where the designated EOT boundary had been inferred based on the lithostratigraphic, calcareous microfossil, and magnetic field age models. Preliminary examination of core samples from U1558A and U1558F indicates that ocean floor currents changed rapidly during the EOT, with tentative evidence of erosion apparent in the stratigraphy. Significant variation in bioturbation intensity is present, with U1558A showing a bioturbation intensity (BI) of between 4 and 5 immediately below the EOT, which decreases to between 1 and 2 above the EOT boundary. Ichnologically speaking, the EOT is marked by a reduction in diversity, with *Chondrites* being the only taxa evident in several sections; numerous stretches of core display no obvious trace fossils at all, i.e. biogenic mottling. The apparent lack of biological activity could indicate anoxic/dysoxic conditions or biologically rapid changes in paleoclimate/bathymetry/currents.

CRYSTALLIZATION EXPERIMENTS OF THE LEPIDOLITE ± SPODUMENE + H_2O SYSTEM IN A HYDROTHERMAL DIAMOND-ANVIL CELL

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Spodumene and lepidolite are the primary industrial minerals in granite-related Li deposits. The reasons for their predominant occurrence in pegmatite-type and granite-type Li deposits, respectively, remain unclear. To address this issue, we conducted crystallization experiments of lepidolite ± spodumene + H_2O systems using a hydrothermal diamond-anvil cell (HDAC), focusing on the pressure and temperature conditions under which spodumene and lepidolite crystallize. In the lepidolite-spodumene-H_2O system, spodumene, which recrystallized during cooling, co-grew with muscovite rather than with lepidolite. The marginal part of muscovite was identified as Li-rich muscovite, containing 2.0–3.0 wt.% LiO_2. The spodumene and muscovite crystallized at 510–750°C and 295–980 MPa, and 420–710°C and 175–910 MPa, respectively, with average growth rates of approximately 0.10 and 0.11 mm^3/day. In the lepidolite-H_2O system, lepidolite primarily formed at 500–650°C and 100–550 MPa, with average growth rates of ~0.02 mm^3/day. The experimental results show that lepidolite tends to crystallize at lower pressures than spodumene. In the lepidolite-H_2O system, certain lepidolite crystals formed under P-T conditions favourable for petalite and spodumene growth, which is attributed to F enrichment in the crystallization medium. Thus, granitic magma characterized by F enrichment and low emplacement pressures is more likely to produce granite-type lepidolite than pegmatite-type spodumene deposits. Lepidolite exhibited lower growth rates than muscovite and spodumene, which can be attributed to their various crystallization pressures. The growth rates observed in this study are significantly higher than those in hydrous melts, which is attributed to the rapid diffusion of components in a H_2O-rich medium (e.g. aqueous solutions). The presence of Li-rich muscovite along the margins of muscovite in our experiments indicates that Al↔Li substitution can occur in muscovite co-grown with spodumene. Consequently, high Li concentrations in muscovite may serve as a potential indicator for spodumene prospecting.

TRACE ELEMENT VARIATIONS IN QUARTZ OF PEGMATITES FROM THE FREGENEDA-ALMENDRA FIELD (SPAIN AND PORTUGAL)

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The Fregeneda-Almendra pegmatite field (FA) is located in the Central Iberian Zone (Spain and Portugal). This is a granite-pegmatite system where 10 different types of lithium-cesium-tantalum (LCT) pegmatites, some of them containing up to 1 wt.% LiO_2, have been distinguished. Overall, the pegmatites display a spatial zonation from barren to chemically evolved types northwards from the nearest batholith, with increasing Li-F contents. With the aim of contributing to the knowledge of this geologically complex area, quartz from the four most fractionated types of pegmatites -have been analyzed by LA-ICP-MS to determine concentrations of trace elements, mainly Al, Ti, Li and Ge. Based on the degree of fractionation, quartz chemistry was studied from one intermediate pegmatite (with montebrasite as accessory mineral) and from three evolved pegmatites (petalite-rich, spodumene-rich, and Li-mica-rich). The mineralogically most primitive pegmatite contains quartz with the lowest total trace element concentration whereas, on the contrary, the highest Ge and Li concentrations are observed in quartz from the Li-rich pegmatites. It is remarkable that notable differences in Li and Ge concentrations have been found in quartz from the selected pegmatites. In general, all the pegmatites from FA that are mineralized in Li have quartz with Li concentration > 30 ppm. Quartz with high Li but low Ge (< 4 ppm) concentrations may be indicative for petalite-rich pegmatites. Quartz with high Li and Ge concentrations in the range of 4 to 10 ppm may be characteristic for spodumene-rich dykes. Finally, quartz showing high Li concentration and Ge values of > 10 ppm seem to be indicative for Li-mica-rich pegmatites. Our study shows that in Fregeneda-Almendra pegmatites trace element concentrations in quartz may be used not only as a petrogenetic indicator of pegmatite fractionation, but also as a tool for Li-exploration.

FIXATION OF CARBON DIOXIDE BY SERPENTINE IN LOW-PRESSURE DRY CARBONATION

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Utilizing silicate-based minerals to convert carbon dioxide (CO_2) into carbonate compounds is a compelling alternative for carbon dioxide storage. Due to the benefits of permanent storage and abundant mineral resources, mineral carbonation

https://doi.org/10.12789/geocanj.2024.51.211

(MC) is one of the most effective strategies for sequestering CO_2. The combination of mineral processing for primary metal recovery and mineral carbonation for carbon sequestration is an emerging field of study with the potential to minimize capital costs. A detailed study of low-pressure gas-solid carbonation of ultramafic tailings in a dry environment has been accomplished. To track the changing structure of serpentine minerals and their reactivity as a function of temperature (300–900°C), CO_2 partial pressure (25–90 mol%), and thermal preconditioning, thermogravimetry has been utilized. The incongruent CO_2 van der Waals molecular diameters with the octahedral-tetrahedral lattice constants of serpentine were used to explain the mild carbonation reactivity. Serpentine requires additional thermal treatment to remove hydroxyl groups, resulting in the chemical transformation to pseudo-forsterite, which is a mineral composed of isolated SiO_4 tetrahedra linked by octahedrally coordinated magnesium ions. The heating treatment above 850°C is adequate to remove chemically bound water from the lattice. Particles with a diameter < 34 μm are desirable, and thermally treated serpentine at 850°C for 2.30 hours reached 65% CO_2 storage capacity. The decrease in particle size, increase in temperature, and magnetic separation can dramatically enhance carbonation.

LITHIUM-CESIUM-TANTALUM (LCT) PEGMATITE EXPLORATION: ENLARGING THE FOOTPRINT!

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Until recently, exploration for lithium proceeded with a "stumbling-across-a-pegmatite-in-the-course-of-prospecting-for-other-commodity" approach. Known occurrences were soon exhausted and explorationists started developing new methods to detect pegmatite swarms. Lithium is an alkaline metal and does not accumulate as a cation in soil or sediments, ruling out approaches based on hydromorphic dispersion. However, most lithium minerals such as spodumene and petalite resist weathering and are preserved in glacial sediments. Consequently, lithium concentration in sediments is controlled by mineral abundances, which can be deconvolved from chemical analyses. Other LCT-diagnostic minerals such as pollucite (Cs), rubicline (Rb), and beryl (Be) exist that resist weathering and can be used for exploration, and grains of Li-Cs-Ta-bearing minerals can be counted to define dispersion trains. For example, surveys were conducted counting spodumene, feldspar, and tantalite grains. Nevertheless, difficulties resided in detecting grains of these minerals in a reproducible manner, so routines were developed based on automated scanning electron microscopy (SEM). Because lithium is too light to be detected using EDS (or WDS) analyses, counting spodumene required measuring Si/Al ratios and validating using EBSD in each grain. Although tedious, the method proved efficient at detecting signal from known occurrences and led to new discoveries. A more cost-effective approach was developed and consists in counting grains of tantalum oxides (e.g. columbite-tantalite, microlite, wodginite), tin oxides (e.g. cassiterite, romarchite), or tungsten oxides (e.g. liguowuite, tungstite) in the 10–50 μm fraction of glacial sediments. Indeed, these minerals are almost exclusive to differentiated peraluminous granites and pegmatites, and their presence in glacial dispersion trains implies the erosion of these sources. Here, based on experience acquired by working in Quebec's James Bay, i.e. the epicenter of lithium exploration, a review of LCT pegmatite mineral and geochemical dispersion in the secondary environment will be presented.

IN SITU Lu-Hf GARNET DATING OF ARCHEAN DEEP CRUST GRANULITES FROM THE POLYMETAMORPHIC GRENVILLE FRONT TECTONIC ZONE

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Recent advances in geochronological techniques now allow to efficiently decipher the timing and duration of geological processes in complex high-grade polymetamorphosed orogenic terranes. This is the case for the Grenville Front Tectonic Zone, which truncates the Superior Craton to the southeast. The zone exposes parautochthonous Archean rocks that underwent mid- to high-pressure granulite facies metamorphism of uncertain age. The metamorphic assemblages have been either interpreted as Archean in age during the final stages of the Superior craton assembly, or as the result of Mesoproterozoic Grenvillian metamorphism, based on cross-cutting relationships and traditional geochronology methods such as U–Pb zircon dating and $^{40}Ar/^{39}Ar$ mica systematics. Herein, we revisit the extent of the Grenvillian metamorphic overprint in the parautochthonous domain and provide new age constraints for granulite facies metamorphic assemblages through direct in-situ garnet dating within migmatitic paragneiss, migmatitic orthogneiss, and mafic granulites, combined with in-situ trace element mapping. Garnet Lu–Hf isochrons from six samples in which lutetium zoning in garnet is bell-shaped and occasionally sharp and oscillatory reflecting growth zoning, yield Archean identical dates of ca. 2.6 Ga. Sparse analyses of material trend toward Grenvillian ages (ca. 1 Ga) in one sample from which garnet shows lutetium zoning consistent with post-growth fluid-assisted disturbance. Overall, our results indicate that the widespread granulite facies metamorphism within the Grenville Front Tectonic Zone is dominantly late Neoarchean in age, unveiling a rare exposure of Archean lower crust in the southern Superior Craton. Our results also point towards a limited Grenvillian metamorphic overprint though the spatial extent and precise thermal conditions of this metamorphism are still unknown. The results presented herein demonstrate the potential of in-situ isotopic geochronology on rock-forming minerals like garnet in polymetamorphic terranes.

ARCHEAN CRUSTAL GROWTH HISTORY HIDDEN IN PALEOPROTEROZOIC OROGENS: EXAMPLE FROM THE SOUTHEASTERN CHURCHILL PROVINCE, TRANS-HUDSON OROGEN, QUÉBEC, CANADA

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Deciphering the genesis and evolution of crustal lithotectonic blocks and defining the nature of their boundaries are prerequisites for assessing the nature and duration of crustal assembly processes through time. However, ancient small-scale crustal masses and peripheral areas of large cratons have been often involved in subsequent orogenic cycles, heavily reworking and partially overprinting primary geological records, hindering straightforward tectonic reconstruction. In this study, we present a new comprehensive summary of the geochronological record of the Southeastern Churchill Province (SECP), Québec, Canada. New time-space diagrams and distribution maps of the Archean to Paleoproterozoic bedrock units form the foundation of our understanding of the tectonic history and cratonization processes in this region. The SECP rocks recorded Archean evolution from ca. 2.92 to 2.5 Ga marked by tonalite-trondhjemite-granodiorite magmatism forming a newly defined crustal block; ca. 2735–2690 Ma sanukitoid magmatism at the margins of the latter; ca. 2690–2620 Ma tholeiitic to calc-alkaline volcanism and partial melting of basement-rocks upon rifting in its core; and a period of tectonic quiescence until ca. 1.9 Ga. The Paleoproterozoic tectonic evolution of the SECP is interpreted as successive accretions of crustal blocks over a period of ~100 Myr (ca. 1900–1800 Ma) and reactivation of inherited structures at the lithospheric scale. Our work emphasizes the necessity of redefining the lithotectonic block paradigm, especially in terranes that have been subjected to multiple orogenic cycles.

INTERPLAY OF EDIACARAN GLACIATION AND SEDIMENT PROVENANCE REVEALED BY DETRITAL ZIRCON U–Pb GEOCHRONOLOGY AND Hf ISOTOPE GEOCHEMISTRY IN THE BONAVISTA PENINSULA, AVALON TERRANE (NEWFOUNDLAND)

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Identifying glacial influence in active volcanic arc basins is challenging due to the overprinting effects of tectonism on the climatic fingerprint. The Neoproterozoic

Avalonian margin records protracted arc volcanism within thick volcanic-sedimentary successions that also contain glacial diamictites of the Gaskiers glaciation. Such glaciogenic strata are recognized from deep and shallow marine settings in two basins in the Avalon terrane, i.e. St. John's and Bonavista basins, offering an opportunity to disentangle changes in sediment provenance through terrane-scale glacial cycles. This study provides more than 1600 single-grain detrital zircon U–Pb ages combined with zircon trace element and Lu-Hf systematics from the Trinity Diamictite and underlying units (e.g. Monk Bay and Plate Cove members) in the Bonavista basin. The maximum depositional ages of the studied units approach their depositional ages, suggesting very short (< 5 Myr) lag times from sediment generation to deposition, and suggesting the presence of two Gaskiers diamictite horizons. The Monk Bay Member displays a narrow unimodal age distribution around ca. 580 Ma, contrasting with the Trinity Diamictite and older conglomeratic units, which capture a more widespread Tonian to Ediacaran age distribution and minor peaks at ca. 1000, 1400, 2000, and 2700 Ma. Zircon trace elements confirm a generally magmatic arc affinity with lesser within-plate zircons with low degrees of melt fractionation. Hafnium isotopes from zircons in the Monk Bay facies record primitive initial εHf of +2.6 to +12.0, whereas the Trinity Diamictite and conglomeratic units hint at a broader bimodal distribution in intital εHf of -4.9 to +15.2, suggesting an increase in sediment catchment during deglaciation. Finally, the Hf isotopic signatures from detrital zircons in the Bonavista basin contrast with the coeval St. John's basin, which contains more isotopically evolved zircons demonstrating different sediment provenances and reduced connectivity between these two sedimentary basins.

TOWARDS A MINERAL SYSTEM MODEL FOR LITHIUM-CESIUM-TANTALUM PEGMATITES

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Since PEG 2019 in California, increasing interest in lithium as an economic commodity has driven extensive research on lithium-cesium-tantalum (LCT) pegmatites. This talk will draw on our research, published literature, and broader discussions with many geologists in the field, to summarize the ongoing development of a mineral systems model for these pegmatites. The source of LCT pegmatites has been debated extensively. Two end-member models exist: (1) pegmatites represent the most evolved melts from a parental granite, and (2) pegmatites are formed directly by anatexis of metasedimentary rocks. In reality, it is becoming increasingly clear that initial melting of metasedimentary source rocks can be followed by a variety of processes operating at different levels in the crust to enrich the melts and produce LCT pegmatites. A key question which remains is how enriched in lithium the source rocks need to be, and whether we can define key targets for melting based on geological history. For magmas to evolve and be emplaced at different levels in the crust, pathways must exist that enable them to migrate upwards, and traps must be in place to ensure that pegmatite bodies of a suitable size are formed. Targeting of pegmatite fields can be linked to major structures such as shear zones, but there remains a need to systematically identify which types of structures are key targets for LCT pegmatites. Finally, preservation is critical in the formation of LCT pegmatites; these volatile-rich magmas create a complex paragenesis, with extensive replacement of magmatic minerals through metasomatic and weathering processes. Understanding the controls on these processes is fundamental in LCT pegmatite targeting. We look forward to lively discussion on all these aspects at PEG 2024, and to further developing the mineral system model.

PRELIMINARY EXAMINATION OF UPPER CRETACEOUS PALYNOFACIES ASSEMBLAGES FROM DINOSAUR PROVINCIAL PARK, ALBERTA, CANADA

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Palynofacies analysis, reinforced by sedimentology and stratigraphy, can enhance reconstructions of paleoenvironmental dynamics. Although the palynology of Dinosaur Provincial Park (DPP) in Alberta, Canada, has been comprehensively studied, there has been a notable absence of research on palynofacies/kerogen analysis within DPP. This has limited the reconstruction of paleoenvironmental dynamics at a higher resolution for outcrops spanning ~3 million years at DPP. Therefore, this study aims to determine the nature and variations of palynofacies assemblages within the park, as well as to assess the extent to which palynofacies assemblages at DPP can be utilized for studying Late Cretaceous environments. Rock samples were collected every 0.5 m along a 32 m stratigraphic section dominated by a floodplain deposit. After extracting the sedimentary organic matter content from the rock samples, thin sections were prepared and subsequently analyzed microscopically under transmitted white light and UV fluorescence light. Based on field observations and stratigraphic correlations, the sampled stratigraphic section was assigned to the Oldman Formation and the Dinosaur Park Formation. Palynofacies assemblages within the Oldman Formation consist of abundant palynomorphs, while in contrast, palynofacies within the Dinosaur Park Formation phytoclasts dominate and contain little or no palynomorphs. However, amorphous organic matter content is relatively consistent across all samples. Collectively, the palynofacies assemblages within the stratigraphic section suggest exposure to freshwater conditions, thus supporting existing paleoenvironmental interpretations for the formations. Furthermore, while opaque and translucent phytoclasts predominated, palynomorphs also show large variations in colour (translucency). The observed changes in colour and variations in the abundance of these palynofacies suggest their potential as a robust proxy for high-resolution paleoenvironmental reconstructions at DPP.

THE GITXAALA NATION VERSUS BRITISH COLUMBIA MINERAL STAKING DECISION: BACKGROUND AND CURRENT STATUS

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In recent years Canadian universities have developed programs supporting Indigenous students and incorporating Indigenous knowledge. However, research and advocacy for Indigenous peoples beyond the classroom has lagged, especially in the extractive sectors. A case study of advocacy starts in 2014, when Banks Island Gold Ltd. initiated production from their underground Yellow Giant gold and silver mine on the traditional lands of the Gitxaala Nation. In 2015 the company received a pollution abatement order due to a "…spill of water with sedimentation…". In 2023 the former CEO of the company was found guilty of 13 environmental violations in relation to waste discharges from the mine. The violations prompted the Gitxaala Nation, later joined by the Ehattesaht First Nation, to challenge the constitutionality of the non-discretionary, free entry mineral claim registration (staking) system in British Columbia. In 2022 the authors applied for and were granted intervenor status to support the two First Nations before the Supreme Court of British Columbia. Our view was that a progressive 21st century pluralistic society cannot afford to mine minerals using a 19th century legal regime. The authors were opposed by the Attorney General of British Columbia and a collective of exploration and mining industry association intervenors. In the September 2023 decision of Gitxaala vs. British Columbia (Chief Gold Commissioner), the Court declared that the province and its Chief Gold Commissioner owed the two First Nations a duty to consult prior to the registration of minerals claims. The court suspended implementation of its declaration to March 2025 to ensure sufficient time for the Chief Gold Commissioner, or the executive branch, to consult and design a mineral title regime that allows for consultation, or for the province to amend legislation.

LONG-RANGE ORDERING WITHIN THE CHANNELS IN THE BERYL CRYSTAL STRUCTURE

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The crystal structure of beryl contains Si_6O_{18} rings that define a channel parallel to the c axis. Within the channel H_2O or larger alkali cations (mainly Cs) can occupy the 2a site at (0,0,0) and Na, which is primarily needed to charge balance divalent substitutions at the Al position, can occupy the smaller 2b site at (0,0,¼). There are

https://doi.org/10.12789/geocanj.2024.51.211

two orientations of water within the channels: Type 1 has an H-H vector parallel to the c axis, and Type II water has an H-H vector perpendicular to the c axis. Assuming a beryl with no Cs, Na at the 2b position is coordinated by H_2O II at one 2a site, and the other 2a site on the other side of the Na cation is vacant. With these constraints we can generate ordering schemes resulting in 0 to 0.66 Na pfu and 0 to 1 H_2O pfu and applicable to most beryl compositions. For example, a potential ordering scheme is 0-Na-H_2O II-0-H_2O II-Na, which results in 0.66 Na pfu and the same for H_2O; this is probably the upper limit for Na. The above constraints appear to hold for the majority of beryls, but not all. For example, diffractions studies of a dark blue beryl from the Yukon show 0.42 Na and 0.90 H_2O pfu. With the constraints given above the closest we can get is 0.42 Na and 0.66 H_2O pfu. In order to duplicate the diffraction results 12% of the Na ions must have H_2O at both coordinating 2a sites. Whether these H_2O molecules are type I or II or something in between is presently unknown. Determining the relative amounts of the different orientations of H_2O molecules in beryl structures will require careful spectroscopic work.

ORIGIN OF AN EMERALD CABOCHON FROM A ROMAN VILLA AT GERACE, SICILY

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The late Roman rural estate of Gerace is in Enna province in Sicily. Between 2016 and 2019 excavations focused on a bath house (ca. 380 AD) approximately 50 m ENE from the main villa. During excavation of the fill in a tepidarium (warm room) in 2017 an emerald cabochon was discovered. The cabochon is medium green, translucent to opaque, round in outline with a flat back, ~9 mm in diameter and 4 mm high, and ~2.5 ct in weight. At the time, emeralds enjoyed great popularity in ring settings, and its shape, size, and flat base all suggest that this sample was lost from a ring. A flake that was almost detached from the back surface of the cabochon was removed and fashioned into a mount for origin determination, in which two LA-ICP-MS trace element compositions were compared to 774 analyses from 401 comparison samples, mainly from the Gemological Institute of America reference collection. In compositional graphs the Gerace points plot close to or within a field defined best by points representing compositions of reference samples from Egypt. This determination is bolstered by the presence of a F-rich phlogopite inclusion in the sample fragment, suggesting a Type IA emerald deposit. Given that the bath house was built ca. 380 AD and destroyed by an earthquake after 450 AD, the emerald was most likely mined at Sikait, as mining at other sites in the Eastern Desert only began in the middle 500s AD. We can surmise that it was fashioned into a cabochon at a workshop close to the mine, then transported by caravan to Edfu or Qift on the Nile River, then by boat to a Mediterranean city for sale. This study illustrates how origin determination, which is of increasing importance to the gem trade, can be useful to archeology.

LESSONS LEARNED FROM REAL-WORLD APPLICATIONS OF LITHIUM-CESIUM-TANTALUM PEGMATITE EXPLORATION TECHNIQUES

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The increasing global demand for lithium has fueled a surge in exploration efforts targeting lithium-cesium-tantalum (LCT) pegmatites, recognized as significant hosts for economically valuable lithium deposits. The interest in these types of deposits has resulted in many geology professionals encountering these rocks for the first time. Hence, it is extremely important that the exploration and mining sector are informed in the numerous techniques driving successful LCT pegmatite exploration in the Canadian landscape. This presentation will focus on exploration approaches into the specific techniques and methodologies where geological complexities and geographical considerations play a crucial role. Topics discussed will include the potential and limitations of certain exploration techniques including the use of hand-held analyzers, satellite imagery remote sensing, geophysical surveys, and different sampling techniques for geochemical assays. The importance of understanding the geology context of a region and integrating techniques catered to specific projects will be discussed. An emphasis will also be given to the importance of accurate mineral identification and proper interpretation of geophysical, structural, and geochemical data sets. Real-world industry examples from lithium exploration projects in the Bird River-Separation Lake belt of Manitoba/Ontario will be presented, highlighting successful applications of these techniques, and providing valuable insights into the challenges encountered. The presentation will conclude with a forward-looking perspective on industry and academic collaborations, and potential areas for further research.

LEGACY OF 35 YEARS OF SEISMIC INVESTIGATIONS FROM THE TRANS-HUDSON OROGEN AND LATEST RESULTS

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Seismic reflection-refraction elements of the Canadian National Lithoprobe Program established 3-D subsurface images of the Saskatchewan-Manitoba portion of one of the world's best preserved Paleoproterozoic orogenic belts, the 1.8 Ga Trans-Hudson Orogen (THO). The reflection profiles mapped the structurally variant lithospheric floor (MOHO) and revealed deep crustal involvement during convergence of Archean cratons. The Moho is significantly deeper than 40 km; from 54 km across its eastern margin to flat within its western part. The discovery of the Sask Craton explains preservation of the ~500 km wide Proterozoic Reindeer Zone. The Superior Boundary Zone (SBZ) forms the northwestern margin of the Archean Superior craton, constituting the THO tectonic foreland. The seismically well-defined Superior Boundary Fault (SBF) separates SBZ from the adjacent Reindeer Zone, a collage of Paleoproterozoic juvenile intracratonic rocks, which seismically comprise an east-dipping crustal-scale tectonic stack. The SBZ is characterized at shallow depths by east-dipping reflectivity. Current analysis of SBZ is that it reflects ca. 200 Myr convergent margin history through lithospheric delamination into a steep transpressive boundary. Three western margin reflection profiles examined the later stages of arc terrane accretion to the Archean Hearne craton prior to terminal collision(s). Southeast-dipping reflectors record evidence for early accretion and thrusting of Paleoproterozoic arc terranes over the Hearne craton. Data analysis shows the margin developed into a region of transpression as continental collision progressed. Formation of the Athabasca Basin on top of these deformed rocks is possibly related to collapse of the orogen and extension at ca. 1750 Ma. The basement rocks below the Athabasca Basin and the Wollaston Domain were affected by a well-defined mid-crustal discontinuity of unknown age, interpreted as a low-angle extensional structure. Emboldened by the THO seismic investigation results, several locations in the Athabasca Basin tested the potential implementation of this technology for mineral exploration.

MAGMATIC HYDROTHERMAL EVOLUTION AND THE ASSOCIATED HIGH 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 frontier is associated with Miocene dykes of diorite porphyry; the deposit contains high metal grades due to porphyry-style mineralization overprinted by Au-rich high-sulphidation hydrothermal activity. Study of samples from deep (down to 1000+ m) zones within the Aurora zone show two distinct mineralization events and associated alteration. The early magmatic hydrothermal activity formed mushketovite and biotite with anhydrite (Anh), plus chalcopyrite (Ccp), bornite, and early pyrite (Py1). Sulphur isotopic compositions of co-existing Anh and Ccp yield temperatures between 550 and 450°C, which are consistent with typical temperatures for porphyry Cu deposits elsewhere forming the biotite-magnetite assemblage. Sulphur isotope analyses indicate

high porphyry temperatures associated with Anh-Ccp equilibrium within the Aurora zone; contrasting lower porphyry temperatures associated with Anh-Py of 335 to 365°C, north of the Aurora zone. Later hydrothermal activity by cooling of magmatic fluids produced high Au grade and overprinted an earlier mineralization. The fluids were oxidized and acidic, and formed alunite, as well as a high-sulphidation assemblage of enargite, digenite, covellite, chalcocite and later pyrite (Py2). A pair of intergrown alunite-enargite indicate a sulphur isotope temperature of 260°C. Pyrite, which is omnipresent in the deposit, shows textures not in equilibrium with other minerals. Its sulphur isotope compositions confirm several generations of pyrite crystallization. Similar styles of high-grade Cu-Au porphyry deposits are being recognized around the world, yet not well documented. The results of this study of the Filo del Sol porphyry Cu-Au deposit indicate that the high-grade overprint is related to an evolved magmatic-hydrothermal system. The information may contribute to exploration for and assessment of this type of deposit.

MELT INCLUSIONS IN QUARTZ PHENOCRYSTS FROM ARCHEAN PORPHYRY SYSTEMS, TIMMINS DISTRICT, ONTARIO: INSIGHT INTO MAGMA EVOLUTION AND METAL ENDOWMENT

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This study examines primary silicate melt inclusions in quartz phenocrysts from calc-alkaline dioritic intrusions (Paymaster, Crown, and Carr porphyries, and associated fragmental volcanic rocks) within the Porcupine Group (2.690–2.685 Ga), Timmins-Porcupine gold camp, Ontario. These melt inclusions preserve magmas related to early porphyry-style Cu-Au-Mo mineralization in some intrusions that pre-dates major orogenic gold mineralizing events. Melt inclusions were trapped in concentric growth zones (observed by cathodoluminescence) at T~650–720°C and P~4–10 kbar, based on integrated Ti-in-zircon and Ti-in-quartz thermobarometry for the host quartz phenocrysts. Combined with the occurrence of muscovite and epidote daughter phases in the inclusions, some immiscible CO_2-H_2O fluid, and microprobe analysis of H_2O (by difference; 3–5 wt.%), these P-T constraints indicate entrapment of water- and CO_2-saturated magmas within relatively oxidized reservoir/s at 15–35 km depth. Inclusions in the Crown porphyry were trapped at significantly higher P than in the Paymaster porphyry and porphyry fragments in the Krist Formation. Melt inclusions have incompatible trace element parameters (LA-ICP-MS: Zr/Sm vs Nb/Ta, Sr/Y vs. Y, $(La/Yb)_N$ vs Yb_N) that are consistent with Archean tonalite-trondhjemite-granodiorite (TTG) and adakitic volcanic arc magmas. Inclusions in the Paymaster porphyry and the Krist Formation are very similar with respect to all major and trace elements and are highly enriched in specific arc metals (As, Ag, Bi, Mo, Sb, Sn, W) compared to inclusions from the Crown porphyry. These data recognize that while these porphyry magmas are part of a broadly coeval suite, melt inclusions and associated thermobarometry demonstrate distinct differences in primary metal endowment and magma reservoir depth that likely impacted their differential porphyry ore-forming potential.

INVESTIGATION OF ACCESSORY MINERALS WITHIN THE ATHABASCA BASIN FOR ASSESSING POTENTIAL ORIGINS OF URANIUM AND REE IN UNCONFORMITY-RELATED URANIUM DEPOSITS

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The unconformity-related uranium deposits in the Athabasca Basin host some of the world's largest high-grade U deposits, many of which are also enriched in rare earth elements (REE). It remains unclear whether U and REEs were derived from the basin or the basement. This study aims to analyze the petrographic features and chemical compositions of detrital and diagenetic accessory minerals in the Athabasca Basin sandstones to evaluate whether U and REE are extracted from accessory minerals in the basin, and if so, the degree to which they contribute to regional ore systems. Scanning electron microscope-energy dispersive spectroscopy, SEM-cathodoluminescence, Raman spectroscopy, and TESCAN integrated mineral analyzer mapping revealed intense alteration patterns within U- and REE-rich minerals such as zircon, rutile, and anatase. Notably, halos of U and REE depletion were observed both in the mineral rims as well as deep within their cores, indicating their release into the basinal fluids during alteration. In contrast, analyses of aluminum phosphate sulphate and hematite minerals revealed enrichment of REEs, primarily in their outer rims, suggesting capture of these elements from fluids and potentially pointing towards their role as "sink" minerals retaining some of the REEs within the basin. Further quantification of U and REEs in the detrital and diagenetic minerals using combined laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and electron probe microanalysis data, alongside existing whole-rock analyses as well as mass balance calculation, will allow the estimation of the potential contribution of U and REE sourced from the Athabasca Basin to the formation of the unconformity-related uranium deposits. Results from this study may provide exploration strategies for exploration models and resource assessment in unconformity-related uranium deposits in the Athabasca Basin and similar geological settings.

THE PALEOPROTEROZOIC GRANITE FACTORY: FORMATION OF VOLUMINOUS POST-COLLISIONAL, FERROAN, A-TYPE GRANITES, LABRADOR, CANADA

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Arc magmatism along convergent plate margins is a major contributor to crustal growth and provides valuable insights into crust-mantle interactions during the growth of supercontinents. Granitoid plutons form the major component in convergent margin architecture and thus the lithogeochemistry and isotopic compositions of the granitoid rocks can elucidate the role (if any) of mantle contribution in their genesis. This is particularly true for A-type granites (sensu lato), where despite their widespread global occurrence, there is still much debate on their origin. The southern margin of the Archean North Atlantic Craton witnessed a major pulse of continental arc magmatism at ca. 1800 Ma, following arc-backarc-continent collision. Lithogeochemistry indicates compositions typical of ferroan, alkali to alkali–calcic, A-type granites formed through fractional crystallization. The granites have εNd(t) values varying from -5.3 to +2.0 and T_{DM} model ages from 2750 to 1880 Ma, suggesting derivation from variably recycled/assimilated Neoarchean to Paleoproterozoic lithosphere with a noteworthy juvenile component. Oxygen fugacity (fO_2) ratios, estimated by the proxy ratio of $FeO^T/(FeO^T + MgO)$, range from 0.58 to 0.99, indicating the parental magmas formed in both reducing and oxidizing conditions; this, coupled with observed alkali–calcic alteration makes them prospective for a variety of intrusion-related styles of mineralization including iron-oxide-copper-gold (IOCG) and uranium. Based on petrology, lithogeochemistry, and isotopic compositions, the ca. 1800 Ma magmatic rocks developed post-collision following the docking of the Cape Harrison Arc/micro-continent with the North Atlantic Craton (during the assembly of the supercontinent Nuna). This collision was followed by slab roll-back (possible break-off), extensional collapse and mantle upwelling resulting in the generation of the abundant ca. 1800 Ma felsic magmas. The timing of plutonism in the Makkovik Orogen overlaps with significant felsic plutonism from ca. 1818–1799 Ma in the Julianehåb Igneous Complex and Ketilidian Orogen in the North Atlantic Craton of southern Greenland.

EFFECTIVE DRIFT PROSPECTING FOR LI-BEARING PEGMATITES IN MANITOBA, CANADA

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Drift prospecting is a commonly used tool within the mineral exploration industry to facilitate the discovery of mineral deposits. However, effective drift prospecting methods that are focused on exploration for Li-bearing pegmatites are poorly under-

https://doi.org/10.12789/geocanj.2024.51.211

stood and are rapidly evolving to meet industry demands. Here, we focus on the Cat Lake-Winnipeg River pegmatite field, part of the Bird River domain of the Superior Province located in southeastern Manitoba. We investigate the mineralogical and matrix geochemical signature of till sampled down-ice of known Li-bearing pegmatite occurrences and compare this to samples collected within areas with no known occurrences. This analysis includes examining two size-fractions of the till matrix (< 63 µm and 1–2 mm) using three analytical digestions (aqua regia, four acid and sodium-peroxide fusion) to gain insight into which geochemical analysis can provide the best signal to background signal. Furthermore, each till sample was also picked for spodumene grains within the 0.25–2.0 mm fraction after a mid-density separation (specific gravity 3.0–3.2). Preliminary results of this analysis indicate that spodumene counts within till are an effective tool to highlight areas with known Li-bearing pegmatites and provide a promising avenue for drift exploration. The efficacy of using till-matrix Li values is still being assessed, but till sampled down-ice of known Li-bearing pegmatites in the Bird River area is not elevated above background values.

ECOSYSTEM RELOCATION ON SNOWBALL EARTH: THE CLADES THAT LIVED ON AND THE TALES THAT THEY TELL

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Many independent lines of evidence, informed by numerical simulations, support the Snowball Earth hypothesis—a self-reversing ice-albedo tipping-point—for the Sturtian (717–662 Ma) and Marinoan (645 ± 5–635 Ma) glaciations (Cryogenian Period). Such evidence comes from paleomagnetism, sedimentology, geochronology and geochemistry. Numerical simulations imply that Snowball oceans were covered by ice shelves hundreds of metres thick, which flowed under their own weight and closed off holes from meteor strikes. This means that Snowball oceans were perpetually without sunlight. Yet, fossil marine phototrophs, including multicellular eukaryotic macroalgae, are known from before, between and soon after the Snowball events. This can be explained given two conditions. One is that periglacial and englacial microbial biomes were established in polar and alpine areas long before the Cryogenian. The other is that such habitats survived the post-Sturtian greenhouse. When each Snowball began, the preestablished polar–alpine ecosystems simply migrated with their ice margins to the equatorial zone of net ablation. There they flourished, their habitat area vastly larger and the cruelty of winter reduced. When each Snowball finally ended, much of the surface biota would find itself in a rapidly-warming, nutrient-rich, meltwater-dominated and nearly-abiotic surface ocean. Some taxa returned to the mountaintops whereas others exploited vacant niches. This ecosystem relocation model has been tested in two ways. First, the metabolic, taxonomic and molecular diversity of modern polar–alpine ecosystems, absent recently-evolved forms like diatoms, is sufficient to account for the Ediacaran and Cambrian radiations assuming extirpation of pre-Cryogenian marine clades. Second, many findings from molecular phylogenetics and genomics can be reconciled with the fossil record if the relocation model is true. Pre-Cryogenian freshwater ancestry for all living marine phototrophs can be reconciled with pre-Cryogenian marine fossils if the latter represent extinct clades. The two-fold division of all green plants can be understood as sole survivors, not a singular divide.

POST-COLLISIONAL EDUCTION OF TALTSON TECTONIC ZONE, NT-AB: A DYNAMICALLY COUPLED ORIGIN FOR NONACHO AND TU CHO (GREAT SLAVE) BASINS, 1889–1867 Ma

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Eduction is the upward and outward extrusion of previously-subducted wedges of continental crust. They are floored by thrust systems and roofed by normal-sense detachments, giving rise to disparate sedimentary basins. We proposed that Taltson tectonic zone is an arcuate wedge educted northwestward, bounded below by Tu Cho (Great Slave) basin and above by Nonacho basin. In Tu Cho basin, eduction-related flexural subsidence began at the Sosan–Kahochella group transition, coincident with basin-wide phreatic volcanism of Seton Formation which we dated in Sachowia cauldron at 1889.0 ± 0.7 Ma (U–Pb zircon CA-ID-TIMS). Eduction-related thrusting ended with intrusion of quartz-diorite laccoliths in a 10 × 240 km swath along the thrust front, perpendicular to the trend of the coeval Great Bear magmatic arc in Wopmay orogen to the west. Laccolith trace-element geochemistry closely resembles post-collisional granitoid rocks (< 8 Ma) in Papua–New Guinea. A date of 1866.9 ± 0.9 Ma (U–Pb zircon CA-ID-TIMS) for the laccolith at Stark Lake constrains eduction-related subsidence and thrusting to a 22-Myr window that postdates the 1950–1920 Ma collision in the adjacent Taltson tectonic zone by > 30–53 Myr. We speculate that eduction and Seton volcanism were triggered by Slave slab failure, and that cessation of eduction and laccolith magmatism were caused by crustal delamination, induced by loss of footwall buoyancy caused by transfer of subducted Slave upper crust to the educted wedge. The proposed mechanical coupling of Tu Cho and Nonacho basins predicts that the latter is 1889–1867 Ma in age, correlative with the Kahochella, Pethei and Christie Bay groups in Tu Cho basin, and not with the younger Et-Then Group as previously inferred on lithologic grounds. Slave slab failure and post-collisional eduction into the foreland may explain why no passive-margin sequence is preserved in Tu Cho basin, unlike other Orosirian peri-Slave basins (Kimerot Group in Kilohigok basin and Epworth Group in Coronation basin).

KEY FEATURES AND PROCESSES OF OROGENIC GOLD BELTS OF THE EXPLOITS SUBZONE, NEWFOUNDLAND APPALACHIAN OROGEN

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Accretionary terranes of the Exploits Subzone, in the central Newfoundland Appalachian orogen host significant orogenic gold systems that require detailed research to advance early-stage exploration and development. The two main structural corridors being developed include the Valentine Lake Shear Zone (VLSZ) and the Appleton Fault Zone (AFZ). These belts differ with respect to geological setting and style of mineralization. Along the VLSZ, low-grade to locally high-grade, mesozonal, Devonian deposits are hosted mainly by shallowly dipping 'QTP' extension veins that cut Neoproterozoic granitoid rocks ± mafic dykes and unconformably overlying Pridoli (latest Silurian), extension-related polymict conglomerate and associated bimodal igneous rocks. Along the AFZ, undated epizonal networks of quartz-filled fracture meshes hosting high-grade mineralization cut Cambrian to Early Devonian clastic sedimentary rock sequences and Ordovician to Devonian gabbro bodies. Polymict conglomerate and associated Pridoli magmatic rocks are diagnostic of the VLSZ but are apparently absent along the AFZ. Southeast along strike of the AFZ belt, new temporal constraints for bimodal igneous rocks suggest that high geothermal gradients associated with Pridoli extension were widespread in the Exploits Subzone prior to Devonian (Acadian and Neoacadian) orogenic gold mineralization. This notion of widespread Pridoli extension is further supported by the preservation of polymict conglomerate along the orogenic gold-mineralized Day Cove thrust in the southeasternmost Exploits Subzone. The northwest dips of the VLSZ, AFZ, and Day Cove thrust oppose the overall structural vergence direction associated with Acadian and Neoacadian compression, suggesting that back thrusting was important in focusing auriferous fluids derived from metamorphism of uplifted rocks of the Gander Zone. The distinct, shale-rich setting of the AFZ may imply that host-rock chemistry, in addition to geothermal gradient and structural fluid focusing, played a role in producing the epizonal, high-grade orogenic gold prospects. The long-term preservation of both mesozonal and epizonal orogenic gold systems is consistent with minimal post-orogenic uplift.

APATITE AND MAGNETITE IN THE WUYANG BANDED IRON FORMATION, NORTH CHINA CRATON, AS PROBES INTO DISSIMILATORY IRON REDUCTION PROCESSES

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Banded iron formations (BIFs) are ancient sedimentary deposits that provide critical insights into Earth's early atmosphere, hydrosphere, and biosphere. These BIFs are essential in studying dissimilatory iron reduction (DIR)—a key process in the post-depositional transformation of iron that is indicative of the activity of iron reducing bacteria (IRB). The Wuyang BIF is located along the southern margin of the North China Craton and is positioned in the central part of the Lushan-Wuyang-Huoqiu BIF belt. The Wuyang BIF may be compositionally and texturally divided into a banded pyroxene-magnetite quartzite (BPMQ) and disseminated quartz-magnetite pyroxenite (DQMP). The BPMQ ranges in thickness from 0.5 to 2 cm, predominantly featuring quartz bands, with ~35% pyroxene. The DQMP mainly consists of ~45% pyroxene and ~35% magnetite with smaller amounts of garnet, quartz, and accessory minerals apatite and zircon. Apatites in BPMQ are characterized by high Sr (1544 to 27,175 ppm), high OH (0.33 to 0.58%), and relatively high εNd (t) values (-4.1 to +0.4). In contrast, DQMP apatite samples feature high F (0.71 to 0.90%), low Sr (71 to 6252 ppm), and relatively low εNd (t) values (-6.3 to -1.0). What's more, the magnetite in the Wuyang BIF is characterized by low δ^{56}Fe values: -2.09 to -0.62‰ for BPMQ and -1.36 to -0.77‰ for DQMP. Low δ^{56}Fe values in BIFs (< -2‰) could be caused by DIR processes due to the IRB. Moreover, the correlations between δ^{56}Fe values and OH, Y/Ho, and Nd isotopic characteristics in apatite might also be related with biological processes. These phenomes from magnetite and apatite underline the potential roles of dissimilatory iron reduction process, and by extent iron reducing bacteria in the formation process of the Wuyang BIF.

PUBLIC EARTH SCIENCE AND MINERAL RESOURCE EDUCATION - RAISING AWARENESS, INCREASING LITERACY AND ADDRESSING PERCEPTIONS

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Mining Matters is a national charitable organization dedicated to educating people to develop knowledge and awareness of Earth Sciences, the minerals industry, and their roles in Society. Our key programming areas include Teacher Training and School Programs, supporting teachers though professional learning opportunities and resources; Indigenous Community Education and Outreach Programs, providing educational opportunities for indigenous youth, and professional learning workshops for teachers in indigenous communities, STEM Partnerships, collaborating with other organizations to deliver customized education to a wide audience, and Public Outreach, increasing awareness about rocks, minerals, metals and mining through interactive activities at events across Canada. Since our founding in 1994, Mining Matters programming has reached 860,000 students, teachers, and members of the public. The goals of the Mining Matters Public Outreach Program are raising awareness of Canada's local and regional geology, modern mining, the transition to a low carbon economy, and geoscience and minerals industry careers. Mining Matters regularly participates in public outreach events, including in collaboration with STEM partners, which focus on increasing Earth science literacy, connecting society to the Earth, and communicating STEM research and practice, reaching thousands of people annually. National public education events such as Science Rendezvous and Earth Science for Society provide venues where customized, engaging Earth science and mineral resources educational content, including scalable hands-on learning activities can be created, and key messages communicated to a wide audience. Facilitating an educational exhibit at a commercial Gem and Mineral Show provides an opportunity to include geoscience in the conversation, important in providing context, which otherwise may not be present. Public Earth science and mineral resources education increases understanding of the role that Earth Science plays in daily life, and careers which increases awareness of post-secondary pathways.

TENSIONS IN ELASTIC THERMOBAROMETRY: QUARTZ-IN-GARNET BAROMETRY AND ITS APPLICATION TO THE NELSON BATHOLITH IN SOUTHEASTERN BRITISH COLUMBIA

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Quartz-in-garnet thermobarometry (QuiG) is the most widely used method of "elastic thermobarometry", a technique based on the relative expansion or compression of mineral inclusions within a host. In contrast to classical thermobarometry which uses the chemical compositions of minerals to determine the pressure-temperature conditions of metamorphism, QuiG uses the present-day pressures experienced by quartz inclusions in garnet to determine the P-T conditions of garnet growth. QuiG has been applied mainly to collisional and subduction-related metamorphic sequences worldwide. However, it has not been thoroughly tested in low-pressure settings (~5 kbar and lower). In these settings, quartz inclusions in garnet are predicted to preserve tensional rather than compressional stresses. Here, QuiG is applied to the thoroughly characterized contact metamorphic aureole of the Nelson batholith in southeastern British Columbia - a staurolite + andalusite bearing aureole which preserves pressures of metamorphism at ~3.5 kbar. This talk will discuss the results of this study, which carry implications for the strengths, pitfalls, and nuances in the method and its application to metamorphic recrystallization.

OXYGENATION OF THE PROTEROZOIC EARTH'S SURFACE: AN EVOLVING STORY

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Proterozoic Earth surface oxygenation is an intensely debated topic central to understanding the evolution of complex life. The emerging story is that Proterozoic background atmospheric O_2 levels were stable but low over ten- to hundred-million-year time frames. Although not universally agreed upon, a baseline pO_2 of 0.1 to a few percent of present atmospheric levels seems reasonable based on the results of models seeking to quantify stable atmospheric O_2 reservoirs and those seeking to explain the continuously expanding geochemical record. A surface ocean in equilibrium with such an atmosphere would have dissolved O_2 abundances ranging from a few single to tens of μm and the deep oceans would have remained broadly anoxic. Indeed, many independent lines of evidence point to a mild and heterogeneously oxygenated surface ocean overlying anoxic deeper waters at many different times during the Proterozoic. Transient geochemical trends found at various times in the Proterozoic sedimentary record are interpretable as evidence of a briefly better oxygenated Earth surface over durations from < 1 to 250 Myr. These include the 2.31–2.06 Ga Lomagundi-Jatuli Event, middle Proterozoic events at ~1.6 Ga, ~1.4 Ga, and ~1.1 Ga, and multiple Neoproterozoic events. For each event, there exists an associated counterargument, i.e. an alternative interpretation of the data, particularly regarding the extent of deep-ocean oxygenation. The Neoproterozoic is classically thought to mark a stepwise increase in Earth's surface O_2 levels concurrent with the rise of animals, but the Lomagundi-Jatuli oxygenation event may have had permissibly high O_2 levels and yet did not trigger animal evolution. A variety of genetic, ecological, and environmental challenges largely unrelated to O_2 may have caused the dominance of eukaryotes and animals to be delayed long past the time permissible O_2 thresholds were first crossed. This review will appear in the upcoming 3rd edition of the *Treatise on Geochemistry*.

ARCHEAN LITHIUM-CESIUM-TANTALUM PEGMATITES OF WESTERN AUSTRALIA: TIMING, MELT ORIGINS AND EMPLACEMENT CONDITIONS

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The Archean cratons of Western Australia are host to the earliest examples of lithium-cesium-tantalum (LCT) pegmatites in the geological record, including some of

https://doi.org/10.12789/geocanj.2024.51.211

the world's largest hard rock lithium deposits (e.g. Greenbushes, Mt Holland, Pilgangoora, and Wodgina). Despite the economic importance of these pegmatites, little consideration has been given to the tectonic and igneous processes responsible for generating Li, Cs, Ta, and Sn enriched intrusions in Archean terranes. These advancements have been hampered in part by the limited geochronological data available for these LCT pegmatites, and by the complex and incomplete geological history of Archean crustal blocks. In this study, geochronological data were collected from major LCT pegmatite fields across Western Australia — utilizing in-situ LA-ICP-MS methods on cassiterite and columbite group minerals. The characteristics of these LCT pegmatite fields — including timing, structural and metamorphic setting, and associated igneous activity — were reviewed against current understanding of the crustal evolution of their host terranes. Several commonalities were identified in the melt generation and emplacement conditions of the reviewed LCT pegmatites. These include (1) a genetic association with late granitic suites, derived from the reworking of older granitic suites with limited juvenile or metasediment input; (2) a spatial association with terrane boundaries or other crustal scale structures; and (3) preferential emplacement in upper greenschist to amphibolite facies mafic-ultramafic packages. The results presented here support a pluton-related origin for the Archean LCT pegmatites of Western Australia — reflecting the unique crustal compositions and melt production conditions of this time period. This is an important consideration for future LCT pegmatite exploration in Archean terranes.

THE HAMMER AND THE CRUCIBLE: AN EXAMINATION OF MODERN PETROLOGICAL RESEARCH

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The methodologies we employ to solve petrologic problems have undergone many changes over the 20th and 21st centuries. However, despite these advancements, two main approaches to conducting this research have remained: observation and simulation. Geology in general has always been field rooted in observations of nature, but petrology was changed irreversibly by the advancements in experimental petrology in the 20th century. Experiments allowed researchers to simulate natural processes, providing insights into phase equilibria that remain crucial to petrological research. Observation has since evolved to include increasingly more powerful microscopes effective down to the atomic scale and chemical analyses of a wide variety of isotopes and sub-μg/g levels of trace elements. Simulation is now possible on computers, and phase equilibrium modelling has become ubiquitous in petrologic studies. Over time, the accessibility of observation- and simulation-based work has become reversed—previously, simulations required specialized equipment available to a limited number of individuals and observation involved relatively few tools. Today, significant observation-based advancements in petrology generally require data from expensive analytical instruments and can be time-consuming to collect and interpret, whereas petrologic modelling can be done relatively quickly and at low cost. Although both approaches contribute to high quality, high impact research, I argue that there is an inherent order in the ideal petrologic study: simulations must follow observations. Without grounding in the geological record, simulations—by necessity, simplified and idealized representations of nature—have little meaning. Modelling can provide thought-provoking predictions, but these must be balanced with existing basic field, compositional, or microstructural data. As it becomes easier than ever to conduct petrological research with little to no connection to primary observations, bringing mindfulness to modelling has never been more important.

AURIFEROUS FLUID EVOLUTION AND THE ROLE OF CARBONACEOUS MATTER IN A SADDLE-REEF AU DEPOSIT: DUFFERIN DEPOSIT, MEGUMA TERRANE, NOVA SCOTIA, CANADA

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The metaflysch-hosted ~380 Ma Dufferin Au deposit in the Meguma terrane (MT) of Nova Scotia, Canada, is a typical metasedimentary rock-hosted orogenic gold deposit with mineralized saddle reef-type quartz veins localized between metasandstones and black slates in a tightly folded anticline. Ubiquitous to the veins is carbonaceous material (CM), occurring as immature organic matter (i.e. pyrobitumen), lining cavities and along grain boundaries proximal to vein contacts or wallrock fragments. The occurrence of native Au inclusions (≤ 1 μm; 88–92 at.% Au; balance Ag) in CM-filled cavities indicates gold mineralization is genetically related to CM. Through a combination of microanalytical methods, we show that Au precipitated through the coupled fO_2 reduction and pH increase of aqueous-carbonic fluid (H_2O-NaCl-CO_2, N_2, CH_4) that was Au-undersaturated (0.045 ± 0.024 ppm Au; 1σ; n = 58). Importantly, Au-bearing fluids are always petrographically late, occurring exclusively as secondary inclusion assemblages in recrystallized quartz domains. The proposed mineralization mechanism is supported by: (i) a decrease in Au and redox-sensitive semimetals (As, Sb), and an increase in the concentration of elements inherited from metasedimentary wall rocks (i.e. Mg, K, Ca, Sr, Fe) in saddle-hosted fluid inclusions with time; (ii) a corresponding decrease in the XCO_2 from Au-bearing to Au-depleted fluids, consistent with CO_2 removal via reduction/respeciation and late carbonate precipitation; and (iii) gold embedding in or on the surface of CM inside mineralized cavities and fractures. Despite mineralizing fluids only transporting low concentrations of Au, far from saturation ([Au]calc. ≈ 0.1–2 ppm), they produced Meguma-type (metasediment-hosted) deposits indicating that the efficiency of Au precipitation from these fluids was high, a process promoted by the presence of CM. This work illustrates the role played by carbonaceous material during gold mineralization in the Meguma terrane and re-emphasizes CM as a potential prerequisite for efficient gold precipitation within similar orogenic metasedimentary settings globally.

THE ECONOMIC IMPORTANCE OF PEGMATITES IN AFRICA WITH A FOCUS ON LITHIUM

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Pegmatites occur across the African continent. These range in age from Archean to Neoproterozoic, correlating with orogenic events in the Kibaran (~1000 Ma) and the Pan-African (~550 Ma) orogens. In some provinces both lithium-cesium-tantalum (LCT) and niobium-yttrium-fluorine (NYF) pegmatites were intruded at the same time, e.g. the Orange River Belt in South Africa and the Pan-African Damaran and Madagascar Belts. Many pegmatites have been mined for gemstones, tin, or tantalum with some having produced lithium mainly for the ceramics industry, such as Bikita in Zimbabwe. A reappraisal of a number of former Sn-Ta mines has led to the reopening of several prospects in response to the demand for lithium. Pegmatites in the Kibaran belt of East Africa are being re-evaluated for both tin and lithium production. The Manono-Kitolo pegmatite in the Democratic Replublic of Congo, produced 140,000 tons of cassiterite and 10,000 tons of columbite-tantalite between 1915 and the mid 1980s with suggested reserves of 120 Mt of spodumene-bearing ore, making it one of the largest lithium reserves globally. Similarly, the Uis mine in Namibia has re-commenced cassiterite mining but is also producing recently discovered lithium resources. Acadia in Zimbabwe, a former Be-feldspar-Li mine has also re-opened for lithium production. In southwestern Mali, the undeveloped prospect of Goulamina, hosts steeply-dipping, spodumene-bearing pegmatites with ore reserves of 52 Mt, while the Ewoyaa lithium project, on the Ghanaian coast, also under development, hosts ore reserves of 25.6 Mt in a Birimian (~2.2–2.1 Ma) spodumene-bearing pegmatite. Lithium is a critical material for a low-carbon future: according to published data between 2011 and 2020 the requirement for lithium in batteries increased from 27% to 71% of total lithium production and recently the World Bank estimates that society will need a 488% increase in lithium production by 2050 to meet its needs for the transition to green energy.

AN APATITE FOR HEAT-PRODUCING ELEMENTS: THE EFFECTS OF ACCESSORY MINERAL STABILITY ON HEAT PRODUCTION AND HEATING TIMESCALES DURING CRUSTAL DIFFERENTIATION

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Cratonization is achieved through the stabilization of the lower crust via melting and transfer of material to higher crustal levels. Key to this is removing heat-producing elements (uranium, thorium, potassium), leaving a cold, rigid residue. These elements are often assumed to concentrate in the melt during anatexis and consequently, interpretations typically suggest decreasing heat production with depth. However, this assumption relies heavily on xenoliths, which offer limited insights. The distribution of these elements during anatexis and their impact on heat budgets, timescales of heating, and crustal structure remain elusive. To address these outstanding questions, we combine field relations and whole rock petrography combining major and accessory phase, trace elements, and heating time modelling. The Archean Kapuskasing Uplift in western Ontario provides a natural laboratory recording the process of crustal differentiation. The Kapuskasing Uplift is comprised of upper crustal greenstones, middle-crustal tonalite-trondhjemite-granodiorite (TTG) gneisses, and lower-crustal high-grade metabasites. The TTGs were likely formed by melting of high-grade metabasites which represent high-grade equivalents of the supracrustal greenstones. The crustal column was frozen during crustal differentiation and uplifted by thrusting, allowing sampling across a range of paleodepths. Modelling reveals that apatite, hornblende, K-feldspar, and melt primarily harbour heat-producing elements during anatexis. Apatite plays a crucial role in retaining these elements in the lower-crust residue. However, their partitioning into low-density melt diminishes heat production in the lower crust, subsequently prolonging heating times. Our findings indicate: (1) the mantle rivals or exceeds heat production from these elements during metabasite anatexis, (2) the lower crust retains its heat-producing element content during anatexis, and (3) from the onset of anatexis, over 30 million years of heating is required to reach 850°C. These insights challenge perceptions of cratonization heat-sources, the depletion of heat-producing elements in the lower crust and therefore encourages revised approaches to crustal heat-production estimation.

MESOPROTEROZOIC ULTRA-HIGH TEMPERATURE METAMORPHISM AND ANDEAN-STYLE TECTONISM OFFSHORE LAURENTIA

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The Frontenac Terrane, situated in the southeastern Grenville Province, records the opening of an ocean basin and subsequent collision resulting in (ultra-) high-temperature metamorphism. This lithotectonic block exhibits a diverse geological composition, including quartzite, quartzofeldspathic schist, aluminous schist, marble, and mafic schist grading into one another indicating they form a quasi-conformable supracrustal sequence. The intrusion of substantial monzonite-syenite-granite magmas, along with minor amounts of gabbro, diorite, and anorthosite, occurred at ca. 1166–1157 Ma. This magmatic activity occurred prior to and synchronous with (ultra-) high-temperature metamorphism. The Frontenac Terrane displays three generations of folding discernible at both outcrop and regional scales. D_1 and D_3 produced reclined folds closing to the NE-SW, temporally separated by NW-SE closing reclined folds associated with boudinage. Granite plutons and regionally derived leucosomes align broadly with D_1. Geochronology of shear zones and high-temperature magmatism/metamorphism points to synchronous tectonothermal activity during the Shawinigan orogeny, with minor reheating during the Ottawan and potentially Penokean phases. Metamorphic and magmatic ages indicate concurrent processes. Thermobarometry and phase equilibrium modelling of garnet-sillimanite-cordierite-orthopyroxene-perthite gneisses reveal a geotherm exceeding 150ºC/kbar, with temperatures locally surpassing 900ºC. Geochemical analysis suggests granites formed from collision or an island arc setting, while sediment origins align with the proximal Adirondack Highlands. Collectively, these findings contribute to a clearer understanding of the tectonic history of the Frontenac-Adirondack Belt, development of (ultra-) high temperature metamorphism, and the evolution of the Grenville Orogenic Belt. The Frontenac Terrane signifies an ancient back-arc basin that closed during the Shawinigan orogeny, forming Adirondas offshore Laurentia. Syn-collisional high-temperature metamorphism and magmatism shed light on hot orogen formation. Intercollisional extension and Ottawan reheating suggest the Frontenac Terrane was a well-protected block within Adirondas and together, this tectonic model supports a Mesoproterozoic Andean-style margin offshore Laurentia.

NATURE, ORIGIN AND RELEVANCE OF METASOMATISM IN RARE-METAL ORE SYSTEMS

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Rare-metal (RM) mineralization (e.g. Ta, Nb, Sn, W, Li, Be, REEs) occurs in a variety of magmatic rocks, notably carbonatites, A-and S-type granites, and lithium-cesium-tantalum (LCT) and niobium-yttrium-flourine (NYF) type pegmatites. Common to these systems is that the RM mineralization is of hybrid origin, thus attributed to both primary magmatic and later metasomatic processes. Importantly, concurrent with the latter is the formation of pervasive and intense zones of alteration via coupled dissolution-precipitation (CDP) that is manifest, for example, by the development of albite-rich zones in LCT-type pegmatites, the so-called aplitic albite rocks, but also more rarely mica-rich zones in similar settings. This presentation uses a variety of examples from widespread settings such as LCT pegmatites (e.g. Tanco, MB; LNPG, NWT; Brazil Lake, NS) and specialized granites (Mongolian ongonite; Beauvoir, France; East Kemptville, NS) to explore the nature, origin, and relevance of metasomatism in RM ore systems. As will be evident, no single model can accommodate the observations and it is suggested instead that both primary magmatic and later localized remobilization and upgrading of RM ore occur due to interaction with both flux-rich melts and magmatic fluids. Thus, for LCT pegmatites magmatic RM ore is accompanied by aplitic albite and cleavelandite zones with related RM mineralization originating from incursion of late-stage hydrous sodic melts carrying Ta-Nb. In contrast, in specialized granite settings, primary magmatic RM ore (e.g. columbite-tantalite) is converted to secondary phases (e.g. pyrochlore) via CDP, whereas for Sn both magmatic and hydrothermal cassiterite can occur. Thus, as RM mineralization includes both primary magmatic and secondary magmatic and hydrothermal processes means that ore zones can be hybrid in origin which must be considered when evaluating the nature and origin of RM mineralization from aspects of both ore-deposit models and economic viability.

THE RARE-METAL RICH (Li-Be-Sn-Ta-Nb-W) BEAUVOIR GRANITE, FRANCE: INSIGHT INTO THE SOURCE AND PROCESSES OF LITHIUM-CESIUM-TANTALUM PEGMATITES

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The Beauvoir Granite (BG, Massif Central, France) lies in the European Variscan belt of rare-metal (RM)-rich peraluminous granites and lithium-cesium-tantalum (LCT) type pegmatites. This highly evolved lepidolite-zinnwaldite-two feldspar-topaz-amblygonite granite is currently mined for high-quality kaolinite in its apices but is known from historical (900 m deep GPF1 of the 1980s) and recent (Imerys, France) drilling to contain substantial RMs (Li-Be-Sn-Ta-Nb-W). Previous studies of GPF1 identified three vertically stacked, mineralized granitic units (B1, B2, B3) with average (and maximum) grades (in ppm) for B1 of 4575 Li (9643), 153 Be (506), 1077 Sn (4000), 179 Ta (447), 102 Nb (170), and 40 W (78) related to primary micas, cassiterite and columbite/tantalite phases, respectively. Such RM enrichment in a strongly peraluminous leucogranite suggests analogs with LCT pegmatite suites and supports their derivation from similarly evolved parental magmas. However, as the nature and origin of RMs in such rocks remain contentious (i.e. magmatic, hydrothermal, or hybrid), we undertook a detailed study of archived GPF1 materials (n = 150) using petrography, SEM-EDS, optical CL, and LA-ICP-MS analyses (mica, plagioclase). This work reveals that although primary magmatic textures are preserved, the silicate mineralogy records pervasive coupled dissolution-precipitation

https://doi.org/10.12789/geocanj.2024.51.211

(CDP) processes best reflected in the microtexture (e.g. pitted, fluid inclusion-rich, perthite types) and chemistry (Ab_{100}, $Or_{92–95}$) of feldspars (plagioclase and orthoclase). Furthermore, whereas Sn and Ta-Nb mineralogy is dominated by magmatic textures and chemistries, there is an imprint of hydrothermal processes, notably enrichment of Sn and formation via CDP of secondary U-Ca-Na Ta-Nb phases (e.g. pyrochlore) in the upper few 100 m of GPF1. Since the features noted in the Beauvoir Granite are similar to those seen in many LCT pegmatites, we suggest the processes identified in the Beauvoir Granite provide relevant insight into the evolution of LCT pegmatite systems and should be incorporated into models for their rare-metal enrichment.

STRUCTURAL CONTROLS ON THE EMPLACEMENT AND MINERALIZATION OF LITHIUM-BEARING PEGMATITES

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Lithium-rich pegmatites are an important subset of lithium-cesium-tantalum (LCT) type pegmatites which host economic concentrations of spodumene and petalite. Significant work has focused on understanding the source enrichment processes required to form Li enriched melts, leading to the development of two formation models: low-degree partial melting, and high-degree fractional crystallization. However, recent work has shown that neither, in their simple sense, is able to enrich a melt sufficiently to form economic concentrations of spodumene. In addition, the focus on petrogenesis subverts the importance of geological structures on the spatial distribution of pegmatites, especially as pegmatites can migrate significant distances from their source. We present a case study on the Archean Zulu pegmatite field (ZPF) in Zimbabwe. Based on field observations, we propose pegmatites of the ZPF emplaced along an active Riedel-type shear zone. We find the most voluminous pegmatites (G1) are emplaced parallel to R, with subordinate pegmatites (G2) along both R' and X structures. Additionally, G2 pegmatites retain a predominantly magmatic, petalite-dominated mineralogy, suggesting a rapid and contracted cooling history. In contrast, the G1 retain structural signatures of significant reworking during sinistral shearing, coinciding with extensive albitization and conversion of petalite to spodumene-quartz intergrowths (SQUI). We propose that the G1 pegmatites experienced a protracted cooling history due to emplacement along an active shear zone, which promoted the formation of SQUI. Therefore, pegmatites with different orientations have significantly different mineralogy and volume, despite being emplaced at the same time. We propose that further exploration in pegmatite fields should focus on constraining the major structures along which pegmatites are emplaced, defining whether they are emplaced syn- or post-tectonically, to identify potentially promising targets.

STRUCTURAL CONTROLS ON MESOZOIC KIMBERLITIC MAGMATISM IN THE TIMISKAMING GRABEN

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Many kimberlitic fields in Africa, Australia, Eastern Europe, and Siberia are associated with paleorifts and fault zones. However, it remains unclear whether the reactivation of such structures can be a sole driver of the kimberlitic magmatism and impose the main structural control on their spatial distribution. In Canada, the Jurassic–Cretaceous kimberlites of Timiskaming and Kirkland Lake fields were emplaced across the Timiskaming Graben - a 300 km-long, SE-NW trending branch of the St. Lawrence rift system that has remained intermittently active since its Proterozoic inception, experiencing reactivations during Rodinia and Pangea dispersals and displaying present-day seismic activity. In this study, we explore the structural settings of the Timiskaming and Kirkland Lake kimberlites to assess whether Mesozoic reactivation of the Timiskaming Graben provided the primary structural control on the spatial distribution of these intrusions. We analyze country rock fracturing patterns in outcrops using direct measurements and digital outcrop models constructed from drone imagery to constrain the mesoscale structural settings associated with kimberlite emplacement. We use potential field data to reveal regional-scale structures that host kimberlitic intrusions. We find that of 21 intrusions examined, 20 were emplaced along the SE-NW-trending regional faults or contain prominent subvertical SE-NW-trending fracture sets that could be associated with the tectonic activity of the Timiskaming Graben. However, 5 of these 20 are located at the intersections of these SE-NW-trending structures with E-W-trending Cadillac– Larder Lake and Destor-Porcupine faults, and 7 kimberlites of the Timiskaming field are emplaced where a normal fault of the Timiskaming system intersects a contact zone of a buried intrusion. We speculate that the interaction of the pre-existing Archean weakened zones with the rejuvenated faults of the Timiskaming rift system proved to create the most favourable setting for kimberlite emplacement.

HIGH RESOLUTION TRACE ELEMENT MAPPING OF THE WEELI WOLLI BANDED IRON FORMATION (AUSTRALIA): IMPLICATIONS FOR METAL SOURCES AND OXIDATIVE WEATHERING IN THE LEAD UP TO THE GREAT OXIDATION EVENT

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Banded iron formations (BIFs) are iron and silica-rich chemical sedimentary rocks that are characteristic of Earth's deep past, having been deposited primarily in the Archean to Paleoproterozoic. Importantly, BIF provide a window into Earth's evolving marine and atmospheric conditions billions of years ago. Due to regularity in the alternating iron- and silica-rich bands, BIFs have been suggested to reflect regular variations in conditions that led to iron and silica deposition on seasonal or longer time scales and have been correlated to orbital cyclicity. Interestingly, the Weeli Wolli Formation (2451 Ma to 2449 ± 3 Ma) coincides with the proposed onset of the Great Oxidation Event (GOE) around 2.45 Ga. This provides a unique opportunity to examine fluctuations in redox-sensitive and bioessential trace metals, their sources, and the state of global oxidation ~2.45 Ga. Here, laser ablation ICP-MS mapping of samples from the Weeli Wolli BIF provide a high-resolution record of fluctuations in trace metals that coincide with cycles in banding. Collectively, these provide an improved understanding of the origin of these trace elements, their relation to oxidative weathering or hydrothermal activity during deposition of the Weeli Wolli BIF and support the increasing importance of oxygen in Earth's atmosphere ~2.45 Ga.

FINGERPRINTING OF LITHIUM-CESIUM-TANTALUM PEGMATITES AROUND THE WORLD: INSIGHTS FROM TRACE ELEMENT VARIATIONS AND CHANGES IN THE LITHIUM ISOTOPE RATIO

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Even though lithium-cesium-tantalum (LCT) pegmatites are the most important source of lithium from hard rock resources and occur globally, the active large mines are mainly limited to Australia, Brazil, and Canada. However, lithium-rich pegmatites also occur in conflict regions or are locally associated with environmental pollution. The ability to distinguish between different spodumene deposits is also becoming increasingly important due to the politically motivated requirement for traceability of raw materials along supply chains. Contrary to the classic idea of grouping deposits based on their similarities, the parameters that make it possible to specifically differentiate between these deposits are of interest for lithium fingerprinting as proof of origin. The geological parameters of various pegmatite provinces worldwide, such as host rocks, age, and structural composition, differ from field observations. However, as soon as mineral concentrates are produced, certain information is lost and uncertainty increases. Although mineral distribution analyses allow deposits or occurrences to be differentiated based on the presence or absence of certain minerals or distinct mineral parageneses (e.g. columbite-tantalite minerals, cassiterite, pollucite, apatite), these are only a snapshot and can change over decades

of mining, whether due to geological zonation or quality fluctuations during mineral processing. Additionally, a certain variability of trace element concentrations can be assumed. However, this can be counteracted by appropriate sampling in addition to analyzing only mineral concentrates. It can be assumed that the host rocks have an influence on the minor and trace element distribution in the pegmatite minerals, i.e. also in the contained spodumene, petalite, and lepidolite. A difference in the lithium isotope ratios depends not only on the weathering state and the presence of alteration minerals, but also on the origin of the pegmatites, i.e. whether derived from anatexis or from granitic plutons.

TIMING OF DUCTILE SHEAR ALONG THE WOPMAY FAULT ZONE

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The Wopmay fault zone is a north-south striking, dextral transform fault zone located in the Northwest Territories, Canada, which extends ~300 km from Great Bear Lake in the north, to Great Slave Lake in the south. The Wopmay fault zone separates the western margin of the Slave craton from the eastern margin of the Hottah terrane. Until now, the timing and duration of ductile shear along the Wopmay fault zone has lacked precise age information, which has limited our ability to reconstruct the plate motion of the Hottah terrane. In this study we couple electron backscatter diffraction (EBSD) analysis with in situ apatite U–Pb geochronology to determine the timing of apatite shear recrystallization along the Wopmay fault zone. We found evidence for shear recrystallization (plastic deformation) in the rock forming phases quartz, anorthite, and orthoclase as well as in accessory apatite. Microstructures observed across the width and length of the fault zone (e.g. S-C fabrics, C' planes, mica fish, strain shadows) indicate dextral non-coaxial deformation. Variations in the crystallographic preferred orientations (CPOs) of quartz and feldspar are consistent with a west to east (foreland to hinterland) shift in the dominant recrystallization mechanism, from dislocation-mediated strain to volume diffusion, coinciding with increasing metamorphic temperatures and pressures. Apatite recrystallization in the 7 samples dated occurred between ca. 1890–1820 Ma with a final concentrated stage of ductile shear between ca. 1850–1820 Ma. Evidence for this final stage of shear is preserved in four samples that span ~150 km of the length of the fault zone. Our new data indicate the Wopmay fault zone accommodated dextral shear at the same time as the conjugate dextral Great Slave Lake shear zone, necessitating a 20–70 Myr period during which the Slave craton was rotating counterclockwise relative to the Rae craton.

FIRST-PRINCIPLES CALCULATIONS OF JADARITE AND OTHER LITHIUM SILICATE MINERALS: FTIR, RAMAN, AND Li AND B K-EDGE XANES SPECTRA

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Lithium as a critical ingredient for the transition to a low-carbon economy. It is currently extracted from either spodumene pegmatites or brines, although lithium-bearing claystones in volcano-sedimentary systems have attracted recent attention. Among lithium-bearing claystones, the world-class jadarite ($LiNaSiB_3O_7OH$) deposit in the Miocene Jadar lacustrine basin (western Serbia) raises interesting questions about its formation conditions and potential occurrence in other sedimentary basins. First-principles calculations have been conducted to investigate the FTIR and Raman as well as Li and B K-edge XANES spectra. Our theoretical results allow definitive assignments of all vibrational modes in the measured FTIR and Raman spectra of jadarite. Also, theoretical calculations have reasonably reproduced the measured Li and B K-edge XANES spectra of jadarite. In addition, Li K-edge XANES spectra of other major lithium silicate minerals (eucryptite, hectorite, holmquistite, lepidolite, petalite, and spodumene) have been calculated and are compared with their respective measured spectra.

STRUCTURAL AND GEOCHRONOLOGICAL ANALYSIS OF THE KENO HILL AREA, CENTRAL YUKON

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The geological evolution of western North America is dominated by the Cordilleran orogen. Middle Cretaceous convergence across the Cordillera produced many compression-related structures including the northeast-vergent Selwyn thrust and fold belt (STFB), which trends northwest-southeast across central Yukon. The STFB includes the Robert Service Thrust (RST) and Tombstone Thrust (TT), which borders the Keno Hill silver district. The TT includes a high-strain zone that is several kilometres thick, even extending into the hanging wall of the overlying RST. In the study area, these structures predate ca. 94 Ma intrusions and Late Cretaceous Ag-Pb-Zn mineralization. As much of the previous work in the Keno Hill area has focussed on mineralization therein, questions about the structural evolution of the Keno Hill area and how it fits within the regional framework remain unanswered. In particular, the timing of an isoclinal folding event relative to movement along the RST has been debated. Here we present 1:25,000 scale detailed structural field mapping, combined with petrographic and microstructural analyses, including quartz c-axis crystallographic preferred orientation investigation, crystallographic vorticity analyses, and grain size piezometry on the low-metamorphic grade, clastic sedimentary rocks across the study area. Those data are complemented by in situ $^{87}Rb/^{87}Sr$ and $^{40}Ar/^{39}Ar$ geochronology on cleavage-forming white mica, and Raman spectroscopy-based thermometry on carbonaceous material. Our new data outlines at least two folding events in the area; an older overturned (to-the-north) isoclinal fold, and a younger, subvertical open folding event that strikes southeast-northwest. The overall shear sense is predominantly top-to-the-northwest, with an average peak temperature of ~466°C. In situ $^{87}Rb/^{87}Sr$ geochronology from the hanging wall of the RST yielded an age of ~116 Ma, which we propose dates the movement of the RST; $^{40}Ar/^{39}Ar$ dating is in progress. Integrating the results of this project with regional data will help inform the structural evolution of the STFB.

SLAVE PROVINCE PEGMATITES: OCCURRENCE AND FIELD CHARACTERISTICS

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Hundreds of granitic pegmatites have been documented in the Slave Province in the Northwest Territories, Canada. These pegmatites are of both the lithium-cesium-tantalum and niobium-yttrium-fluorine families and contain important resources of lithium, tantalum, niobium, tin, beryllium, rare earth elements, and other critical and rare metals required for the global transition to green and modern economies. Although the presence of rare metals in these pegmatites has been known since the 1940s, the pegmatites have never attracted commensurate exploration attention until the current 'rush'. Successful exploration and development of the pegmatites require an understanding of their field and geological characteristics. Here, we present an overview of some field characteristics that can be used during prospection and preliminary assessment based on recent reconnaissance visits to some mineralized and barren pegmatites and literature review. The pegmatites occur in both metasedimentary and crystalline granitic units as dykes, commonly in clusters and typically around major granitic intrusions. However, only those in high grade metasedimentary units tend to contain economic lithium mineralization. Both mineralized and barren pegmatites occur together in the same cluster. Lithium occurs in various minerals including spodumene, lepidolite, amblygonite-montebrasite, polylithionite, and lithiophilite-triphylite. However, spodumene is the main target ore mineral. Spodumene occurs as laths, varying from submillimetre to over 2 m long and 50 cm wide. It shows variable and, in places, complex paragenetic relationship with amblygonite-montebrasite and quartz ± mica ± albite assemblages. Other (potential) economic commodities include niobium, tantalum, tin, beryl, and graphite. Tourmaline is a major phase in barren pegmatites, but it is extremely rare

https://doi.org/10.12789/geocanj.2024.51.211

in those containing spodumene. Unlike rare-metals pegmatites in many geological provinces, those in the Slave Province do not show preferential affiliation with greenstone belts, and generally lack gem-quality minerals.

SEDIMENTOLOGY, DEPOSITIONAL ENVIRONMENT AND RESERVOIR PROPERTIES OF THE EARLY SILURIAN INTERLAKE FORMATION, SOUTHERN SASKATCHEWAN

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The Interlake Formation is early Silurian in age and was deposited on the northern shelf of the Williston Basin. The formation is dominated by dolostone lithology and occurs in SW Manitoba, southern Saskatchewan, eastern Alberta, and US states adjacent to the Canadian provinces. The formation contains hydrocarbon-producing reservoirs in North Dakota. In Saskatchewan, localized wells have produced oil for a short time but ceased since 2003. The objective of this research is to decipher the lithofacies properties and their depositional environments within the formation in southern Saskatchewan. Moreover, the study aims to characterize the reservoir properties of the formation and subsurface distribution of potential reservoir intervals. Well-data, including cores and wireline logs, are used to achieve the research objectives. At this stage, core and petrographic data were collected from 30 wells. Preliminary results show that the formation can be divided into two informal lower and upper members. The lower member consists of bioturbated dolostone lithofacies and subordinate reddish argillaceous dolomudstone. The latter are marker beds that are good for correlation. The upper member is characterized by various facies of intraclastic and fossiliferous dolostone and subordinate anhydrite layers and nodules. Millimetre-scale argillaceous dolomudstone seams are also present. The core and petrographic analyses of the formation allow recognition of six lithofacies that include: dark greenish grey microbially-laminated dolomudstone (Lf1), greyish red to brown argillaceous dolomudstone (Lf2), grey intraclastic, bioclastic dolowackestone to packstone (Lf3), light grey, bioturbated peloidal and bioclastic dolomudstone to wackestone (Lf4), grey bioturbated, intraclastic bioclastic dolopackstone-grainstone (Lf5) and anhydrite (Lf6). Lithofacies properties, sedimentary structures and textures, and fossil content along with lithofacies associations indicate that the formation was deposited in shallow marine subtidal to supratidal settings. The various lithofacies are arranged in a metre-scale cyclicity of shallowing-upward successions envisaged to be driven by Milankovitch cycles and sea level fluctuations.

GEOLOGY AND 3-D MODELLING OF THE SANTOY GAP HANGING WALL DEPOSIT, SEABEE AREA; GOLD MINERALIZATION IN A UNIQUE LITHOSTRUCTURAL SETTING WITHIN THE TABBERNOR FAULT SYSTEM, NE GLENNIE DOMAIN, TRANS-HUDSON OROGEN

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The Gap Hanging Wall is one of several highly endowed gold deposits along the Santoy shear zone, a splay of the Tabbernor fault. The deposit is unique in being hosted by an apophysis (or 'sill') of a tonalitic pluton, rather than by mafic volcanic rocks. Mapping shows that the apophysis is folded about N-plunging axes, reflecting D_3 shortening along the western limb of the Carruthers Lake synform. Gold is associated with two main stages of quartz veins, an earlier generation expressed as a healed microfracture network, with locally pervasive silicification, interpreted to have been emplaced during early stages of D_3 shortening; and a second generation of thicker, tapered veins that are axial planar to deposit-scale (F_3) folds, introduced due to fluid overpressuring during continued shortening. Alternatively, the secondary veins may have originated as extension fractures along outer arc folds that were later rotated and flattened. Both stages of veins are restricted to the plutonic host rock and associated with a distinctive, locally sulphide-bearing cream- to pistachio-green alteration known for its significant gold grades. The 3-D modelling included an initial cubic model built in Leapfrog Geo™ using lithologs to identify hanging wall and footwall contacts of the apophysis, together with a detailed model that demonstrates the down-plunge continuity of the fold structure, open at depth. By adding Au assay results, a numerical model was created which shows that gold anomalies are concentrated within a synformal trough of one of the deposit-scale (F_3) folds. Accordingly, it is proposed that gold-bearing fluids migrated from depth into fold hinge zones, where dilational space was created by microfracturing in the early stages of shortening/incipient folding. The more competent plutonic host thus exerted a strong rheological control on the folding process, creating a unique structural site that was exploited by deep-crustal fluids migrating along the Tabbernor fault.

XMAPTOOLS: A (CANADIAN) METAMORPHIC PETROLOGIST'S BEST FRIEND

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Elemental or isotopic sample mapping is one of the most common methods of analysis for the modern metamorphic petrologist. With the increase in spatial resolution, access to a variety of mapping instruments and the emergence of petrochronology studies, sample mapping is becoming increasingly important to a wide range of geological applications. Over the past ten years, the software solution XMapTools has become one of the most widely used programs by metamorphic petrologists to analyze mapping data. The free, open-source, multi-platform program performs a variety of tasks such as map visualization, calculation of modal abundances with the aid of machine learning algorithms, extraction of local bulk compositions, element plotting and semi-quantitative to quantitative data conversion. XMapTools offers over 70 thermometry functions including a variety of garnet-mineral thermometers and single-phase thermometers, as well as functions for mineral structural formula calculation and monazite age dating. This presentation will highlight several XMapTools and use cases to demonstrate its effectiveness in metamorphic petrology research.

EFFECTS OF SYN- AND POST-MINERAL DEFORMATION ON ORE DISTRIBUTION AT THE WHALE TAIL GOLD DEPOSIT - AMARUQ PROPERTY, NUNAVUT, CHURCHILL PROVINCE

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Syn- and post-mineral deformation plays a major role in the formation and modification of gold orebodies in Archean greenstone belts, with implications for exploration and mining. The Whale Tail deposit of the Amaruq property (2.1 M oz. Au reserves) is a stratabound orogenic gold orebody that was deformed and metamorphosed during the Archean and the Paleoproterozoic in the Rae craton. It contains replacement- and vein-style mineralization in silicate facies BIF, chert and iron-rich volcaniclastic rocks bounded by variably mineralized shear zones and mafic-ultramafic volcanic rocks to the north and south. Detailed underground mapping in shallow east-plunging oreshoots of the Whale Tail zone was undertaken to examine the effects of deformation on ore distribution. The mineralized stratigraphic package is subvertical and was affected by deformation at amphibolite to greenschist facies (D_2), and at greenschist facies (D_3). Tight to isoclinal F_2 folds shallowly plunging eastward are associated with a steep S_2 foliation dipping north or south and containing a downdip mineral lineation. A shallowly dipping S_3 crenulation cleavage is axial-planar to F_3 open folds that are colinear with those of F_2 folds and show thickening of the mineralized volcano-sedimentary package in hinges. The veins in mafic-ultramafic rocks along shear zones bounding the volcano-sedimentary package are transposed and folded syn-D_2 shear and extensional veins. The competent chert and BIF unit shows syn-D_2 layer-parallel extension and boudinage, and shear and extension vein arrays, whereas the iron-rich volcaniclastic rocks contain sulphide-rich replacement zones. The intersection of shear and extension veins ($\sigma 2$) in both the volcano-sedimentary package and adjacent volcanic rocks is shallowly east-plunging and mostly colinear with F_2 and F_3 fold axes, and with the shallow-plunging oreshoots. These observations suggest that superimposed syn- (D_2) and post-mineral (D_3) deformation with colinear folds and main intermediate stress ($\sigma 2$) were instrumental in forming the oreshoots in rocks of favourable composition.

REFLECTANCE SPECTROSCOPY OF LUNAR METEORITES

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The Moon has rocks that are older than those on Earth, providing a window into early Solar System evolution. Major minerals identified on the lunar surface include olivine, feldspar, ilmenite, and pyroxenes. While returned lunar samples can give us some insights into the geological history of the Moon, lunar meteorites provide additional opportunities to understand lunar geology, even though their source regions are unknown or poorly constrained. Lunar meteorites can also give us insights into space weathering, impact shock and melting processes, and possibly the presence of volatiles. Within the last several decades a large amount of research was conducted on reflectance spectroscopic analysis of lunar samples. We have undertaken a spectral reflectance (350–2500 nm) study of a suite of 12 lunar meteorites of diverse compositions in order to expand our understanding of lunar geology derivable from reflectance spectroscopy. We used a reflectance spectrometer to determine the mineralogy and chemistry of lunar meteorites based on absorption bands and their band positions. Our samples include feldspathic breccias, fragmented breccias, and impact melts. For each sample we identified ten regions of interest for which we acquired reflectance spectra. After collecting whole rock spectra, we dry sieved a fraction to produce a < 1 mm powder for additional spectral measurements. The spectral diversity and identification of specific phases in the samples will be reported at this meeting, but we were able to identify the presence and types of major mafic minerals and impact-affected lithologies. The data collected from this study can help in the determination of lunar geological diversity and support present and future missions with similar spectrometers deployed to the Moon. The use of in situ reflectance spectrometers on the Moon can aid in mineral explorations and for in situ resource utilization (ISRU) exploration.

DISTRIBUTION, INTENSITY, AND TIMING OF PALAGONITIZATION IN GLACIOVOLCANIC DEPOSITS, CRACKED MOUNTAIN VOLCANO, CANADA

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The Cracked Mountain volcanic edifice is a basaltic subglacial volcano (i.e. tuya) situated in southwest British Columbia, Canada. The edifice is dominated by subaqueously deposited, massive to poorly stratified, variably palagonitized lapilli tuff intruded by syn-eruptive dykes and lobes of peperitic pillow lavas (15–20 vol.%). Minor stacks of pillow lava are found on the margins of the edifice. Here, we present mineralogical, textural, and physical property data for 134 sample cores from the palagonitized volcaniclastic deposits. Our sample suite includes three specific field environments defined by proximity to intrusive heat sources: (i) proximal (< 1 m) deposits (ENV1), (ii) deposits within 1–5 m of intrusions (ENV2), and (iii) deposits far removed (> 5 m) from discernible heat sources (ENV3). Increased palagonitization is marked by increases in authigenic mineral abundance (smectite and analcime), density, strength, and P-wave velocity and concomitant decreases in porosity and permeability. Palagonitization is most intense in ENV1, where dykes raised temperatures for a prolonged duration (< 1 year) and weakest in ENV3 deposits reheated to lower temperatures (< 150°C). Paleomagnetic data show a common pole direction recorded by all deposits (i.e. lavas, dykes, lapilli tuffs) indicating: (i) explosive to effusive phases of eruption occurred within a single paleomagnetic moment (< 2000 years), (ii) palagonitization of volcaniclastic deposits was coincident with resetting of magnetism, and (iii) the timescale of palagonitization was short and coincident with heating and cooling of volcaniclastic deposits by syn-eruptive intrusions. The mapped intensity of palagonitization and thermal modelling are used to define a 'palagonite window' as a function of time and distance from heat sources (i.e. dykes).

CARBONATE SATURATION IN FELSIC MAGMATIC SYSTEMS: IMPLICATIONS FOR LOW-T FELSIC MAGMATIC EVOLUTION

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Most pegmatites are relatively evolved felsic magmatic systems, so they generally have quite low concentrations of Ca and other compatible components that are removed by fractionation. However, carbonates and fluorite are recognized petrographically more often in felsic magmatic systems, as is apatite. This has significant implications for how we examine felsic magmatic compositions in the absence of full compositional analyses including CO_2, F, and P_2O_5. The stabilization of fluorite is due to increasing activity of F, saturation of calcite is a function of increasing $P(CO_2)$, and apatite saturation is linked to P_2O_5 activity. Magmatic fluorite in felsic systems and magmatic calcite are rarely recognized. Magmatic anhydrite is recognized in many oxidized magmatic systems. The very low relative solubility of CO_2 versus H_2O is very well known in silicate systems, so calcite is not expected to be present in silica-saturated magmas, especially since the wollastonite-forming reactions would limit its stability significantly. Calcite, fluorite, apatite, and anhydrite are obviously well-known minerals in hydrous carbonatitic systems, crystallizing at P-T conditions similar to those of evolved silicate systems. One end-member hypothesis is that carbonatitic melts are exsolved from silica-undersaturated magmas, followed by immiscibility that evolves with decreasing T or decreasing P. Lower temperature fractionating silica-saturated felsic magmatic systems can evolve similarly to peralkalic systems. This is important to appreciate in attempting to unravel the evolution of these low-T magmatic systems, as liquation or crystallization of carbonate, fluorite, and (or) anhydrite can significantly change the behaviour of many elements in such systems. Like apatite, calcite and fluorite host significant Sr, REE+Y, and other elements that favour those minerals or favour ionic liquids (carbonatitic). The intrinsic calcium concentrations of evolved felsic magmas may be low, but reactions between magma and carbonate-bearing host rocks, assimilation, skarnification, or hybridization can increase both Ca and $P(CO_2)$ through decarbonation reactions.

NITROGEN ISOTOPES: A POTENTIAL TOOL FOR TRACING THE SOURCE AND PETROGENESIS OF GRANITOID ROCKS

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Nitrogen is one of the few elements distributed throughout all Earth's reservoirs, i.e. as a major element in the atmosphere and the biosphere, and a trace element in the lithosphere. The geochemical behaviour of nitrogen in the lithosphere is two-fold, depending on its speciation. Nitrogen can be highly volatile when it is in the form of N_2 or NH_3 but can also be compatible (to some silicate minerals) and fluid-mobile when it is in the form of NH^{4+} (which is close to Rb^+ in ionic radius and thus in geochemical property). Attributed to the single substitution of NH^{4+} for K^+ or Na^+ or coupled substitution of $NH^{4+} + Al^{3+}$ for $Mg^{2+} + Ca^{2+}$ in a mineral lattice, nitrogen can be fixed in a variety of major and accessory minerals in granitoid rocks, such as plagioclase, K-feldspar, muscovite, biotite, amphibole, clinopyroxene, and garnet. Compared with fluid inclusion N_2, which is highly susceptible to late-stage alteration, structurally bound NH^{4+} can better preserve the magmatic signature. Meanwhile, it is well known that nitrogen isotopes show distinct contrast between the mantle and crust, and that nitrogen isotope fractionation can occur at high-temperature processes. Thus, nitrogen isotopes could serve as a novel geochemical tool to trace the material source and petrogenesis of granitoid rocks, but the application is still limited so far due to analytical difficulty and poor knowledge of nitrogen isotope behaviour in igneous processes. In this presentation, we will introduce the recent advances in precise nitrogen isotope analysis of low NH^{4+} bearing silicate minerals and rocks, constraints on N isotope fractionating processes in magmatic systems and their application to understanding granitoid petrogenesis.

https://doi.org/10.12789/geocanj.2024.51.211

GARNET AS INDICATOR OF MAGMA EVOLUTION AND RARE-METAL MINERALIZATION: A CASE STUDY OF THE GRANITE-PEGMATITE SYSTEM FROM THE MUFUSHAN COMPLEX IN SOUTHEASTERN CHINA

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Pegmatite is an important source of rare-metal resources, and its genesis is commonly associated with granite. The Mufushan granitic complex in southeastern China, closely related to the genesis of rare metal pegmatites, is formed by multistage magmatic activities. As the degree of magma evolution continues to increase, seven lithologic units have formed successively: biotite granite, two-mica granite, muscovite granite, microcline granite, microcline-albite pegmatite, albite pegmatite, and spodumene-albite pegmatite. Garnet collected from the above seven lithologies belongs to the solid solution series of almandine-spessartine, and all garnets are of magmatic origin. The low CaO contents (0.07–0.59 wt.%), high MnO contents (13.29–31.84 wt.%) and the linear evolution of MnO, REE, Y, Sc contents and $(Gd/Yb)_N$ versus Y/Yb ratios of garnets indicate that the granites and pegmatites in the Mufushan complex are the products of continuous evolution of homologous peraluminous magma. With the increase of the degree of magmatic evolution, the pegmatite gradually changes from barren to Be, Nb-Ta, and Li mineralization, successively. MnO content of garnet can be used as an indicator of rare-metal mineralization types. It is worth noting that there is an abrupt drop of HREE content in garnets in the spodumene-albite pegmatite stage implying a chemical switch from peraluminous composition to a Na-rich aqueous silica-bearing fluid. The H_2O concentration in garnets also show an abrupt increase. Therefore, a significant increase of H_2O content of magma can be identified at the spodumene-albite pegmatite stage, which may be an important condition for the formation of Li-pegmatite.

RECONSTRUCTING FOOD CHAIN/WEB IN THE CRETACEOUS INTERIOR SEAWAY FROM BIOTIC INTERACTIONS IN A MANITOBA COMMUNITY

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The Upper Cretaceous Millwood Member (Campanian) is well exposed in the Russell area of SW Manitoba. Bulk sampling along a fossiliferous horizon near the middle part of the member revealed a diverse time-averaged community dominated by molluscs. More than 900 macrofossil specimens are assigned to Scaphopoda (Dentalium), Gastropoda, Pelecypoda, Cephalopoda, and Decapoda (a crab). Previous study recovered Foraminifera from a similar horizon at a nearby site, it is feasible to include these microorganisms in the community. Trace fossils help uncover some other components. Abundant bioerosion traces are believed to be made by spinoid polychaetes. Well-preserved and commonly presented predatory drilling traces are interpreted to be made by Euspira, the only naticid gastropod in the community. Crushing/peeling predation traces and repaired scars are interpreted to be caused by crab Cretacocarcinus. On the basis of these biotic interactions within the benthic community and the feeding habit of living Dentalium, reconstruction of the local food chain/web was attempted. A diverse Campanian vertebrate fauna has been reported in the Cretaceous interior seaway (CIS), including fish, mosasaurs, plesiosaurs, sharks, etc. Based on previous studies on the food remains in the body chambers of ammonites, durophagous predation on scaphitids, tooth marks on an ammonite, gut contents of mosasaur and plesiosaur specimens, the food chain above Cretacocarcinus in the CIS is proposed as: Cretacocarcinus -Hoploscaphites/ Baculites-fish (e.g. Enchodus)-plesiosaur (e.g. Polycotylus)/ mosasaur (e.g. Tylosaurus)/shark. The extended 8-level food chain and complex food web may represent a mature marine ecosystem of the CIS during Campanian. The long food chain limited the energy reaching to the top levels, which may have an innate instability. The ecosystem would become vulnerable when the environment changes, foreshadowing the mass extinction at the end of the Cretaceous.

PROVENANCE SOURCE ANALYSIS OF LOWER CRETACEOUS SEDIMENTARY ROCKS IN THE NORTHERN SICHUAN BASIN AND CONSTRAINTS FOR URANIUM METALLOGENESIS

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The Sichuan Basin, as a prominent exploration region for sandstone-type uranium deposits in continental sedimentary basins of South China, has been successively uncovered in the northern part of Sichuan with numerous uranium deposits and uranium sites (belts) of industrial value and great metallogenic potential. Previous studies have been conducted on the provenance source in the northern part of the basin, but the influence of the provenance source characteristics of ore-bearing sandstone on uranium metallogenesis in the study area has not been systematically researched. To find the relationship between them and further deepen the theory and regularity of uranium metallogenesis, this paper examines Lower Cretaceous sandstone-type uranium deposits in the northern Sichuan Basin, traces the provenance source, and discusses the characteristics of uranium metallogenesis using mineralogy, petrology, sedimentology and detrital zircon U–Pb geochronology.

GEOPHYSICAL EXPLORATION IN LI PEGMATITE FROM NORTHERN PORTUGAL

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Lithium-rich pegmatites are more than 50% of Li sources in the world market. They became crucial for the energy transition. Different tools are being developed to apply to pegmatites to increase the resources in these deposits. Geophysical methods were not so commonly applied in the past. Depending on the host rock compared with pegmatite intrusion, radiometry and resistivity were tried on Li pegmatites in northern Portugal. The Alijó mining concession was chosen as a test site to realize these methodologies, due to the high amount of geological information compiled during many years of research. Firstly, a terrestrial radiometric survey was completed to check which radiometric element responds best to pegmatites. Measurements were taken along dirt roads in the mining concession with an average spacing of 5 metres. The results show that thorium is the element that best responds to lithological differences. In pegmatites, thorium has a lower content than that found in the host rock. Later, resistivity profiles were measured in the anomalous thorium zones. This survey aimed to verify the continuity of these pegmatitic bodies in depth. The non-altered pegmatitic bodies have resistivities between 5000 ohm/m and 11,000 ohm/m, while kaolinized pegmatitic bodies have a resistivity lower than 5000 ohm/m. In both cases, the pegmatites were shown to have deeper extensions. Lastly, a regional aeroradiometric survey was carried out in northern Portugal. This campaign made it possible to demonstrate the use of radiometry on a regional scale, allowing the identification of potential areas with pegmatite bodies. Zooming in on the Alijó mining concession, we can see anomalous zones in thorium (lower content), indicating the presence of pegmatites. These zones were previously confirmed using the methods described earlier. These methodologies, in combination with good geological mapping, can be applied to explore new pegmatitic areas or to increase the knowledge of known deposits.

MINERALOGY APPLIED TO EXPLORATION AND MINERAL DEPOSIT GENESIS

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Rocks by definition are ‘an aggregate of one or more mineral’. Thus, understanding mineralogy is key to interpreting geochemical trends in exploration and for con-

straining mineral deposit hypotheses. An example of an application of mineralogy to mineral exploration is the use of field portable SEM-EDS, to identify specific minerals or changes in mineral compositions. This has been used to identify sulphate minerals in orogenic gold deposits and Mg/Fe variations of silicate minerals in platinum-group element (PGE) deposits. A more direct tool for identifying minerals in the field is Raman spectroscopy, which is particularly useful for lithium pegmatites. Field-based mineralogy studies have also long been used as a means for evaluating whether chemical variations are the result of specific process(es). For example, the trace element compositions of muscovite are interpreted to record crystallization in boundary layers within melts. In terms of constraining mineral deposit hypotheses, mineral solubility studies are particularly relevant for pegmatite-hosted deposits. Melt composition and temperature are important controls of accessory phase (ore mineral) solubilities. Oxygen fugacity has been shown to be a fundamental control of magmatic cassiterite. Minerals of Ta and Nb are most commonly double oxides and consequently their solubilities can be expressed as solubility products. A major control on the mineral species of the double oxides are the bivalent cations (Ca, Fe, Mn). This in turn suggests that crystallization in some cases may be the result of mixing of aqueous fluid-mobile components with silicate melt components. The origin of spodumene-bearing and petalite-bearing pegmatites also must be interpreted in terms of the solubilities of these minerals in silicate melts. Purely anatectic models are not likely to be feasible and at least some fractional crystallization is required for melts to attain spodumene-petalite saturation.

EARTHQUAKE SOURCE PROPERTIES AND STRESS INVERSION IN EASTERN CANADA SEISMIC ZONES

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The St-Lawrence paleorift system hosts three active seismic zones in eastern Canada, including the Western Quebec, Charlevoix, and Lower St-Lawrence Seismic zones from south to north. Here we summarize our recent source mechanism studies of earthquakes in this region. We apply a neural network-based phase picking and event association workflow to enhance the seismicity catalog in the Western Quebec Seismic Zone (WQSZ) during periods of denser station coverages (2013–2015, 2020–2023). The application of EQTransfomer results in approximately a five-fold increase in detected earthquakes from the Natural Resources Canada catalog. Relocated seismicity from the enhanced catalog highlights several local clusters that suggest the presence of previously unmapped active fault structures near the Greater Montreal Area (GMA). Preliminary analysis of data from a one-month (November–December 2023) deployment of 48 nodal sensors in the GMA also suggests significantly more abundant microseismicity in this area. Further downstream in the Charlevoix Seismic Zone (CSZ), relocated seismicity is diffusely distributed around the paleorift faults and earthquakes on average have higher static stress drop values within the meteorite impact structure, indicative of distributed fracture networks and compositional alteration. Stress inversion using a recently compiled CSZ focal mechanism solution database reveals a systematic clockwise rotation of the maximum horizontal stress with depth, which may reflect the transition from a shallow crustal stress regime to glacial isostatic adjustment influence at depth. Our approach underscores the need for improved earthquake detection and source parameter inversion toward a better understanding of intraplate earthquakes and their contributions to seismic hazards near population centers in eastern Canada.

ALKALI (HYDROGEN) CARBONATE FLUIDS: POWERFUL FLUXES TO DRIVE CRYSTALLIZATION OF Li ALUMINOSILICATES

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Fluid inclusion and experimental evidence indicate that alkali (hydrogen) carbonate fluids are involved in the evolution of peraluminous granitic pegmatites. The relationship between such alkaline fluids and Li-aluminosilicate formation in granitic pegmatites is still not well understood. Here, using a hydrothermal diamond-anvil cell and Raman spectroscopy, we studied the influence of alkali (hydrogen) carbonates on the formation of major Li aluminosilicate minerals, to constrain the conditions at which they are generated in granitic pegmatites. Our results show that spodumene and petalite can crystallize in (hydrogen) carbonate- and Al-Si-rich fluids at temperatures as low as 550°C. By contrast, there were nucleation barriers for Li aluminosilicates in the Al-Si-rich but (hydrogen) carbonate-absent system at 550–700°C and even at Li-supersaturation conditions. We conclude that (hydrogen) carbonate-rich alkaline melts and/or fluids are favourable for Li-aluminosilicate formation. Alkali (hydrogen) carbonates act as powerful fluxes in a double sense: (1) lowering the crystallization temperature and (2) facilitating the nucleation of Li aluminosilicates. In addition, eucryptite and Li-silicates appeared to predominate over spodumene and petalite if peraluminous phases (e.g. muscovite) were absent. This points to the requirement of bulk peraluminous compositions of pegmatite-forming liquids for the substantial precipitation of spodumene and petalite. The occurrence of eucryptite in pegmatites may be an indicator of alkaline conditions. The presence of alkali (hydrogen) carbonates in pegmatite-forming liquids may help explain the generation of primary Li mineralization and late-stage metasomatic growth of Li aluminosilicates.

ADVANCING PEGMATITE GEOCHRONOLOGY: LA-ICP-MS/MS Rb/Sr GEOCHRONOLOGY OF HYPER-RADIOGENIC MICAS

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In situ Rb/Sr dating by laser ablation techniques has rapidly advanced in the past few years, notably for shales and crystalline micas; however, there have been few systematic studies on the ablation behaviours and their impact on resulting LA-ICP-MS/MS data for micas. Here we present results of a systematic investigation into the role of downhole fractionation, crystal orientation, and laser fluence to Rb/Sr dates of a variety of di- and trioctahedral (true) mica compositions. Using orthogonal polynomial decomposition, we quantitatively demonstrate that the NIST and BCR standard reference materials (glasses) are a more appropriate match for downhole fractionation patterns observed for crystalline micas than the commonly used MicaMg nanopowder. Moreover, the apparent Rb/Sr ratios are more precise when normalized against glass reference materials. However, accurate age calculation using either MicaMg or glasses as the primary reference material also requires subsequent matrix-matched standardization to correct for matrix-induced offsets. Additionally, the mica crystal orientation has a significant impact on the determined Rb/Sr date, with offsets of up to 15% in the worst case. SEM imagery reveals distinct physical differences during ablation, dependant on orientation. Finally, we provide preliminary age determinations of Rb-enriched (1–4 wt.%) Li-micas (lepidolite and zinnwaldite series) from lithium-cesium-tantalum pegmatites around the world, spanning from Archean to Cretaceous. Although the technique and its application to hyper-radiogenic micas is challenging, we provide a significant advancement in our ability to repeatedly generate reliable and accurate data.

INCEPTION AND PASSIVE MARGIN REACTIVATION OF AULACOGENS ON THE NEOPROTEROZOIC TO ORDOVICIAN LAURENTIAN IAPETAN MARGIN

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Aulacogens of the Laurentian Iapetan margin contain a stratal, structural, and magmatic record of their syn-rift evolution and passive margin reactivation through an entire Wilson Cycle. To understand the plate tectonic context of aulacogen evolution, the histories of the Ottawa and Saguenay grabens are reviewed along with the plate tectonic evolution of the northeastern Laurentian margin. These aulacogens formed as branches of the St. Lawrence Rift System during 620–570 Ma rifting and breakup between Laurentia and Baltica. This regional synthesis concludes that the St. Lawrence Rift System emanated from a triple junction above a rising asthenospheric pierce point, based on the prolonged mantle-derived magmatism, its branching architecture, and magmatic and structural similarities to the East African Rift.

https://doi.org/10.12789/geocanj.2024.51.211

During the subsequent opening of the Taconic Seaway, 554 Ma flood basalt flows and deltaic progradation at the mouth of the Ottawa Graben record renewed mantle upwelling and rifting, likely related to edge-driven convection beneath the hyperextended margin. Following breakup, passive margin reactivation of aulacogens illustrates a significant influence of inherited structures on strain partitioning. During the 510–500 Ma "Hawke Bay event" while rifting and breakup occurred in the southeastern Laurentian margin, the Missisquoi transverse fault zone was reactivated along with the collinear Ottawa Graben, taking up margin-normal extensional stress through strike-slip deformation. Furongian (497–495 Ma) reactivation may have been related to distant fore-arc spreading in the Iapetus Ocean, coeval cratonic uplift of Laurentia, or yet unknown plate tectonic events. Tremadocian (485–482 Ma) reactivation is linked to the onset of segmented fore-arc spreading in the Taconic Seaway, which made use of existing fracture zones that reactivated the collinear Ottawa and Saguenay grabens. Late Tremadocian to Floian reactivation of the Ottawa Graben (477–475 Ma) is linked to flexural strain from the onset of loading on the most distal parts of the Laurentian margin.

PREPARING THE NEXT GENERATION OF GEOSCIENCE EDUCATION RESEARCHERS: EFFORTS AT THE UNIVERSITY OF BRITISH COLUMBIA

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Early geoscience education researchers were characterized by the National Research Council (NRC) in 2012 as 'border crossers' who were formally trained in geoscience and became interested in and engaged with inquiry activities centered on aspects of teaching and learning geoscience. As the community of practice of geoscience education research evolved, so too did the training opportunities. Degree-based programs of study for geoscience education research emerged in geoscience departments for the formal preparation of future geoscience education researchers. Currently, there are at least 15 such programs in North America. A recent published survey indicates the number of individuals in (or have graduated from) graduate degree programs centered on geoscience education research has increased over the last decade. In 2021, the Earth, Ocean and Atmospheric Science Department at the University of British Columbia hired an Assistant Professor of Research who specializes in geoscience education research. This talk will provide an overview of the efforts of the author to prepare the next generation of geoscience education researchers. Degree program design, mentoring strategies, challenges, and future directions will be discussed.

TOURMALINE FROM THE LEDUC PEGMATITE, NEAR VAL-DES-MONTS, QUÉBEC, CANADA

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The Leduc pegmatite is one of few Li-bearing pegmatites in the Grenville Province. Since 1884, it has been intermittently mined, initially for large mica sheets and subsequently for high-quality tourmaline. Following a decades-long hiatus, recent artisanal mining efforts have produced a variety of exceptional tourmaline specimens. Hosted within Archean paragneiss, the pegmatite is well-zoned, consisting of a quartz core, an intermediate zone (fluor-elbaite, microcline - var. amazonite, lepidolite-zinnwaldite, and quartz), and a heterogeneous wall zone (schorl, peristerite, and graphically intergrown quartz and feldspar). The pegmatite contains tourmalines of diverse form, size, colour, and chemical composition, with three general types being consistently observed; type 1 consists of colour-zoned aggregates of parallel fluor-elbaite crystals; type 2 are massive, single crystals of olive-to-lime green fluor-elbaite; and type 3 are optically homogeneous black crystals. Type 1 tourmaline crystals show pronounced sequences of colour-zoning (light green to pink to green/blue to dark green) along the c-axis, whereas type 2 tourmaline crystals show only subtle sector-zoning. Both types 1 and 2 tourmaline crystals range in size from centimetre to decimetre scale, occur mostly in the intermediate zone in close proximity, and occasionally yield fracture-free gem-quality material. Both types are also frequently mantled by a thin (~5 mm) layer of schorl, associated with resorption textures. Type 3 tourmaline crystal occur mostly in the wall zone and are typically < 5 cm in maximal dimension. Tourmaline colours vary subtly as a function of Fe:Mn ratio, with average compositions of blueish-green and pinkish-red materials being $[X(Na_{0.6}Ca_{0.2}Vac_{0.2})\ Y(Li_{1.0}Al_{1.5}Mn_{0.1}Fe_{0.4})\ ZAl_6\ (BO_3)_3\ (Si_6O_{18})\ V(OH)\ W((OH)_{0.3}F_{0.7})]$, and $[X(Na_{0.5}Ca_{0.2}Vac_{0.3})\ Y(Li_{1.0}Al_{1.7}Mn_{0.2}Fe_{0.1})\ ZAl_6\ (BO_3)_3\ (Si_6O_{18})\ V(OH)\ W((OH)_{0.2}F_{0.8})]$, respectively. Throughout the Leduc pegmatite, tourmaline varies predominantly along the schorl ↔ fluor-elbaite exchange mechanism, $YAl^{3+} + YLi^{+} + WF^{-} \leftrightarrow Y_2Fe^{2+} + W(OH)^{-}$. Along with field mapping, this study uses detailed compositional analyses (major and trace elements) of tourmalines to better constrain the emplacement history of the Leduc pegmatite.

PARAGENESIS AND EVOLUTION OF Ba-SILICATE MINERALIZATION IN DEVONIAN STRATA AT THE GUN OCCURRENCE, YUKON, CANADA

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The Gun occurrence in central Yukon contains Ba-silicate minerals that are unique to this locality or only found in a handful of occurrences worldwide. The Ba–Si mineralization resulted from contact metamorphism triggered by intrusion of the Gun pluton into barite-rich siliceous mudstone. The paragenesis is grouped into four main stages, with textural evidence for overlapping periods of formation. Stage (1) is predominantly anhydrous; host rock mineralization is characterized by diopside, celsian, meierite, walstromite, and pellyite formation. Trace uvarovite and alforsite formed from local Cr, P, and Cl in the sediment, while trace fresnoite, bazirite, and pabstite crystallized from Ba–Si-rich host rock interacting with Ti, Zr, and Sn from the pluton. The formation of anhydrous minerals hedenbergite, sanbornite, and gillespite overlaps with stage (1) and extends into stage (2). Stage (2) is marked by the onset of the incorporation of CO_3, B, and Cl into the crystal structures of Ba–Si minerals. Kampfite, itsiite, a potentially new Ba–Ca–CO_3–Cl silicate, and taramellite/titantaramellite formed during this stage. Stage (3) is characterized by sulphide saturation, at which point localized precipitation of pyrrhotite, sphalerite, and chalcopyrite occurred. Hydration and additional carbonation of the system characterizes stage (4). Actinolite, cymrite, edingtonite, witherite, cerchiaraite-(Fe), and cerchiaraite-(Al) replace earlier minerals in the assemblage. "Muirite-Fe" and ronpetersonite mineralization also formed at this stage. Rare veins of barite are observed crosscutting all other features. The mineralogy and chemistry at the Gun occurrence imply that early mineralization occurred in a reduced environment with P-T conditions and partial pressures of H_2O and CO_2 at levels where barite was readily destabilized. The system was open enough to prevent released sulphur from saturating the fluid phase, allowing for all early barite to be replaced. Reduced conditions are maintained up to sulphide mineralization, after which cerchiaraite, which contains ferric iron, began to form.

THE KIPALU FORMATION OF THE BELCHER GROUP, NUNAVUT, AS A POSSIBLE SOURCE OF JASPER CLASTS IN MANITOBA TILL

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Jasper and granular iron formation clasts occur in till located in Manitoba and northern Ontario and are thought to have originated from the Kipalu Formation of the Belcher Islands, Nunavut by Pleistocene glacial transport. For this reason, these jasper and granular iron clasts have been called "kipalus". The source of these clasts is thought to be the Kipalu Formation because: i) they are typical of the distinctive jasper layers that host iron-rich granules, ii) the source from the Belcher Islands is permissible from Pleistocene ice-flow trends originating from the Quebec Dome, and iii) the jasper clasts are found in tills alongside omars, which are thought to be from the Omarolluk Formation of the Belcher Group. While their origin is assumed to be from the Belcher Islands, in part due to their co-occurrence, this has not been rigorously tested with petrographic or other methods. We use petrographic and semi-quantitative mineralogical data for both kipalu clasts and the Kipalu Formation

of the Belcher Group to show that the majority of our kipalu samples were likely sourced from the Kipalu Formation. This interpretation, however, is predicated on the internal variability of Kipalu Formation mineralogy observed among our samples. We document the range in characteristics that each studied clast can have in hand sample, thin section, and their semi-quantitative mineralogy. Our analysis shows that there is a wider range of clasts being called "kipalus" than can be solely derived from the Kipalu Formation. Thus, further work is required to determine the full range of source possibilities for "kipalus" in Manitoba till.

THE HYDRA LITHIUM-CESIUM-TANTALUM PEGMATITE IN SOUTHWESTERN NEWFOUNDLAND

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Critical metals such as Li, Cs, Rb, and Ta can be sourced from lithium–cesium–tantalum (LCT) pegmatite bodies. The geology of southwestern Newfoundland has potential to host LCT pegmatite due to its favourable geology and presence of voluminous, peraluminous granitic plutons. The Killick LCT pegmatite field was discovered in 2021 and very little work has been done since the discovery. These LCT pegmatite bodies are located near the undeformed Peter Snout and sheared Rose Blanche plutons. The granitic plutons and LCT pegmatite bodies are hosted in the Dolman Cove Formation, which is metamorphosed to upper greenschist- to amphibolite-facies metavolcanic and metasedimentary rocks. The pegmatite dykes are located next to a major shear zone, the Bay d'Est fault zone. This research focuses on the Hydra dyke. It is unique to the rest of the Killick pegmatite bodies because it is rich in pollucite ($Cs(Si_2Al)O_6.nH_2O$), as opposed to the predominantly spodumene ($LiAlSi_2O_6$)-bearing dykes that comprise Kraken pegmatite. Hydra is the first high-grade Cs discovery in Atlantic Canada. Preliminary work shows that the dyke is 5–6 m wide and can be traced ~100 m at surface. The dyke trends NE–SW, is steeply dipping, and shows zonation in the exposed area. The modal percentage of minerals in these zones varies, but so far, we have optically identified quartz, albite, microcline, pollucite, spodumene, white micas, tourmaline, columbite-tantalite, zircon, garnet, and apatite. Preliminary chemical data from grab and channel samples shows elevated concentrations of Cs_2O, Li_2O, Ta_2O_5, and Rb_2O. The goal of this study is to determine the age, mineralogy, and petrogenesis of the Hydra dyke to better understand its relationship to regional tectonics and the nearby Rose Blanche and Peter Snout peraluminous granitic plutons.

MINERALOGICAL CHARACTERISTICS OF THE PAK, SPARK AND PENNOCK PEGMATITES AT FRONTIER LITHIUM'S PAK LITHIUM PROJECT

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Our understanding of lithium–cesium–tantalum (LCT) pegmatite bodies has steadily increased over the last few years with the renewed interest in their economic potential. In 2022, the Ontario Geological Survey's Resident Geologist Program conducted several property visits at projects exploring for LCT pegmatite. Most notable was the visit completed by the Red Lake District office to Frontier Lithium's PAK Lithium Project, which consists of four identified pegmatite bodies: PAK, Spark, Bolt, and Pennock. The PAK Lithium Project is located 175 km north of the Municipality of Red Lake along the Bear Head fault that defines the boundary between the Berens River and Sachigo subprovinces. To date, Frontier Lithium Inc. has focused most of the geological studies on the PAK pegmatite. With the more recent discovery of Spark, and renewed interest in Pennock, Frontier has increased the geological work completed at both pegmatite occurrences. The PAK pegmatite is hosted in the two-mica Pakeagama Lake pluton and metasedimentary rocks that occur in the northern extension of the North Spirit Lake greenstone belt. The PAK pegmatite consists principally of spodumene + quartz (squi) that replaced the primary petalite and potassium feldspar, albite and muscovite. The accessory phases include fluorapatite, montebrasite, lepidolite, pollucite, beryl, and tantalite. Frontier identified quartz, spodumene, potassium feldspar, albite, and muscovite at the Spark pegmatite, that also included minor lepidolite and garnet, and accessory tourmaline, fluorapatite, löllingite, and beryl. Exploration work completed by Frontier at Pennock has only identified spodumene and quartz. The district office staff collected 10 samples from the PAK, Spark, and Pennock pegmatite bodies to complete mineralogical analyses using XRD and SEM methodologies. Pegmatite classification schemes and the degree of fractionation are primarily defined by the mineralogy of a pegmatite. With this work, we identify the mineralogy of the Pennock pegmatite and contribute to the characterization of the Spark pegmatite.

SIOUX VALLEY DAKOTA NATION'S PHEZIH OTA (SAGE) GEOPHYSICAL TEST SITE: IMPLICATIONS FOR INDIAN RESIDENTIAL SCHOOLS SURVEYS AND GROUND-PENETRATING RADAR OPTIMIZATION

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There is a nationwide effort to locate unmarked graves of children who died at Indian Residential Schools (IRS). While the related geophysical surveys have commonly been reliant on ground-penetrating radar (GPR), there is a lack of empirical evidence pertaining to GPR performance across various physical and environmental contexts. This community-led collaboration with Sioux Valley Dakota Nation has developed a geophysical testing area near the grounds of the Brandon IRS to better understand the capabilities and limitations of GPR for near-surface targets. The site has 10 test units filled with various targets and homogeneous backfill. Initial reference of geophysical responses was collected prior to establishing the test site pits. Selected units had additional targets (air-filled wooden boxes, or hydrated sodium polyacrylate bundles) included to simulate soil disturbances and votive deposits with high reflection coefficients. Procedures for ongoing monitoring are to repeatedly conduct 2D common offset profiles in a uniform grid using a bistatic GPR cart system in 3-month intervals. Preliminary results of GPR trials discussed are: 1) GPR monitoring of test units to analyze changes in the pit architectures throughout various climate conditions, 2) a time-lapse analysis of immediate soil hydration performed by a deluge of container water, and 3) testing common midpoint analysis of wide-angle reflection data to resolve subvertical faces of a shallow pit. The optimization of GPR surveys is of utmost importance in the search for clandestine IRS graves. Understanding how immediate soil conditions impact GPR responses is required for the successful application of this technology to locate near-surface features under varied conditions. This test site offers a unique opportunity for ultra near-surface geophysical and forensic science but also serves as a controlled and culturally safe place to train Indigenous peoples in the fundamentals of geophysical surveying.

PEGMATITIC ALKALI FELDSPAR AS A ROBUST PATHFINDER LEADING THE WAY TOWARD THE DISCOVERY OF NEW LI DEPOSITS

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One of the challenges of exploration for spodumene and petalite, the main hosts of the critical metal Li, is the location of the Li mineralization, which is usually confined to the interior zones of pegmatite dykes. These Li-rich zones are often not exposed at the surface, giving no indication of the mineralization potential of a pegmatite. In such cases, locating the ore zones and constraining their dimensions requires an extensive, costly, and environmentally disruptive trenching and/or drilling program. Experimental results show that alkali feldspars record the degree of Li enrichment of pegmatite-forming melts throughout the crystallization process. As an example, Li-poor granitic melts (~40 ppm initial Li) produce alkali feldspars with < 10 ppm Li, whereas Li-rich melts (9000–25000 ppm initial Li) generate feldspar crystals with Li concentrations that exceed 500 ppm in the presence of spodumene and/or petalite. Comparison of experimental products with natural samples from both barren and economic pegmatite bodies corroborates this observation.

https://doi.org/10.12789/geocanj.2024.51.211

The ability of alkali feldspars to record the Li concentration of pegmatite-forming melts can be used as an inexpensive exploration tool to discover pegmatite hosting economic levels of Li minerals with minimal environmental disruptions. For this method to be effective, a framework of reference linking the Li concentration of alkali feldspars as well as other rock-forming pegmatitic minerals (e.g. micas and quartz) to the Li content of the melt at magmatic temperatures needs to be established. Since Li is easily mobilized during alteration, the extent of Li loss at post-magmatic temperatures also needs to be evaluated. New experimental simulations address these questions by following the crystallization of progressively more Li-enriched melts from temperatures just below the liquidus down to the solidus (600–500°C) at pressures within the stability field of spodumene and petalite (500 and 100 MPa, respectively).

SANIDINE, ORTHOCLASE AND MICROCLINE, ALL ARE POSSIBLE IN FELSIC PEGMATITES

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Students taking Mineralogy 101 are taught about polymorphs, phase transitions, and field of stability expressed as a function of temperature and pressure. They learn that in sanidine, which may be written $(K,Na)[Al_{0.25}Si_{0.75}]_4O_8$, the Al–Si distribution is disordered, just like in a magma. In orthoclase, ideally $(K,Na)[(Al_{0.5}Si_{0.5})_2]Si_2O_8$, Al and Si are partially ordered, whereas in microcline, ideally $(K,Na)AlSi_3O_8$, full order is achieved below 350–400°C. Limited ordering of Al and Si is possible in sanidine if the fluid is alkaline in hydrothermal experiments lasting many weeks. The phase transition requires H_2O as a catalyst. As H_2O is an essential component of felsic magmas likely to produce pegmatite, one might expect well-ordered microcline to form as the rocks cool. Reality is somewhat more complicated: achieving Al–Si order depends not only on temperature, but also on the fluid's composition, namely the activity of H_2O in the fluid phase, its pH, and time. Odd as it may seem, K-feldspar is a neglected species in pegmatite studies. Very few now evaluate its degree of Al–Si order by X-ray diffraction, infrared spectroscopy or nuclear magnetic resonance. In nepheline syenite pegmatite, I expect well-ordered microcline to be achieved. The same applies to niobium-yttrium-fluorine (NYF) pegmatites; the transition San → Or → Mcc is expected to be complete. In peraluminous systems, for example in calc-alkaline suites, orthoclase and even ideal orthoclase can form, and domains of orthoclase typically persist in twinned microcline. In the case of anatectic granitic pegmatite bodies, particularly at sites of continent–continent collision, coeval anatexis of marble and of gneiss causes the ambient fluid to be carbonated. Sanidine may be expected in such pegmatite as a carbothermal fluid cannot mobilize the Al and Si among the tetrahedra. An evaluation of the structural state of K-feldspar in pegmatitic systems provides valuable petrogenetic information.

ARCHEAN PORPHYRY SYSTEMS AND DIORITE INTRUSIONS: LESSONS LEARNED FROM TWO GOLD-BEARING MINERALIZED SYSTEMS OF THE SUPERIOR CRATON, QUÉBEC

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In Archean greenstone belts, such as those of the Superior craton, Canada, gold is found in a variety of settings. Orogenic gold systems dominate and other mineralizing styles, such as porphyry style of mineralization, can also produce significant gold deposits (e.g. Côté-Gold deposit, Ontario). Archean porphyries tend to be related to diorite-bearing intrusive suites, and much remains to be done to document the petrogenesis and fertility criteria of these magmatic systems. This contribution focuses on two porphyry systems located in Québec, the Au–Cu deposits related to the Chibougamau Pluton (Abitibi greenstone belt) and the diorite-hosted Regnault Au–Ag mineralization (Frotet-Evans greenstone belt). Using field descriptions, whole-rock analyses, and petrographic observations, the source, emplacement mechanism, and chemical evolution of the tonalite–trondhjemite–diorite (TTD) intrusive suite that constitutes the Chibougamau Pluton, and the fertility of the Regnault granodiorite–diorite–gabbro intrusive suite are evaluated. The Chibougamau intrusive suite evolved toward K enrichment, which distinguishes it from tonalite–trondhjemite–granodiorite (TTG) suites, the dominant type of Archean magmatic system, that evolves toward Na enrichment. The Chibougamau Pluton was produced from a heterogeneous source composed of a hydrated basalt and possibly of metasomatized mantle. At Regnault, amphibole chemistry indicates that the magma was moderately oxidized, that it emplaced at a shallow depth, and that it was likely extracted from a metasomatized mantle. In both cases, water-bearing magmas that differentiated significantly are involved, and the diorite phase is likely the main source of metals and mineralizing fluids.

DEVELOPING AN UNDERSTANDING OF PRECIOUS METAL DEPORTMENT BASED ON MICRO- TO NANO- SCALE ANALYSIS OF 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 detail, and this project aims to develop a broader understanding of the evolution of BIF and in particular metals hosted within these rocks. The region of interest sits in a complex transition zone of Archean and locally Paleoproterozoic deformation, containing greenschist–amphibolite-facies rocks, 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, including 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 micrometre-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 sulphur 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.

CONSTRAINTS ON THE EVOLUTION OF THE EASTERN MARGIN OF THE HEARNE CRATON: NEW DATA FROM THE SOUTHWESTERN ROTTENSTONE DOMAIN, TRANS-HUDSON OROGEN, SASKATCHEWAN

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The Rottenstone Domain in Saskatchewan, Canada, is a lithotectonic belt of the Paleoproterozoic Trans-Hudson Orogen. Based on bedrock mapping, U–Pb, Sm–Nd and lithogeochemical data, the rocks of the southwestern Rottenstone Domain were subdivided into several lithodemic entities. Newly defined metasedimentary assemblages and granitic crustal blocks were used to reconstruct a plate tectonic framework for the western part of the Manikewan ocean during Orosirian time. A U–Pb zircon crystallization age of 2518 ± 6 Ma for augen granite from the Black Bear Island Lake structural inlier (BBILsi), and previously published seismic interpretation, confirmed that the BBILsi is part of the Hearne craton. The newly discovered Clam Lake structural inlier (CLsi), located 15 km farther east, consists of a central unit of augen granite, which yielded a U–Pb zircon crystallization age of

2045 ± 9 Ma and depleted mantle model ages (TDM) between 2.8 and 2.6 Ga. Based on its age, geochemistry, isotopic composition, and its occurrence within a tectonically bounded structural block of isotopically evolved (TDM 3.3 Ga) gneissic granite, the CLsi was interpreted as representing a rift-related granite, emplaced into Archean rocks of the Hearne craton. Feldspathic quartzite of the Sturdy Island Assemblage contains detrital modes at 1910 and 1860 Ma, and lesser Archean modes. The broadly contemporaneous Birch Rapids Assemblage consists of migmatitic psammite to pelite. Both metasedimentary assemblages are interpreted to have been deposited in a forearc basin to the 1.86–1.85 Ga Wathaman Batholith, receiving detritus from the circa 1.92–1.91 Rottenstone–Porter Bay continental arc and the eastern Hearne craton. A structural contact along the eastern edge of the CLsi likely represents a fundamental break between the juvenile Reindeer Zone to the east and structurally overlying metasedimentary assemblages and Archean granitoid units belonging to the Hearne craton to the west.

PRECAMBRIAN TERRESTRIAL SEDIMENTATION ON SINGHBHUM CRATON, INDIA

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The Singhbhum Craton of India preserves an extensive Precambrian terrestrial volcano-sedimentary record. A recent surge of geochronological data from the Archean sedimentary successions of the Singhbhum Craton provide us an opportunity to infer early Earth surface processes and crust–mantle interactions. The Paleoarchean (3.5–3.2 Ga) Iron Ore Group of rocks in the western and eastern belts bear alluvial fan–fluvial facies associations and indicate continental emergence in the earlier part of the Earth history. The banded iron formations and associated clastic rocks of the Iron Ore Group indicate largely shallow marine to shelf sedimentation. The extensive Mesoarchean sedimentary record (the Bisrampur and the Dhanjori formations in the northwestern and northern part of the Craton) implies continuation of terrestrial sedimentation because of subsequent relative sea level fall. Rise of relative sea level around 3.0 Ga is inferred from the shallow marine sedimentary facies associations of the Simlipal Group in the east and the Birtola Formation of the Darjing Group in the west. A ~2.8 Ga extensive felsic magmatic record is well-preserved in the Singhbhum Craton. No supracrustal rocks around 2.5 Ga are preserved on the Singhbhum Craton, although Neoarchean (2.8–2.5 Ga) detrital zircon is reported from the Paleoproterozoic metasedimentary rocks of the craton. Extensive terrestrial sedimentation took place on Singhbhum Craton during the Proterozoic time. The Paleoproterozoic Chaibasa Formation is largely marine and is unconformably overlain by the entirely terrestrial Dhalbhum Formation. Dalma volcanism and sedimentation took place in a terrestrial setting as also the overlying Chandil Formation. The topmost part of the Chandil Formation formed in a marine depositional setting. Published sedimentological and geochronological data suggests non-deposition and/or erosion on the Singhbhum Craton and thus development of a prolonged unconformity along the northern margin of the Singhbhum Craton throughout the Neoarchean.

THE STATE OF CESIUM AND RUBIDIUM SUPPLY

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Cesium (Cs) and rubidium (Rb) are geochemically similar mineral commodities deemed 'critical' by the United States due to their high net import reliance, absence of domestic mining, and unconstrained global resources. Up-to-date global production and consumption statistics have been consistently unreported for these resources since 1989 because of the restricted resource availability and niche markets of these commodities. Demand for these commodities is limited to mostly specialty applications (e.g. Rb: fiber optic telecommunications, solar panels; Cs: medical treatment, oil and gas drilling fluid, atomic clocks). To understand the supply risks associated with these commodities from a U.S. perspective, it is necessary to compare their global resources and production alongside present U.S. consumption. This research focuses on estimating supply statistics, including (1) global Cs and Rb mine production during 2005–2022, and (2) global hard rock Cs and Rb resources. A combination of mill and refinery capacity data and reported mineral chemical data is used to estimate global production. Both commodities are presently sourced from granitic pegmatite (e.g. Tanco, Bikita, and Sinclair pegmatite occurrences) and greisen-style (e.g. Yichun granite complex, China) mineral deposits from similar pollucite and lepidolite ores. Other types of geologic deposits, such as geyserite (e.g. Taron deposit, Argentina) and brines also host sizable resources of both commodities, but no known production has occurred from these latter deposits. Pegmatite-derived pollucite is the main source of Cs, and potentially the main source of Rb. During the 18-year timeframe of this study, it is estimated that a Cs metal equivalent of approximately 39,000 tons was mined as pollucite. Total pollucite-derived production of refined Cs products, including Cs salts and formate brine, and Rb salts are estimated to be approximately 33,000 tons Cs and approximately 125 tons Rb. These tonnages are likely higher with the inclusion of by-product production lepidolite ores.

EDIACARAN MISTAKEN POINT FORMATION, NEWFOUNDLAND: PRELIMINARY PALEOMAGNETIC INVESTIGATION OF EXPOSURES IN THE ST. JOHN'S REGION

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The 565 Ma Mistaken Point Formation of the Avalon terrane, eastern Newfoundland is part of an arc-related Ediacaran marine turbidite siliciclastic succession in an off-shelf setting. It contains the world's oldest soft-bodied macrofauna, preserved in their ecological context. The Avalon arc paleocoastline orientation and global paleogeographic relations remains uncertain but may be resolved with paleomagnetic investigation. Mistaken Point Formation strata in the St. John's area, northeastern Avalon Peninsula are openly to tightly folded about NE-trending axes, with excellent exposure available in roadcuts. Oriented samples were taken at five reconnaissance sites in lavender and purple mudstone–siltstone beds, representing SE-and NW-dipping fold limbs and fold hinge zones. Specimens from these sites underwent measurement of anisotropy of magnetic susceptibility (AMS) and stepwise demagnetization to investigate their remanent magnetic record and possible origin(s). Preliminary results show an AMS foliation fabric and maximum susceptibility axes in fold limb sites consistent with near-vertical cleavage planes, suggesting a structural control on the AMS fabric. Magnetic susceptibility values typically range from 0.1–0.6 $x10^{-3}$ SI units, consistent with magnetite. Stepwise demagnetization found a well-expressed viscous remanent magnetization with a NNW, steep down direction likely of recent origin. Further demagnetization steps revealed two characteristic components coexisting within most specimens: an A component that is removed by 75 mT applied field and 580°C, and a B component of different direction that is retained at temperatures > 620°C. The A component directions are carried by magnetite, having better S, downwards grouping before tilt correction, suggesting that A was acquired syn- or post-folding, possibly of Devonian age. The B component is carried by hematite, with poorly grouped but antipodal shallow directions upon tilt correction. B component origin is uncertain but may be primary. A more complete collection will be needed to investigate the possibility of primary 565 Ma remanence for the Mistaken Point Formation.

MELTING ICE AND MAKING MINERALS: MICROBIAL IMPACTS ON CLIMATE

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Microbial redox reactions can dissolve and precipitate minerals, thereby altering water and mineral chemistry. While microbe–mineral–water interactions occur on the cellular scale, these processes impact the geochemistry of the broader environment. This presentation will highlight two example processes, both with implications for climate change. First, the role of mineral dust in glacier ice algal growth on the Greenland Ice Sheet will be explored. Mineral dust provides nutrients to these algae,

https://doi.org/10.12789/geocanj.2024.51.211

which grow in blooms on the ice surface and contribute to melting by lowering ice albedo with their dark pigments. Mineral dust found on the ice can be linked to nearby sources by examining dust composition and atmospheric transport pathways. These findings identify a positive feedback cycle between mineral dust delivery, glacier ice algal growth, and surface melting that will have important implications in the face of a warming climate. Next, the ability of cyanobacteria to precipitate carbonate minerals using mine tailings as a starting material will be explored as a strategy for mine site carbon dioxide removal (CDR). Cyanobacteria facilitate the precipitation of carbonate minerals using magnesium found in high concentrations in ultramafic tailings and atmospheric carbon dioxide (CO_2) through alkalinity generation and nucleation site production. While the resulting secondary cements can bind tailings together and sequester CO_2, the transition to mine-scale implementation remains a challenge. Concurrently, mine tailings are being assessed as potential low-grade 'deposits' of key metals required for many low carbon technologies. Microbial redox reactions and metal biosorption have potential applications to recovering these metals from legacy mine sites. Pairing metal recovery from tailings with onsite CDR would help with the transition to more sustainable, carbon-neutral mining. Together, these studies highlight how microbial-scale processes can have positive and negative impacts on climate in geochemically and geographically diverse environments.

GOOD, BAD, OR UGLY: THE UNIQUE CHALLENGES OF GEOCHRONOLOGY IN PEGMATITE SYSTEMS

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Pegmatite geochronology poses unique challenges. Reliable dates depend on assessing geological, textural, and microstructural features across scales from outcrop to mineral lattice. Observing equilibrium textures among geochronometers and surrounding mineral assemblages is also required. Conventional mineral separation obscures these relationships such that detailed geochronology in pegmatite is arguably best achieved using in situ microbeam approaches. A good feature of pegmatite is the abundance of targets for geochronology: minerals with U and Th (for U–Th/Pb), REE (for Sm–Nd, Lu–Hf), and K–Rb (for Ar–Ar, Rb–Sr). These are hosted in silicate minerals (zircon, micas, garnet, feldspars), oxide minerals (tantalite, cassiterite, uranothorite) and phosphate minerals (apatite, monazite, xenotime). The use of tandem mass spectrometry allows us to better exploit micas and garnet where in situ K–Ca, Rb–Sr, and Lu–Hf isochrons can be obtained directly from major mineral assemblages with preserved textural context. The bad side of pegmatite is that inheritance is pervasive. Zircon has low solubility in low-temperature granitic melts so that newly formed zircon occurs as thin epitaxial rims or as small grains clustered with other HFSE-rich phases. Inherited garnet, monazite/xenotime, and possibly even micas has been observed. Another downside of the fractionation process is higher common Pb concentrations that make U–Pb geochronology challenging in low-U phases such as apatite. However, high Pb content in K-feldspar can be used to generate Pb–Pb model ages that provide first-order control on pegmatite crystallization. The ugly side of pegmatite geochronology is manifest at the lattice scale. Highly fractionated pegmatite with U>>Th leads to metamictization and susceptibility to episodic dissolution–reprecipitation mechanisms. In these cases, common in Archean pegmatite fields, there is little chance of recovering a meaningful date from high-U geochronometers. This talk provides some examples of successful results and a few failures. Success is ultimately dependent on available targets and careful workflow from outcrop sampling to microtextural characterization.

HYDROTHERMAL ALTERATION IN THE BRENT IMPACT STRUCTURE, ONTARIO, CANADA

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Impact cratering is a common and continuous geological process that occurs on all planetary bodies within the solar system. Meteorite impacts generate large amounts of energy and when in contact with an aqueous body, this can result in long-lasting hydrothermal systems. These hydrothermal systems have been proposed as likely environments for the origin of life on Earth. Therefore, studying hydrothermal alteration within impact craters can yield insights into the environments for early life. The Brent Impact Structure, found within northern Algonquin Park in Ontario, Canada, represents a good example of a simple impact crater that was infilled with a crater lake. This crater was extensively drilled in the late 1950s and 1960s and a total of 5035 m of core were recovered. The crater core was investigated in the 1970s, however, these observations have not been revisited with modern instrumentation. At that time, focus was given to the impact melts in the core, however, very little has been reported on the hydrothermal alteration within this crater. Initial investigations using X-ray fluorescence and optical analysis have yielded promising data for the presence of hydrothermal alteration. Drill core within the melt zone contains areas rich in calcium and sulphur. Further optical observations of these areas suggest the presence of gypsum and anhydrite surrounded by fine-grained melt. At intermediate depths, fluid inclusions were observed by optical analysis of drill core containing large quartz veins. At shallower depths, zeolites and smectites were noted to be abundant in thin sections. These results follow mineral distribution trends similar to those seen in other impact structures with changes in depth (e.g. Ries impact structure). Further investigation of hydrothermal alteration textures and mineralogy of the drill core is underway using electron probe micro-analysis (EPMA) and X-ray diffraction instrumentation.

RENEWED INTEREST IN ABYSSAL-TYPE PEGMATITE BODIES AS A SOURCE OF CRITICAL MINERALS – FRASER LAKES ZONE B

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The Fraser Lakes Zone B granitic pegmatite- and leucogranite-hosted U–Th–REE deposit in northern Saskatchewan, Canada, discovered in 2008, is seeing renewed interest as a source of both uranium and REEs, particularly as the spot price of uranium has shot up to 17-year highs and governments are seeking domestic sources of critical minerals. Unlike most pegmatite bodies hosting mineral deposits, the Fraser Lakes Zone B pegmatite bodies do not show a connection to a large intrusive body/pluton of similar age, and thus have been interpreted as abyssal-type pegmatite. Mineralized pegmatite intruded as sheet-like bodies along the highly deformed unconformity between Archean orthogneiss and overlying Wollaston Supergroup metasedimentary gneiss, and was concentrated within a NE-plunging antiformal fold nose at Fraser Lakes Zone B. The melt was generated during partial melting at depth of U–Th–REE-enriched Wollaston Supergroup metasedimentary gneiss during peak thermal metamorphism and post-peak isothermal decompression in the waning stages of the 2.0–1.8 Ga Trans-Hudson Orogen. The melt was transferred to the level of emplacement along the regional foliation, folds, and shear zones, where it crystallized to form pegmatite. The U, Th, and REE mineralization consists predominantly of uraninite, U-enriched thorite, monazite, and zircon, with minor amounts in other U–Th–REE phases, some of which crystallized from the melt, with other minerals inherited from the source rocks. Two different groups of pegmatite have been distinguished at Fraser Lakes Zone B based on composition and mineral content, possibly representing different melt sources. The melts underwent varying degrees of assimilation and fractional crystallization during melt transport and have seen variable post-intrusion structural and hydrothermal overprinting. Recent exploration at Fraser Lakes Zone B by Skyharbour Resources Limited and Tisdale Clean Energy Corporation has resulted in increased understanding of the extent of the pegmatite bodies and the contained U–Th–REE mineralization.

THE CANADIAN FEDERATION OF EARTH SCIENCES: WHO WE ARE AND HOW WE SUPPORT THE CANADIAN EARTH SCIENCE COMMUNITY

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The Canadian Federation of Earth Sciences (CFES) is an umbrella organization that serves a federation of 12 Member and 7 Observer Earth Science societies and associations across Canada. Established in 2006 as the successor to the Canadian Geo-

science Council, CFES represents some 15,000 Earth scientists working in industry, government, and academia in all areas of geoscience. Nationally, we advocate on behalf of the Canadian Earth Science community with government and the Canadian public through membership in the Partnership Group for Science and Engineering, the Science Media Centre of Canada and internationally as members of the International Union of Geosciences (IUGS) and UNESCO. Our mission is to be the coordinated voice of Canada's Earth Science community, ensuring that decision makers and the public understand the contributions of Earth Science to Canadian society and our economy. We coordinate overlapping efforts among Member Organizations to maximize efficiency and impact. CFES strategic objectives as determined by the Council of Member Organizations are; to coordinate and provide a common voice for member organizations and the Earth Science community in Canada; to coordinate public policy advocacy on Earth Science in Canada; to facilitate public awareness of Earth Science and support Earth Science literacy; to represent and promote Canadian Earth Science internationally; to provide service to member organizations and the Earth Science community; to coordinate support for professional and academic organizations in Canada. The Canadian Federation of Earth Sciences invites you to come learn about our initiatives to rebuild public confidence in the value of our discipline to Canadian society and encourage youth to consider a career in Earth Sciences. Come join the discussion!

CANADIAN GEOSCIENCE EDUCATION NETWORK: WHAT'S NEXT? A DISCUSSION ABOUT THE FUTURE OF GEOSCIENCE EDUCATION, LITERACY AND ENGAGEMENT IN CANADA

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The Canadian Geoscience Education Network (CGEN), founded in 1996 is the education arm of the Canadian Federation of Earth Sciences (CFES). CGEN is a national network of volunteers involved in Earth science education and outreach across Canada. CGEN promotes improvement of geoscience education and literacy, acts as a forum for discussion of matters related to geoscience education in Canada, supports grassroots, locally driven and focused initiatives, and facilitates larger projects of national significance. Membership includes K-12 teachers as well as geoscience professionals working in industry, government, academia, museums, and other informal education settings. CGEN's sister organization, EdGEO Canadian Earth Science Teacher Workshop Program was formed to support teacher professional development. CGEN members are currently working with other stakeholders on initiatives to meet the challenge of declining interest and understanding of the value of geoscience. The renewed Earth Science Careers Website aims to recruit youth into geoscience post-secondary programs (earthsciencecanada.ca) and encouraging them to consider Earth science as a career. Following two residencies at Pukaskwa National Park, the CFES-Parks Canada Geologist-in-Residence Pilot has now become a permanent program, with a geoscientist volunteer spending 2 weeks during August supporting interpretation of geological assets in Pukaskwa National Park. Talks with Fundy National Park have been initiated, with hopes that other parks will adopt this program. CGEN's longest running and most impactful initiative, the EdGEO Canadian Earth Science Teacher Workshop Program has supported thousands of K-12 teachers through funding of locally organized, curriculum-specific teacher training experiences. EdGEO funding grants of up to $3000 are awarded annually. We hope you will join us at this session to review the results of our recent strategic planning survey and help us envision a path forward along side the new GAC GEC division, that will guide us through this next exciting phase and into the future.

AN UNUSUAL LATE ORDOVICIAN ORTHIDE BRACHIOPOD COMMUNITY FROM THE MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES

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During the Late Ordovician, Laurentia was a largely isolated paleoequatorial landmass covered by a shallow, epicontinental sea. The Mackenzie Mountains were then a subtropical carbonate platform located at the northern edge of this epicontinental sea. The shelly benthos from this region remains understudied, but contains a diverse brachiopod fauna, including a number of orthide lineages. While the Ordovician orthides of eastern and central North America are well-studied, there are few studies from this time that include localities from northern North America. This study focuses on orthide brachiopods from the Whittaker Formation (Sandbian–Katian) in the Mackenzie Mountains, including the orthoids, plectorthoids, dalmanelloids, and enteletoids. The specimens are silicified and display exceptional preservation of morphological features, which allows for detailed morphometric analysis. In comparison to eastern North America, this assemblage represents an unusual community composition due to its high abundance of genera such as *Hesperorthis* and '*Platystrophia*' (probably *Vindlandostrophia*), and presence of *Fascifera* and *Pionodema*. These latter two genera are better known from Baltica, a paleocontinent located south of Laurentia at this time, and on the other side of the paleoequator from the Mackenzie Mountains. Most Late Ordovician brachiopods formed highly endemic communities in the epicontinental seas until they became more cosmopolitan during the Hirnantian glaciation. Therefore, regional studies that fill in gaps in our understanding of the biogeography are useful in understanding the evolution and dispersal of brachiopod lineages. Additionally, the presence of possible cold-water brachiopod forms in this isolated platform raises questions about the paleoecology of these fauna and the ocean currents that played an important role in the dispersal of brachiopod faunas.

CONTRASTING VALUE OF SOIL CHEMICAL MAPPING AND GAMMA RAY SURVEYING IN EXPLORATION FOR RARE METAL PEGMATITE

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Rare metal pegmatite bodies are notoriously difficult to detect because of their small size and generally low geophysical contrast with common host rock types, even if partly outcropping or covered by thin superficial deposits. The EU H2020 GREENPEG project (2020–2024) has tested a wide range of exploration techniques for buried pegmatite. We compare the results of A- and C-horizon soil chemical mapping with hand-held and drone-borne gamma ray surveying in three prospect-scale sites where the sub-surface location of rare metal pegmatite bodies is already known and soil cover is typically 0.2–1.0 m. These include pegmatite at Tysfjord, Norway, which is exploited for ultrahigh purity quartz from pegmatite cores, and spodumene pegmatite prospects near Wolfsberg, Austria, and at Moylisha, Ireland. The niobioum-yttrium-flourine/Group 2 pegmatite bodies and their metasomatic halos at Tysfjord are enriched in Th and U relative to their host rocks, and therefore easily detected in low altitude gamma ray surveys. Although both A- and C-horizon soil chemical mapping provided very effective vectors, and additional information on potential by-products, they are more time-consuming, labour-intensive, and expensive than gamma-ray surveys. The lithium-cesium-tantalum/Group 1 pegmatite bodies and their metasomatic halos in both Wolfsberg and Moylisha have low gamma-ray contrast with their host rocks. In some cases they are slightly more radioactive than host rocks (amphibolite), and in others not significantly different (granite, mica schist), but in general the method was unsuccessful in their detection. However, soil chemical mapping (both A- and C-horizon) was highly effective in both localities because of strong chemical contrasts (e.g. Li, Cs, Ta, Sn) between pegmatite and host rock. We discuss the various factors limiting the effectiveness of these exploration methods and the extent to which they are likely to be applicable in pegmatite exploration.

AMETHYST IN GRANITIC PEGMATITES

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Cavities in miarolitic pegmatite yield many varieties of quartz (milky, smoky, "rock crystal", and rose-coloured). But amethyst is entirely absent in most pegmatite bod-

https://doi.org/10.12789/geocanj.2024.51.211

ies, uncommon in a few others, and very rarely abundant. Why is amethyst so uncommon? The essential requirements are silica in solution, iron as the chromophore, and radiation. The iron must be ferric (Fe^{3+}, converted to Fe^{4+} by radiation). Such iron replaces silicon in the tetrahedral site in quartz, competing with aluminum (which typically produces smoky quartz). Amethyst generally forms at up to 300ºC – higher temperatures destroy the colour centre. In pegmatite, cavity fluids are silica-rich, but the 300ºC limit restricts amethyst to the late stages, typically a last generation of quartz. Other constraints can be higher aluminum concentrations. Iron is typically readily available, especially in Černý's more Fe-rich niobium-yttrium-fluorine pegmatite. But, by the late stages of crystallization, iron has generally been consumed, e.g. in forming siderite, pyrite, or hematite (as inclusions in pink microcline). Rarely, iron can be remobilized by late-stage hydrothermal activity, as evidenced by corrosion of microcline. Radiation sources are ^{40}K, U or Th. Amethyst is commonly a last generation of quartz, occurring as sceptres or other striking overgrowths, including the rare "jacare" habit. Pegmatite with uncommon amethyst include the Erongo Mountains in Namibia, Mimoso do Sul in Espirito Santo, Brazil, and the Papachacra district in northern Argentina. The rarest pegmatite is that with abundant amethyst. Two are in the USA (the Boulder Batholith, Montana, and Oxford County, Maine); a third is the Cusaso al Monte quarry in Italy. All share placement within (or closely associated with) a parent granite. But the most important feature is late-stage hydrothermal alteration. Of these localities, the most interesting is the Little Gem mine in Montana, which is also a most atypical niobium-yttrium-fluorine (NYF) pegmatite.

MINERALOGICAL CHARACTERIZATION OF THE PLUMBAGO NORTH PEGMATITE (MAINE, USA): PRELIMINARY RESULTS

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The Plumbago North pegmatite is located in the Central Maine Belt (USA), part of the Oxford pegmatitic district. Outcrop conditions do not permit accurate determination of the shape and size of this body, but according to drilling results it has a thickness of at least 60 m. Its exposed portion presents an irregular sharp contact with the hosting schist. No internal zoning has been observed inside the pegmatite, which shows a wide grain-size variation, from aplitic up to gigantic (> 11 m long for some crystals). A textural study combined with microprobe analyses and X-ray diffraction has been developed to characterize the mineralogy of the pegmatite. The mineral assemblage includes quartz, plagioclase, spodumene, and muscovite. Other common minerals are K-feldspar, phosphate minerals of the amblygonite–montebrasite series, and triphylite. As accessory minerals, garnet, apatite, Fe–Mn phosphate minerals (secondary after triphylite), cookeite, schorl, cassiterite, and columbite-Fe have been identified. All the feldspars from the pegmatite are alkaline. Albite (> 98.01% Ab) is the most abundant, usually occurring as medium to coarse-sized subhedral crystals. K-feldspar (orthoclase and microcline) is commonly perthitic and exhibits crossed twinning. Feldspars may show relatively high P contents (up to 0.31 wt.% P_2O_5). Medium to coarse-grained book muscovite is the most common mica. Generally, it is F and Li poor (< 0.59 and < 0.49 wt.% respectively). Spodumene usually occurs as sub- to euhedral coarse to gigantic prismatic crystals. These may be fractured, with cookeite partially replacing spodumene along the fractures. Subrounded medium-sized garnet crystals usually occur close to schist, with a composition of almandine with a significant spessartine content (55.58–64.71 mol% almandine and 34.74–43.91 mol% spessartine). According to the mineral assemblage, petrography and mineral chemistry, this pegmatite shows an intermediate to high degree of evolution and its crystallization would have developed at temperatures ≥ 450–500ºC, and pressures in the range of 3 to 3.5 kbar.

ARE MOBILIZED SHALES NON-LINEAR YIELD STRESS FLUIDS?

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While shale is fissile and brittle at the Earth's surface, it can become mobile and deform in a viscous manner under elevated pressure and temperature. The behaviour of shale has the potential to play a major role in subduction zones where the shale content can impact slip dynamics. Furthermore, mobilized shale has been one of the most difficult challenges for exploration geologists interpreting structures along continental margins where shale bodies form mud volcanoes and shale diapirs. Recent studies suggest that mobilized shale units deform as non-linear yield stress fluids. While direct rheological observations on mobilized shale are not feasible, one of the suggested ways to identify them in outcrops is chaotic foliation patterns. Here, we show results from shale of the Franciscan mélange that experienced pressure and temperature conditions suitable for shale mobilization. We use traces of shale foliation from black shale outcropping near San Simeon, California, to investigate the dominant foliation patterns. We compare the foliation patterns collected in the field with deformation patterns in a sheared non-linear yield stress fluid deformed in a laboratory setting. We use Carbopol® as a mobile shale analogue. Carbopol is a non-linear yield stress fluid where the viscosity and yield stress can be tuned independently from each other. This makes Carbopol an ideal experimental material to investigate the impact of rheology on the deformation pattern. Combining field and laboratory results allows us to test the hypothesis whether mobilized shale units deforming as non-linear yield stress fluids indeed display chaotic foliation patterns.

STRUCTURAL GEOLOGY, METAMORPHISM, AND TIMING OF DEFORMATION IN THE PALEOPROTEROZOIC WAUGH LAKE GROUP, SOUTHERN TALTSON OROGEN, LAURENTIA

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The Paleoproterozoic supracrustal sequences within the western Rae craton, including the 2.02–1.97 Ga Waugh Lake group (WLg) in extreme NE Alberta, bordering Saskatchewan, yield crucial insights into superimposed orogenesis. This study focuses on the tectono-metamorphic history of the WLg, initially postulated as an intra-arc/back-arc basin of the 1.99–1.96 Ga Taltson arc. Field work has confirmed previously established stratigraphic relations with the caveat that there appears to be a more fundamental break (e.g. unconformity) between the lowermost metaturbidite of the Martyn Lake Fm (MLfm) and continental siliclastic–volcanic rocks of the upper WLg. Structural analysis of rhythmically bedded turbidite of the MLfm reveals multiple younging reversals indicative of an earlier set of isoclinal folds (F1). Subsequent refolding about NE-trending axes generated 'hook-style' fold interference patterns via co-axial refolding. Progressive D1–2 deformation aligns with the emplacement of a meta-diorite unit, potentially setting an upper limit for deposition and early deformation. While MLfm bedded turbidite units record two folding phases, overlying rocks document only the secondary phase, reinforcing the MLfm's potential antiquity relative to the upper sequence. Further work is also underway to test whether the MLfm is correlative with turbidite units of the Hill Island Lake assemblage (HILa) along strike (southern Northwest Territories). The HILa is lithologically and structurally like the MLfm, and notably shares similar N–S striking, gossanous, gold-bearing shear zones of interest from an economic perspective. This study also evaluates the WLg's contact relationships with marginal granitoid/gneiss units, bearing on the whether the group is autochthonous or allochthonous. In the east, MLfm turbidite is in sheared contact with migmatitic gneiss, whose oldest tonalitic gneiss component may represent basement, or alternatively, a strongly deformed Taltson arc pluton. Upcoming research leveraging U–Pb dating on key units like the metadiorite and tonalite, aims to unravel the timing of the Martyn Lake Formation's deposition and deformation, enhancing understanding of how the Waugh Lake group fits into the regional tectonic evolution.

RESOLVING THE STRATIGRAPHY, AGE, AND METALLOGENIC IMPLICATIONS OF A NEWLY CLASSIFIED VOLCANICLASTIC UNIT AT THE WINDFALL GOLD DEPOSIT, NORTHEAST ABITIBI SUBPROVINCE

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The Urban-Barry greenstone belt, located in the eastern section of the Abitibi Subprovince, hosts several prospective gold projects, notably the 7.4 M oz. Windfall gold deposit (WGD). The WGD is hosted in a deformed bimodal, tholeiitic transitional volcanic assemblage of the ca. 2718–2716 Ma Macho Formation. Overlying this sequence in the northeast of the deposit is a 300 m-thick calc-alkalic intermediate fragmental unit, whose age and origin had yet to be constrained. Crosscutting the above units is a suite of geochemically similar ca. 2698 Ma granodioritic dykes, with gold mineralization often being spatially associated with these dykes. The primary objective of this study is to better constrain the origin, age, and stratigraphic relationships of this enigmatic fragmental unit. To resolve this, detailed facies mapping was done on drill core across three sections which was coupled with whole-rock geochemistry and U–Pb zircon geochronology. Preliminary results show four distinct facies, classified based on fragment abundance, morphology and type. Documented fragment types include: millimetric to centimetric tourmaline and pyrite fragments, variably quartz-phyric juvenile fragments, and variably quartz-phyric lithic fragments which are likely inherited from the underlying volcanic rocks of the Macho Formation. Based on textural and structural characteristics (e.g. bedding and graded sequences) and mappable, horizontal sub-conformable facies, a volcaniclastic origin is most probable; it is unlikely that these structures formed in an intrusive setting. Ongoing U–Pb zircon dating of a typical facies of this fragmental unit by LA-ICP-MS will help bracket the crystallization age. Probable ages for this unit may range from 2715 Ma to 2698 Ma, with the future pinpointed age providing a constraint for an at- or near-surface paleo-environment. With regional work uncovering similar fragmental rocks within the Macho Formation, improving our understanding of this unit will help refine the metallogenic evolution on both a deposit and regional scale.

A NEW RADIODONT WITH A SPECIALIZED POSTERIOR TAGMA FROM THE BURGESS SHALE EXEMPLIFIES EARLY PLASTICITY IN ARTHROPOD SEGMENTATION

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Much of the diversity in euarthropod form is the result of differences in the number and differentiation of segments. By contrast, their closest extant relatives, onychophorans and tardigrades, have conserved patterns of segment differentiation and less variation in segment count. Fossil evidence to date has suggested that the earliest-diverging arthropods, the radiodonts, exhibited a limited range of segmentation patterns, more similar to the situations in onychophorans and tardigrades than in euarthropods. We present a radiodont arthropod from the Cambrian (Wuliuan) Burgess Shale that upends this notion. The new species exhibits a maximum of 28 or 29 segments, the highest number reported for any radiodont. The head is likely composed of two segments, supporting the eyes and frontal appendages. The remaining segments, in the trunk region, bear lateral flaps and bands of gill lamellae, but are differentiated into two main batches. The anterior trunk is composed of 10 segments. Flap size is small anteriorly, but increases to one third of total body width by segment 6, decreasing slightly thereafter. These flaps are inferred to have been the primary locomotory organs. The posterior trunk consists of 16 or 17 segments that are sharply differentiated from those of the anterior trunk, exhibiting extreme size reduction and tightly spaced gills. The reduced flaps were presumably too small to have played a role in swimming. Instead, we infer a specialization of the posterior trunk for respiration. Such posterior regionalization is unique among radiodonts, but convergent examples exist in euarthropod groups such as the chelicerate opisthosoma, malacostracan pleon, and insect abdomen. This finding demonstrates that radiodont segment number and differentiation were more plastic than previously appreciated. Taken together with the segmental variation exhibited by diverse Cambrian euarthropods, this suggests that an increase in plasticity was associated with the origin of the arthropod clade.

THE GREENPEG PROJECT TOOLSET TO EXPLORE FOR BURIED PEGMATITE HOSTING RARE METALS AND HIGH PURITY QUARTZ

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The GREENPEG toolset is the first to set out a comprehensive guide to exploration for all types of granitic pegmatite, including especially cases where they are buried. Its importance lies in the urgent need to identify new deposits of green energy transition and high-tech commodities such as Li for electric vehicle batteries and high purity quartz for the Si metal needed to produce photovoltaics. The toolset is based on four years (2020–2024), EU-funded work by the GREENPEG consortium, which has been drawn from 13 academic, industry and government organizations across Europe. The result is an integrated, multi-method exploration toolset ranging from remote sensing, geological, and numerous geophysical and geochemical techniques equipping small- and medium-scale companies getting started or progressing in their activities for pegmatite exploration. Besides tailored conventional and newly developed exploration methods, the toolset comprises novel workflows and data-processing approaches, three new geophysical exploration systems and two specialist databases designed and optimized from knowledge, experience, and innovations developed during the GREENPEG project. The application of the toolset aims to maximize the success of subsequent and generally more costly techniques such as drilling. Apart from the technical methods of mineral exploration, GREENPEG has also integrated environmental, social, and governance (ESG) practices and considerations into this toolset. The implementation of ESG practices into the toolset emphasizes the need for exploration companies to plan community engagement before starting exploration, to be open and transparent about their intentions, and with their data where it is not commercially sensitive. The accurate application of the toolset will minimize social and environmental impacts of the applied exploration activities employing today's ESG standards. After the completion of the project in October 2024, the project consortium will transition into an expert group, dedicated to ensuring the effective exploitation and dissemination of the toolset, while also offering advice to stakeholders, if needed.

THE USE OF REACTIVE CLAYS FOR STABILIZATION OF UNPAVED ROADS

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Loose gravel roads comprise the majority of the transportation network in most parts of Canada, including ~270,000 km in Saskatchewan and Manitoba alone. These unpaved roads present a chronic environmental and safety problem and are a financial burden for the municipalities that maintain them. Better methods for their construction and maintenance that are compatible with a sustainable future are needed. Our simple solution is to stabilize the loose gravel wearing surface by adding a high percentage of cohesive clay-rich material to an ordinary A-base gravel aggre-

https://doi.org/10.12789/geocanj.2024.51.211

gate, resulting in good particle-size distribution from ~¾ inch down. High-density is achieved with progressively finer particles filling every pore space down to micrometre and nano-scale clays. The bonding or cementing energy is provided by electrostatic forces proportional to the excess negative charges inherent in cohesive (reactive) clays. These clays, which normally adsorb and bond with water, are caused to electrostatically bond to each other via interparticle cations, densification, and the removal of water. The process is facilitated by addition of an organic catalyst that aids in water removal and densification while ensuring the process proceeds in a bath of natural and added cations. The process is brought about via a simple but eloquent construction protocol. The bonding process is likened to a synthetic precursor to diagenesis (the conversion of sediment to rock), with bonded clay particles resembling micas. Roads constructed in this manner are very durable and eliminate the worst environmental problems including most dust and toxic stabilization chemicals, and the use of excess amounts of aggregate. There are also major improvements to safety provided by the strong and durable wearing surface with virtual elimination of potholing, rutting, wash boarding, and loose aggregate. We discuss the role of clay minerals, along with the construction protocol and examples of stabilized roads.

A MANTLE SOURCE FOR WATER IN APPINITE COMPLEXES: IMPLICATIONS FOR GENESIS OF GRANITOID BATHOLITHS AND CRUSTAL GROWTH

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Appinite complexes are ultramafic to felsic in composition, characterized by idiomorphic hornblende and by spectacularly diverse textures, such as multiple comb layers and mafic pegmatite, suggesting that they are anomalously water-rich mafic magmas. They commonly occur as small (~2 km) plutons adjacent to deep crustal faults along the periphery of arc granitoid plutons. The ca. 607 Ma Greendale Complex, Nova Scotia, is typical of appinite complexes. Stable isotopic data from hornblende (δD from –61 to –72 ‰; $\delta^{18}O$ from 3.7 to 7.0 ‰) indicate the water in the appinite magma has a strong mantle component. Hornblende geochemistry indicates crystallization over a range of pressure (3–6 kbar), temperature (750–1050°C) and H_2O content (4–10 wt.%). Collectively, these data imply appinite complexes (i) represent aliquots of hydrous mantle-derived magma derived from mafic underplates emplaced along the base of the crust during protracted subduction and (ii) crystallized and differentiated as they ascended to middle-upper crustal levels. Transfer of heat and fluids triggered coeval (615–604 Ma) granitoid magma by partial melting in the overlying melting-assimilation-storage-homogenization (MASH) zone. These granitoid bodies were emplaced when transient stresses activated favourably oriented structures. The ascent of late mafic magmas was impeded by rheological barriers created by overlying granitoid magma bodies. Greendale Complex magmas evaded barriers by exploiting the Hollow Fault which bounded the plutonic system. More generally, the most mafic components of appinite complexes may provide a window into the composition of the mafic underplate and insights into processes that generate granitoid batholiths and crustal growth in arc systems.

TEXTURES AND STRUCTURES OF APLITE–PEGMATITE DYKES AND Li MINERALIZATION IN THE LAMOTTE–LACORNE AREA, NEOARCHEAN ABITIBI GRANITE–GREENSTONE BELT, QUÉBEC

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In the Lamotte–Lacorne area are variably Li-enriched aplite–pegmatite dykes cutting across the ca. 2680–2640 Ma monzogranite–granodiorite suite and their host volcano-sedimentary sequence. These highly fractionated intrusions (K/Rb = 28, Rb/Cs = 20, and Mg/Li = 4 mean values; n = 45), ranging in composition from syenite to granite, are strongly peraluminous (ASI = 1.51–3.59) with dominant calc-alkaline affinity. They are grey to brown, massive to rhythmically aplite–pegmatite zoned rocks occurring either as isolated bodies (< 0.01–0.2 aspect ratio) or as a network of cross-cutting metre- to kilometre-scale sheeted dyke swarms. Zoned intrusions with obvious quartz core zones are rare. The rocks show porphyritic and fine- to very coarse-grained equigranular textures defined by four distinct paragenetic assemblages. The first assemblage is magmatic, the second and third are magmatic–hydrothermal, and the last is hydrothermal. Spodumene is the main Li mineral, forming crystals a dozen micrometres to a few centimetres wide and a few hundred micrometres to a metre long. This mineral, common to the last three assemblages, occurs as veins and disseminations in the aplite–pegmatite intrusions. The latter are locally faulted and form east-trending elongate domes (sheath folds) and variously oriented dykes on the margins of the plutons. Intra-plutonic and closely to gently folded dykes are also found locally. The dykes commonly exhibit slickenlines on their sides with no obvious related internal strain, which indicates that they crystallized in pre-existing faults with folded aplite–pegmatite dykes indicating hypersolidus deformation. Where present, the layering of these rocks is best ascribed to magmatic differentiation and/or multiple injections of low-viscosity magmas under a horizontal constriction strain regime during late Archean exhumation. It follows that the aplite–pegmatite dykes in the Lamotte–Lacorne area are late- to post-tectonic, decompression-related intrusions in damage zones of pre-existing major faults on the margins of early-formed monzogranite and granodiorite plutons.

AURIFEROUS ALTERATION AND QUARTZ VEINS WITH SPECIFIC LITHIUM ISOTOPIC RATIOS AT COCHENOUR, RED LAKE, CANADA

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Although minerals such as biotite, chlorite, white micas (sericite), and vein quartz are often characteristic of Au mineralization, they are generally not truly diagnostic since they also usually occur outside the ore zones. Here, δ^7Li signatures are measured in drill cores cutting through metasomatized basalt from the Cochenour orogenic Au deposit, Red Lake, Canada, to verify whether Au ore-related biotite, chlorite, white micas, and quartz have specific δ^7Li signatures. Laser ablation-ICP-MS maps show that in the 'arsenopyrite-bearing replacement-style' alteration and mineralization, Au is associated with arsenopyrite, pyrrhotite, and chalcopyrite in the ore zone, but is more concentrated in white mica than in sulphide phases outside the ore zone. In the cross-cutting 'quartz–actinolite vein-style' alteration and mineralization, the maps show Au distributed with chalcopyrite and arsenopyrite in the selvages of the veinlets, but associated with pyrite, calcite, and biotite outside the ore zone. Mass balance calculations suggest that Au ore-related biotite, chlorite, white mica, and quartz have δ^7Li values of ~+4‰, ~0 to +2‰, ~–2‰, and ~+6 to +12‰, respectively. This is explained by Li isotopic fractionation occurring during the retrograde sequence of auriferous biotite–chlorite–white mica alteration and the late auriferous quartz vein event, identified at the Cochenour deposits, in the Red Lake-Campbell mine complex, and throughout the Red Lake greenstone belt. In the 'arsenopyrite-bearing replacement-style' alteration, the intercorrelation of δ^7Li and Au, and their correlation over distance, show greater amounts of Au in biotite-enriched rocks, where biotite has a δ^7Li value of ~+4‰, indicating a mantle source for the early biotite-related auriferous fluids.

SHRIMP U–Th–Pb DATING OF TIN MINERALIZATION AND ASSOCIATED TECTONIC PROCESSES

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Secondary ion mass spectrometry (SIMS) U–Th–Pb dating of cassiterite, zircon and monazite by sensitive high resolution ion microprobe (SHRIMP) has provided direct measurements of the ages of Mesoproterozoic–Neoproterozoic pegmatite and quartz vein Sn mineralization in the Karagwe-Ankole Belt (KAB), Rwanda, and through dates on local igneous rocks, helped to place the mineralization in a tectonic context. Internal textures of the cassiterite are defined by trace element distribution with an enrichment of Ta, Nb, Fe, V, Al, and U in darker cathodoluminescence bands relative to lighter bands, with the majority of the dated cassiterite containing

≤ 1 ppm U. Three stages of Sn mineralization have been identified. The first stage occurred at ca. 1145 Ma. The second stage, which corresponds to the main episode of Sn mineralization, occurred from ca. 1090 to 960 Ma. It started during the period ca. 1090–1040 Ma with fault-controlled Sn mineralization in quartz veins hosted in quartzite and intra-pegmatitic greisen. This was mainly coeval with the ca. 1078 Ma orogenic event in the KAB during the final amalgamation of Rodinia. Peak Sn mineralization occurred during the period ca. 1040–960 Ma in quartz veins hosted in mica schist related to shear zones. It was associated with S-type granitic magmatism, with zircon U–Pb and monazite Th–Pb ages between 1011 ± 18 Ma and 976 ± 11 Ma, possibly related to a late/post-collisional setting linked to the amalgamation of Rodinia. The third and distinct stage of Sn mineralization occurred at ca. 530 Ma in quartz veins hosted in mica schist within a shear zone located close to reworked basement rocks with meridional foliation. The links established between the mode of Sn mineralization, its local geological setting, igneous activity, and regional tectonism, will help in targeting exploration for ore-grade Sn deposits in Rwanda and nearby countries.

PEGMATITES ARE NOT GEOPHYSICAL NON-RESPONDERS

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Pegmatite bodies have for too long been falsely described as geophysical non-responders and can be expressed directly or indirectly in high-resolution and high-quality geophysical and remote sensing datasets, when in the right geological environment. For example, gamma-ray spectrometry surveying can identify surficial pegmatite bodies as discrete potassium anomalies when background levels are adequately considered, and microgravity surveying can delineate pegmatite which intruded into denser lithologies as discrete and linear gravity lows. This presentation will showcase a selection of successful examples of contemporary applications of geophysics for pegmatite exploration from Canada and Australia.

REGIONAL ZONATION OF RARE-ELEMENT PEGMATITES: IMPLICATIONS FOR GENESIS AND EXPLORATION

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Contemporaneous lithium-cesium-tantalum (LCT) and niobium-yttrium-fluorine (NYF) pegmatites are emplaced within the same overall post-collisional tectonic setting in both the Kibaran Orange River Pegmatite Belt (~1000 Ma South Africa) and within the Central Zone of the Pan-African Damara inland belt (Namibia). Mineralogical distinction between these two types of pegmatites in both orogens has been achieved by previous work and our current work shows that there is a geochemical distinction between these two rare-element groups using whole-rock data. This distinguishes between uranium-enriched pegmatites of NYF affinity (Rössing-type) and Li-, Sn-, Gem tourmaline-bearing pegmatites of LCT affinity. The distribution of LCT and NYF pegmatites has been investigated using a mineral systems approach which shows that the different pegmatite types are restricted to particular metamorphic zones within the orogens. This provides a contrast to work undertaken in the 1930s which suggested zonation of pegmatite types around particular granites. Conversely, we suggest that metamorphic processes, particularly anatexis, are key to understanding the formation of granitic pegmatite melts. It must be emphasized that this does not preclude fractionation as an important mechanism for rare-element enrichment in pegmatites. Recent recognition of successive partial melting events, the duration of metamorphism, and variable partitioning of trace elements between muscovite and biotite in melt, restite and peritectic components under varying metamorphic conditions, allows an interpretation of the genesis of these pegmatites to be principally related to metamorphic conditions rather than zonation with respect to parental granites. This work shows that rare-element enrichment and pegmatite types are not always distinguished by tectonic setting, whole-rock data can be used to distinguish pegmatite types and that there is no need for a dichotomy between so-called "anatectic" pegmatites and those produced as a product of the fractionation of large granite bodies to explain rare-element enrichment. This assists in the identification of prospective areas with orogenic environments.

APATITE COMPOSITIONAL SYSTEMATICS AS AN INDICATOR OF FRACTIONATION IN LITHIUM-CESIUM-TANTALUM PEGMATITES: A CASE STUDY FROM THE LATE ARCHEAN YELLOWKNIFE PEGMATITE PROVINCE, NORTHWEST TERRITORIES, CANADA

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Apatite is a minor to accessory ubiquitous mineral in granitic and pegmatitic rocks, capable of tracking magmatic fractionation and petrogenetic evolution due to its ability to incorporate several key trace elements including rare earth elements into its structure. Compositional analysis of apatite is employed in this study to investigate granite fractionation and fertility of lithium-cesium-tantalum pegmatite bodies in the Slave Craton. Granitic pegmatites of the Late Archean Yellowknife Pegmatite Province hosted within the Slave Structural Province are potential sources of rare metals, such as Li, Ta, Nb, and Sn. Pegmatite occurs as dykes in both metasedimentary sequences and granitic rocks, commonly in swarms. The geological and mineralogical characteristics of such pegmatite vary significantly with both mineralized and barren pegmatite occurring together within the same cluster, thus hindering regional assessment. Polished sections from five pegmatite dykes in the region (Best-Bet, Hidden Lake, Moose II, Pancho, and Riber) were scanned by μXRF-EDS to understand apatite's association in the assemblage. Over 170 spots were analyzed of primary pegmatite-hosted apatite by laser ablation-inductively coupled plasma-mass spectrometry for a suite of 36 elements from samples collected from these dykes. The pegmatite bodies have generally low Eu/Eu*, La/Yb, Y/Ho, with maximum values of 3.5, 13 and 51 respectively. Pegmatite bodies at Hidden Lake have the highest Ca/Sr median ratios (12,628) followed by Best-Bet (650), corresponding with lowest median ratios < 0.5 for Fe/Mn, thus suggesting these pegmatite bodies are the most fractionated. This is supported by very low whole-rock and muscovite K/Rb and K/Cs values less than 20 and muscovite chemistry, which indicated pegmatite at Best-Bet as most fractionated and Riber as least fractionated based on their K/Rb and K/Cs ratios. This study highlights the potential of apatite composition to assist in deciphering petrogenesis and lithium fertility of pegmatite when coupled with other tools such as muscovite and K-feldspar chemistry.

NEOTECTONIC ACTIVITY IN PRINCE EDWARD COUNTY, ONTARIO: INSIGHTS FROM POTENTIAL-FIELD DATA AND SEISMICITY RECORDS

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Seismicity in Eastern Canada, particularly in southern Ontario, is often neglected due to the moderate frequency and magnitude of earthquakes documented, excluding the St. Lawrence region. The seismic activity is interpreted to result from a combination of tectonic stress and glacial isostatic adjustment leading to reactivation of Precambrian basement structures. However, the relationship between documented seismicity and subsurface structures remains elusive, particularly in the Prince Edward County region, which is situated on the northern shore of Lake Ontario. Here, infrequent, moderate (M ≤ 3.8) seismicity is documented. This study aims to determine if the documented seismicity can be attributed to basement fault systems. Comparison of the Prince Edward County epicentral data from 1840 to 2024 with the interpretation of NE–SW trending magnetic lineaments to delineate subsurface fault systems including the Clarendon-Linden Fault System, Picton Fault, and Salmon River Fault reveals recorded seismicity may cluster near interpreted basement structures indicating their involvement in ongoing seismicity. Earthquakes are recorded up to 18 km depth, most frequently at 2, 5, and 18 km which may correspond to subsurface discontinuities within the Silurian, Ordovician, and Precambrian basement requiring further investigation.

https://doi.org/10.12789/geocanj.2024.51.211

DIVERSE MINERAL ASSEMBLAGES OF PRIMARY Be-MINERALS FROM INTRAGRANITIC PEGMATITE OF THE TŘEBÍČ PLUTON, MOLDANUBIAN ZONE, CZECH REPUBLIC; AN EFFECT OF EARLY TOURMALINE CRYSTALLIZATION

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The effect of early tourmaline crystallization on sequestration of primary Be-minerals (beryl, helvine–danalite) was investigated in intragranitic niobium-yttrium-fluorine pegmatite bodies from the Třebíč Pluton, Czech Republic. The following textural and paragenetic types of primary and secondary tourmaline were distinguished: primary (a) abundant coarse- to medium-grained aggregates and short prismatic crystals; (b) graphic intergrowths of tourmaline + quartz; (c) rare fine-grained nodules (Tur + Qz + Pl + Kfs); secondary and subsolidus (d) rare tourmaline pseudomorphs after biotite; (e) abundant interstitial tourmaline in thin fractures or intergranular spaces. Chemical composition of primary tourmaline (a), (b) and (c) varies from Ca, Ti-rich Fe-dravite to Mg-rich and Mg-poor schorl to dutrowite both with low to moderate Al (5.1–6.1 apfu), variable Mg (0.1–1.9 apfu) and Fe (1.3–2.2 apfu) low to moderate Ca (0.1–0.4 apfu), typically enriched in Ti (up to 0.5 apfu) and low X-site vacancy. More evolved tourmaline (a) with moderate to high Al (5.9–6.9 apfu), low Mg (≤ 0.4 apfu), high Fe (1.6–2.9 apfu), low Ca (≤ 0.19 apfu) and variable X-site vacancy (0–0.41 pfu) is rare (helvine–danalite pegmatite Číměř I). The interstitial tourmaline (e) is typically Mg-enriched. Two distinct assemblages of Be-minerals were recognized: the assemblage B (beryl ± phenakite) occurs typically in pegmatite with rare interstitial tourmaline (e) whereas the assemblage HD (helvine–danalite ± phenakite) is characteristic for pegmatite with abundant early tourmaline (a). The assemblages of primary Be-minerals in the individual pegmatite bodies manifest how crystallization and abundance of early tourmaline control origin and chemical composition of successive primary Be-minerals. Helvine–danalite is poor in the compatible (Al, Mg, Zn) and enriched in the incompatible (Mn) elements with the tourmaline structure whereas beryl occurs in beryl pegmatite with rare interstitial tourmaline (e).

PETROPHYSICAL AND SEISMIC FACIES ANALYSIS OF THE TERTIARY AGBADA FORMATION, SIGMA FIELD, OFFSHORE NIGER DELTA BASIN, NIGERIA

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The Niger Delta is an extensional rift basin that occurs within the failed rift of the Benue Trough. The Paleogene–Neogene strata of the basin consist of a > 12 km thick succession of overall regressive, off-lapping sediment of mainly deltaic origin. Broad lithologic arrangement of the succession is defined by contiguous facies of prodelta (mudrock lithofacies of the Akata Formation) through delta front (sandstone lithofacies of the Agbada Formation) to delta plain (mixed mudrock–sandstone lithofacies of the Benin Formation) deposits. This study intends to delineate the extent of subsurface distribution of the sandstone lithofacies units of the lower part of the Agbada Formation in the oil-producing "Sigma" Field, offshore Niger Delta. Data from core, wireline logs, seismic attribute extraction, seismic velocity modeling, and identification of hydraulic flow units are collected. Integration and interpretation of the collected data allowed recognition and delineation of the reservoir sandstone of the Agbada Formation. Results show that the prograding delta front to possibly delta plain facies were composed of thick and laterally extensive arkose. Wireline logs were used to correlate the tops and bases of the reservoir sands showing their lateral continuity across the study area. The boundaries are marked by thin shale bodies of deeper depositional setting. The collected data, along with data from previous studies, demonstrate that successive relative sea level rises and drops resulted in at least eleven major cycles of retrogradational–progradational megasequences. These fluctuations controlled the depositional locations of the three deltaic formations. High seismic resolution allowed mapping of both synthetic and antithetic faults with appreciable vertical displacements. The outcome of this research is deemed to facilitate reliable hydrocarbon exploration and production practice with reduced cost and risk. It can also be a guideline for subsequent studies in the Sigma Field and existing and potential hydrocarbon sites within the basin.

GEOSCIENCE COMMUNICATORS IN CANADA: INSIGHTS FROM A NATION-WIDE SURVEY AND EXPERT INTERVIEWS

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Geoscience communicators (those who communicate geoscience to non-technical audiences) are increasingly looked upon to develop innovative ways to engage public audiences. Limited research has evaluated their communication approaches, tactics (e.g. showing warmth, framing) used, formal and informal training, and what motivates and limits them. Through a comprehensive Canada-wide survey, part 1 of this research study determined that communicators are aware of and use the science communication models (deficit, dialogue, and participatory) in planning their engagements. Furthermore, it was determined that few have formal geoscience-specific communication training. Part 2 aims to gather further qualitative evidence to: 1) support the survey findings, and 2) identify themes unique to various communicators (e.g. informal educators, geo-artists, geoscientists). By evaluating these factors, we can understand what support communicators need to communicate geoscience effectively. Expert interviews were conducted with representative communicators of various sub-disciplines of geoscience communication, including informal youth education, geo-heritage/tourism, geoscience policy, stakeholder engagement, geo-art, knowledge mobilization, and public outreach. The transcribed data from semi-structured interviews were evaluated using a thematic analysis approach. Preliminary results indicate that the participatory model has theoretical promise but isn't necessarily appropriate for all forms of communication. Tactics prioritized by communicators varied depending on the communication medium and the individuals' exposure to tactic-specific training. Findings suggest that communicators across Canada need more geoscience and tactic-specific science communication training.

FEELING STRESSED: MAKING SENSE OF MULTIPHASE PALEOPIEZOMETRIC ESTIMATES IN METAMORPHIC CRUST

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The middle to lower crust is mineralogically diverse and heterogeneous in the fact it can include several different interlayered lithologies or protoliths. Moreover, the metamorphic reactions that operate under middle to lower crustal conditions can influence the rheology of certain (solid solution) metamorphic minerals, adding further complexity to the rock record that is difficult to replicate in experiments. Estimating flow stress directly from microstructures of multiple phases in a sheared metamorphic rock may enable more realistic interpretations of natural flow stresses in middle and lower crustal settings. In this talk we present paleostress estimates, derived from subgrain-size piezometry, for three exhumed shear zones that deformed at varying metamorphic grades: 1) an upper greenschist- to amphibolite-facies continental margin shear zone from Northwest Territories, Canada; 2) a relatively dry eclogitic intracratonic shear zone overprinting granulite-facies rocks from central Australia; and 3) an exhumed subduction channel with heterogeneous epidote blueschist mélange to eclogitic blocks from Syros, Greece. In these three case studies, we discuss the impacts that tectonic setting and attendant metamorphic conditions, namely mineral composition, water activity, and temperature, have on estimated paleostress. By combining EBSD analyses with conventional geothermobarometry and pseudosection modelling, we directly link estimates of paleostress to a specific point in a shear zone's metamorphic history. Across all three studies, the stress estimated with the subgrain-size piezometer reflects the final strain event in a shear zone's deformation history, with varying degree of both stress and strain partitioning resulting in a broad range of macro and microstructures.

"DO BRITISH COLUMBIANS KNOW CANADA HAS VOLCANOES?" INITIATING VOLCANIC HAZARDS COMMUNICATION AND EDUCATION IN CANADA

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British Columbia (BC) is a volcanically active province containing 26 Holocene volcanic fields and complexes. Despite a rich volcanic history, research on these volcanoes is limited, with no continuous operational monitoring currently in place. As part of a broader "Volcano Risk Reduction in Canada" project, this research aims to increase community resilience to volcanic hazards in a region without eruptions in living memory. In mid-2022, interviews were conducted with 14 stakeholders in the Squamish–Lillooet Regional District in southwestern BC, where two "Very High"-threat volcanoes, Qwélqwélústen (Mount Meager) and Nch' ay (Mount Garibaldi) sit. The findings show there is currently no specific emergency plan for volcanic hazards due to the infrequency of volcanic activity. While stakeholders are aware of the potential volcanic hazards, they are uncertain about what to expect during an event, expressing a need for information like eruption probability, affected areas and consequences, recommended protective actions, and event time-frames. A province-wide survey was conducted in early 2023 to assess public knowledge and awareness of Canadian volcanic hazards. With > 2980 respondents, the results challenged previous assumptions, indicating that public awareness is more substantial than previously thought: only 3% of participants were unaware of volcanoes in Canada, with a majority recognizing BC's location within the Pacific Ring of Fire. Despite the high awareness, we found that respondents overestimated certain hazards, like pyroclastic density currents and volcanic gases, while underestimating others, such as volcanic ash. Effective communication approaches for conveying volcanic hazard information were also examined. While hazard maps, signage, and videos were generally favoured, preferences varied among age groups, with older individuals preferring virtual tours compared to younger groups. These findings underscore the importance of tailored communication strategies based on demographic factors. As a first-of-its-kind study in Canada, these outcomes will form a solid foundation for future volcano risk reduction.

TECTONIC HISTORY AND PROVENANCE ANALYSIS OF THE PALEOPROTEROZOIC BELCHER GROUP, NUNAVUT

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The Paleoproterozoic sedimentary–volcanic Belcher Group was deposited during several notable transitions in Earth's history, including major changes in atmospheric and oceanic O_2 and the amalgamation of the Nuna supercontinent. In particular, the upper Belcher Group records the dynamics of the Trans-Hudson orogen as it relates to the western Superior cratonic margin. The Belcher Group largely escaped significant deformation, preserving bed-by-bed primary sedimentological structures, and experienced only prehnite-pumpellyite-facies metamorphism, thus preserving an excellent geological record of the Orosirian Period. The ca. 1854 to 1835 Ma upper Belcher Group coincides with important orogenic events that led to the closure of the Manikewan Ocean. However, the analysis of its source terranes for the syn-orogenic strata has not been rigorously tested, leaving gaps in our understanding of its provenance. Additionally, previous geochronological data have been limited to U–Pb methods. Here we show that sedimentary sources change greatly throughout the Belcher Group via provenance analysis using coupled detrital zircon U–Pb and Hf isotope data. We identify specific blocks within the Superior craton that were exposed and eroded during the deposition of the lower and middle Belcher Group, supporting an autochthonous to parautochthonous position of Belcher strata. A change in provenance from dominantly Archean to dominantly Paleoproterozoic sources occurred in concert with a change in paleoslope during the deposition of the upper Belcher Group. A primary age peak from ca. 2000 to 1840 Ma in the Omarolluk Formation and ca. 1950 to 1855 Ma in the Loaf Formation are associated with dominantly juvenile, positive εHf values that overlap between the two units, suggesting similarities in provenance. Using GPlates visualizations, we identify specific provenance sources during the closing stages of the Manikewan Ocean from ca. 1850 to 1830 Ma that, contrary to previous interpretations, are not solely limited to the Sugluk block.

TESTING THE PROVENANCE OF OMAR GLACIAL ERRATICS IN MANITOBA GLACIAL TILL: PRELIMINARY RESULTS AND INSIGHTS FROM THE OMAROLLUK FORMATION IN THE BELCHER ISLANDS, NUNAVUT

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We present preliminary results in an effort to test methods that can confirm the provenance of "omar" erratics as being derived from the Omarolluk Formation of the Paleoproterozoic Belcher Group in Belcher Islands, Nunavut, Canada. The glacial erratics, commonly referred to as omars, have long been proposed to have been eroded from the Omarolluk Formation and transported by the Laurentide Ice Sheet into Manitoba and as far west as central Alberta. This interpretation has been based on the distinct visual similarities between omars and the Omarolluk Formation, such as the presence of rounded, calcareous concretions within the greywacke. However, the provenance of omar erratics has not been tested with quantitative methods such as geochronology and geochemistry. Representative samples of the Omarolluk Formation were collected in the context of measured sections during the 2023 field season in the Belcher Islands, Nunavut, and are compared to omars collected from a variety of localities across Manitoba. A preliminary comparison between the whole rock geochemistry of the Omarolluk Formation and omar samples shows similar rare earth element signatures. Furthermore, preliminary concretion photo analysis shows a distinction between a primary and secondary concretion growth that will be further investigated between omars and the Omarolluk Formation. The hypothesis that omars are derived from the Omarolluk Formation is in the early stages of being tested by our selected research methods. Confirming the provenance of omar erratics is an essential component to provide constraints on Laurentide Ice Sheet dispersal patterns.

BARROVIAN THROUGH CONTACT METAMORPHOSED PELITES: THE NATURAL RECORD

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Thermodynamically calculated phase diagrams underpin our ability to make inferences about the formation conditions of metamorphic rocks (how hot and how deep), and ideally how these conditions have changed with time. The broader geoscience community relies on metamorphic petrology and petrologists to provide this unique information required to understand crustal evolution and other important Earth processes. A minimum requirement for such modelling is the reproduction of repeated patterns of natural mineral assemblages and mineral compositions. Current thermodynamic models (meaning end-member thermodynamic data combined with *a*–X models) do a good job at reproducing some but not all of these, both in metapelite and metabasite. This presentation focuses on a substantial natural database of metapelite metamorphosed over a range of grades from regional Barrovian to contact metamorphic conditions (319 localities; 3138 samples; 11,707 mineral analyses). First, consistent prograde mineral assemblage sequences as a function of pressure are identified. Second, mineral compositional variations (inter-mineral and intra-mineral) in these sequences of differing pressure are examined. Third, the results of different generations of thermodynamic models are assessed against the natural record. Finally, some suggestions are made for the next iteration of thermodynamic model development, in which as many reliable data as possible, both natural and experimental, are brought to bear.

https://doi.org/10.12789/geocanj.2024.51.211

KIMBERLITE DISTRIBUTION IN NORTH AMERICA: A PLATE TECTONIC PERSPECTIVE BEYOND THE 'JURASSIC CORRIDOR'

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The source of intraplate magmatism is a subject of ongoing debate, with two primary hypotheses put forward. These are deep-seated high-temperature sources (plumes), and shallow lithospheric processes, primarily intraplate extension driven ultimately by plate tectonics. A test region in this debate is the 'Jurassic Corridor,' a geological feature proposed to span North America, which contains igneous rocks including kimberlite intrusions that are attributed to the Great Meteor Hotspot (GMH). However, the existence of the GMH lacks supporting evidence. Here, we reassess the distribution of kimberlite in North America and on neighbouring landmasses. We demonstrate the lack of a clear Jurassic Corridor and argue instead that kimberlite and related rocks are more likely linked to the break-up of the Pangean supercontinent and controlled by lithospheric structures. Furthermore, by comparing these findings with global plate models for the last 300 M.y., we identify three prominent age peaks in North American kimberlite occurrence that broadly align with periods of heightened plate velocity with respect to Africa. Additionally, the analysis reveals that in Africa two peaks in kimberlite abundance, and two velocity peaks with respect to North America occur. Here, however, the velocity peaks occurred approximately 20–30 million years before the kimberlite abundance peaks. These observations underscore the significance of plate kinematics in controlling kimberlite magmatism and add to a growing body of work linking periods of tectonic upheaval to kimberlite production. The implications of this extend to our broader understanding of intraplate magmatism and warrant a global revaluation of similar phenomena.

TITHONIAN INTRUSIONS IN NEWFOUNDLAND AND ATLANTIC RIFTING

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The small volume, Mesozoic alkali gabbro intrusions of the Budgell Harbour and Dildo Pond stocks and associated alkaline lamprophyre dykes in Notre Dame Bay in Newfoundland are an example of onshore magmatism that may be associated with North Atlantic Ocean opening. Chemical abrasion isotope dilution thermal ionization mass spectrometry U–Pb dating of zircon from Budgell Harbour Stock drill core samples yielded a weighted average $^{206}Pb/^{238}U$ age of 147.9 ± 0.5 Ma (95% confidence interval, mean square weighted deviation = 0.10). Five $^{40}Ar/^{39}Ar$ laser step-heating, single phlogopite grain analyses from the Budgell Harbour and Dildo Pond stocks, plus a lamprophyre dyke, yielded ages ranging from 146.3 ± 0.2 to 149.5 ± 0.5 Ma. The data demonstrate a ca. 148 Ma (Tithonian, Jurassic) alkaline magmatic event in Newfoundland, contemporaneous with rifting and offshore basin formation. These new age data and published determinations from magmatic rocks on conjugate margins and adjacent regions reveal long-lived episodic magmatism in the embryonic North Atlantic rift environment. In addition, field-mapping and geophysical analyses have shown that in this small magmatic province the dykes form clusters at the ends of density and susceptibility anomalies, interpreted to be lobe-like magmatic conduits. Structural analysis indicates that emplacement of the dykes was controlled by pre-existing geological structures and that they have probably been deformed post-intrusion, potentially via the reactivation of pre-rift faults. We propose a new model whereby magmatism occurred in Notre Dame Bay at the convergence of older crustal-scale faults and localized Moho depth variations that may have triggered lithospheric mantle melting through isothermal, distal, and edge-driven upwelling related to regional extension. Finally, this study demonstrates that magma-poor margins, such as the Newfoundland margin, may host significant volumes of extension-related magmatic rocks, challenging the concept of a distinction between magma-rich and magma-poor rifting.

RAMAN SPECTROSCOPIC DIVERSITY OF LUNAR METEORITES

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Raman spectroscopy is a non-destructive technique for mineral identification and characterization. The lunar surface is primarily composed of olivine, feldspar, pyroxenes, and Fe–Ti oxides, all of which are identifiable by Raman spectroscopy. Having the first Raman spectrometer on the Moon would be an asset for the geological mapping of the lunar surface. Identifying and mapping the lunar surface could tell us more about the geological history and processes that have operated on the Moon. We collected Raman spectroscopic data from 12 lunar meteorites in this study. The data collected were on various spots of exterior surfaces, interior broken and saw-cut and polished surfaces, saw-cut powders, and fine-grained (<150 μm) powders. Raman spectra were acquired using a BWTek i-Raman spectrometer from 175–4000 Δ cm^{-1}, using a 532 nm laser and a spectral resolution of ~4 cm^{-1}. Spot size of each measurement is ~85 μm. The Raman spectra of the whole rocks generally had more discernible Raman peaks than the powdered samples. Meteorite whole rock slabs, NWA (Northwest Africa) 11303b and NWA 12593–96 exhibit Raman peaks associated with plagioclase feldspar ~505 ± 3 cm^{-1}. Olivine features occur in both meteorites around 800–880 Δ cm^{-1}. Unlike the whole rock slabs, the powdered samples lack identifiable peaks. This may be due to differences in scattering properties between whole rocks and powders. This demonstrates that Raman spectra of lunar meteorites yield resolvable and mineralogically diagnostic peaks and that Raman spectroscopy can aid in geological mapping of the lunar surface. A Raman spectrometer could provide mineralogical information on whole rocks and regolith (integration time dependent). The data we collected will aid lunar missions in the future that contain Raman spectrometers, such as the CNSA Chang'e-7 landed mission.

TALL TALES FROM THE MINAS FAULT ZONE: HOW A REPEATEDLY RUPTURED RHYOLITE MAY BE A GEOLOGICAL EXPRESSION OF A MICROEARTHQUAKE SOURCE

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Repeaters, or repeating microearthquakes, occur within creeping portions of fault systems. The recurrence interval of repeaters has been hypothesized to represent the rate of fault creep at depth in active faults under the assumption that the repeater is a locked patch surrounded by an otherwise creeping fault. Alternative models allow for some fault creep within the repeating patch. Here, we examine a rhyolite block entrained within a ductile shear zone which may have served as a repeating microearthquake source to provide geological constraints on geophysical observations. The fault zone forms part of the Minas fault system, Nova Scotia, Canada: an exhumed, late Paleozoic, strike-slip, plate boundary fault system. The rhyolite sits entrained in fine-grained phyllite which deformed through distributed pressure solution accommodated creep (in phyllosilicate-rich domains) and dislocation creep (in quartz-rich domains) at temperatures of ~350°C. The rhyolite is pervasively cross-cut by < 1 mm thick discrete fault surfaces, with individual offsets of 1–5 cm, and lengths constrained by the size of the rhyolite block (~20 m x 250 m). These fault surfaces are variably overprinted by ductile deformation in the phyllite indicating that brittle deformation in the rhyolite and ductile deformation in the phyllite were contemporaneous. We interpret that the rhyolite block represents an exhumed repeater source. Our observations support models that permit fault creep within repeating fault patches and further emphasize geological observations of thick, creeping fault systems.

USING APATITE AND ZIRCON CHEMISTRY TO CORRELATE ORDOVICIAN BENTONITE ACROSS SOUTHERN QUEBEC, ONTARIO, AND NEW ENGLAND

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The St. Lawrence Platform in southern Quebec contains altered volcanic ash beds, known as K-bentonite beds, which are found in Ordovician sedimentary basins throughout eastern North America. The chemistry of preserved zircon and apatite can provide chemical fingerprint of the different bentonite beds, and gain insights into their formation. In the Montreal area, the St. Lawrence Platform stratigraphy comprises Cambrian sandstone of the Potsdam Group, overlain by the Ordovician Beekmantown, Chazy, Black River, and Trenton groups, a series of alternating limestone, shale and dolomite that grades upward into rhythmite and turbidite beds in the Utica and Lorraine groups. Field work and drill core sampling allowed us to identify 39 cm-scale K-bentonite clay beds in the Trenton Group on Montreal Island. Additional beds have been collected in Ontario, New York and Vermont in presumably equivalent formations. To assess the utility of zircon and apatite chemistry as a correlation tool, major, minor and trace element composition of the separated crystals were measured using an electron microprobe and LA-ICP-MS. For apatite, Cl–F ratio, and certain trace elements (e.g. Mg, Mn, Eu, Nd), combined with dissimilarity calculations and multidimensional scaling work well as a stratigraphic correlation tool making it possible to correlate sedimentary units precisely across the Montreal area and understand their links with the bentonite beds in Ontario and New England. Precise correlations can be proposed between samples that are located tens to thousands of kilometres apart. Zircon chemistry is less diagnostic with most bentonite having zircon grains with similar compositions. However, apatite compositions and Ti in zircon allow us to determine that bentonite originates from I-type melts with a volcanic-arc origin. Further work involving zircon Hf isotopes and apatite Sr isotopes as well as U–Pb geochronology will be used to support our correlations and help determine the origin of these important volcanic deposits.

EVIDENCE FOR A METASOMATIC IRON ALKALI CALCIC SYSTEM AND AFFILIATE CRITICAL MINERAL DEPOSITS ALONG THE COBEQUID–CHEDABUCTO FAULT ZONE, NOVA SCOTIA: A CASE STUDY OF THE BASS RIVER COBALT PROSPECT

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Iron-rich hydrothermal mineral deposits are common along the regional Cobequid–Chedabucto Fault Zone (CCFZ) in northern Nova Scotia, but vary in terms of mineralogy and commodities, including Co-rich magnetite–pyrite–biotite breccia of the Bass River Prospect and the Cu–Au (± Co) bearing siderite–ankerite breccia of the Copper Lake deposit and Mount Thom deposits. We have found field evidence that these deposits are spatially associated with zones of intense Na-metasomatism, consistent with metasomatic iron alkali calcic (MIAC) systems that host base and critical metal deposits such as iron oxide copper gold (IOCG) and iron oxide apatite (IOA) deposits. In this contribution, we examine the Bass River deposit using petrography (including micro-X-ray fluorescence mapping and scanning electron microscopy), geothermometry (Ti-in-biotite) and geochronology (Rb–Sr-biotite) to determine the nature (alteration systematics, commodity potential, timing, temperature) of the deposit and whether it may be part of a larger MIAC system. The Bass River deposit is a polymictic, multiphase breccia showing strong Fe–K metasomatism (magnetite–biotite) infilling and replacing clasts of porphyritic and laminated volcanoclastic to siliciclastic rocks of uncertain origin (Neoproterozoic Jeffers Group?). The alteration paragenesis is characterized by i) early sodic alteration (albitization + scapolite) that replaced primary feldspar phenocrysts, ii) magnetite with biotite, Co-rich pyrite and trace REE, U, and Cu mineralization, and iii) Y-rich calcite (± apatite, quartz) veins. Late quartz contains primary polycrystalline inclusions consisting of carbonate, rutile, and quartz phases, and are currently being investigated as possible carbonate melt inclusions. Biotite geochronology/thermometry indicates metasomatism ~ca. 330 Ma and at ~500°C, near the end of the deposition of Windsor Group evaporite and coeval with bimodal volcanism in the region. These results are consistent with a number of current models for IOA–IOCG deposits in MIAC systems, where mineralizing carbonate–evaporite melts and associated Na-rich aqueous fluids produced Fe-rich critical mineral deposits in regional zones of metasomatic alkali alteration.

COMPLEX GENESIS OF REE MINERALIZATION IN ABYSSAL PEGMATITE AT ALCES LAKE (SASKATCHEWAN, CANADA) REVEALED THROUGH MONAZITE AND ZIRCON PETROCHRONOLOGY

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We present a petrochronological study of REE–Th–U mineralized pegmatite bodies at Alces Lake (Saskatchewan, Canada). The REE are hosted primarily in monazite–Ce-rich granitic to mafic residual melt/cumulate pegmatite bodies, which are found within or in close proximity to the Archean/Paleoproterozoic transition zone. The pegmatite bodies were emplaced under middle crustal P-T conditions, forming polyphase anatectic pods/boudins. The studied pegmatite from 2 selected zones (Wilson, Ivan) is predominantly peraluminous and composed mainly of a quartz–K-feldspar–plagioclase–Ti-rich biotite (+/–muscovite)–rutile–monazite–zircon assemblage. The objective of this research is to better understand the petrogenesis of the Alces Lake mineralization through monazite and zircon characterization (using micro-XRF, SEM, and EPMA) and LA-ICP-MS geochronology. Monazite occurs in the form of subhedral to fully rounded, corroded crystals, which are variable in size (up to several mm in diameter) and distribution. Monazite grains tend to have extremely high REE, high Th, and low U contents and form homogeneous to complexly zoned (concentric or patchy zoning) crystals. Zircon grains are locally abundant and typically occur in association with the monazite grains (within or adjacent to biotite), ranging in size from 50 to 600 μm in diameter. Zircon crystals are euhedral to subhedral to rounded, broken or fractured and can be locally clustered together. Zircon grains show either complex oscillatory or patchy zonation. U–Pb dating of monazite grains, yielding composite ages of 1945.7 ± 13 Ma (Wilson zone) and 1930.1 ± 12.7 Ma (Ivan zone), and zircon grains, yielding composite ages of 1859.2 ± 13.9 Ma (Wilson zone) and 1888.96 ± 5.8 Ma (Ivan zone), suggests a connection between REE mineralization and high-grade thermotectonic events associated with the Taltson, Snowbird, and Trans-Hudson orogenies. Consequently, after extensive multidisciplinary analysis, the Alces Lake mineralized pegmatite bodies are interpreted to have originated from processes involving partial melting, melt migration, assimilation, magma mixing, and fractional crystallization during overlapping thermotectonic events of the Taltson, Snowbird, and Trans-Hudson orogenies.

GEOPHYSICAL INTERPRETATIONS TO GUIDE EXPLORATION FOR REE–Th–U MINERALIZATION IN ABYSSAL PEGMATITES AT ALCES LAKE, SASKATCHEWAN, CANADA

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Rare earth elements (REE) are critical raw materials and are essential for our transition towards a low-carbon future. Hence global efforts are accelerating to develop sustainable supply chains for REEs and to explore for new discoveries. Geophysical methods have proved their effectiveness in delineating potential mineralized zones and guiding airborne and ground-based investigations during both greenfield and brownfield exploration projects. We document the integrated multisource method for REE exploration applied to a very promising, extremely high-grade prospect at Alces Lake (Saskatchewan, Canada). The study area is located in the Beaverlodge Domain, approximately 28 km north of the northern margin of the Athabasca Basin. The REE are found predominantly in monazite within pegmatite. The pegmatite exhibits compositions varying from quartzofeldspathic granitic to biotite–

https://doi.org/10.12789/geocanj.2024.51.211

garnet–monazite–zircon-rich restite-bearing/cumulate mush melt, originating from anatectic abyssal processes. The objectives of this research work are: 1) to map/characterize REE mineralization within the Alces Lake area and 2) to propose the exploration workflow for new REE discovery. This was achieved by analyzing and integrating multiscale geophysical (and geological) datasets. Combined geophysical (magnetic, gravity, and radiometric) data were used in conjunction with Shuttle Radar Topography Mission (SRTM) images to identify the major structures at different scales and help delineate mineralized zones. The resulting interpretations revealed that the REE zones identified so far are situated within a large district-scale refolded polyphase fold, with the eastern limb comprising a 30–40 km long, NW-trending shear zone or fault corridor. This corridor (but also the faults, folds, and lithological contacts collectively) served as the crucial pathway for ascending melts/fluids facilitating REE mineralization. The findings presented here offer new interpretations and modeling insights, improve our understanding of REE distribution and lithostructural controls at Alces Lake, and provide updated guidelines for forthcoming exploration initiatives at Alces Lake and elsewhere in northern Saskatchewan.

EARTHQUAKE PREPAREDNESS COMMUNICATION FOR YOUTH: AN ACTIVE LEARNING IDEA WITH REACH

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Natural disasters pose risks to the safety and well-being of communities and require proper preparation and knowledge to manage response and mitigate dangers. Providing resources for youth to foster critical skills in emergency preparedness is crucial to helping them navigate disaster situations, with the added benefit of helping us reach their connected adults. The Grab & Go Bag outreach activity was developed to engage youth in an interactive and creative way while providing the knowledge we want them to have to prepare for an emergency. Through the use of a dual-sided colouring page style "make and take" activity sheet, modified from information found on the British Columbia Government emergency management website, https://www2.gov.bc.ca/gov/content/safety/emergency-management/prepared-bc, we can facilitate a conversation with young people about what can be done to prepare for emergencies, giving them some agency in a scary situation. The page features information on the contents of the Grab & Go bag and how to assemble a shelter-in-place emergency kit. This activity is designed to attract children and youth through art while simultaneously informing them of the essential items to be included in an emergency to-go bag should they need to leave home, while allowing them to personalize it with other non-essential or everyday items. The activity combines pedagogical approaches to create a dynamic experience further encouraging and empowering youth to participate, retain, and learn more about emergency preparedness. During our pilot launch at the Canada Science and Technology Museum's Cool Science Saturday event in February 2024, we encouraged participants to make and take their project home, thus expanding its reach to families and peers. The Grab & Go bag outreach activity aspires to approach preparedness and awareness engagingly and memorably while giving Earth science communicators the opportunity to help members of all ages navigate disaster planning and emergency events.

LITHOSTRATIGRAPHIC AND STRUCTURAL RELATIONS OF SUPRACRUSTAL ASSEMBLAGES ALONG THE SNOWBIRD TECTONIC ZONE AT ANGIKUNI LAKE, NUNAVUT, CANADA

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The Snowbird Tectonic Zone (STZ) is a major crustal-scale structure separating the Archean Rae and Hearne cratons of the Canadian Precambrian shield. The origin of this crustal-scale fault zone has been widely debated, having been variably interpreted as a Paleoproterozoic (ca. 1.9 Ga) suture or rift zone, or an Archean (ca. 2.6 Ga) suture or intracratonic fault that was reactivated in the Paleoproterozoic. This study will investigate three low-grade supracrustal assemblages (Henik Group), variably preserved in fault-bounded domains along the STZ in the Angikuni Lake area of Nunavut. Two of these assemblages contain laminated dolostone units, suggesting that they may be Paleoproterozoic. The primary goal of this thesis is to determine the make-up, age (Archean vs. Paleoproterozoic) and tectonic setting of these assemblages and evaluate how these findings bear on the origin and timing of the STZ. A secondary goal is to evaluate the structural–metamorphic history of these rocks, and their relationship to surrounding high-grade rocks. Preliminary research (summer, 2023) has included study of a large archival sample collection at the Geological Survey of Canada (GSC). In addition to gaining familiarity with the mesoscopic-scale characteristics of rocks and units, samples were selected and prepared for whole rock multi-element geochemistry, U–Pb geochronology and petrography. Field research will take place in July 2024/2025 in collaboration with the GSC and will involve lithostructural mapping and additional sampling for geochemistry and geochronology. Geochronology will target key volcanic units, cross-cutting igneous units that bracket the timing of deposition and deformation, and detrital zircon from relevant siliciclastic units. Preliminary U–Pb SHRIMP zircon data indicate that dolostone and sandstone units on the northwest side of the lake are deposited upon ca. 2.6 Ga felsic extrusive rocks. The outcomes of this project will contribute valuable insights into the origin of the STZ, with broader implications for understanding the tectonic assembly of Laurentia.

TECTONIC EVOLUTION OF 1.3 GA REE-BEARING FOX HARBOUR VOLCANIC BELT, SOUTHEAST LABRADOR: A STRUCTURAL AND PETROCHRONOLOGIC STUDY

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Southeastern Labrador preserves a complex geological history including Paleoproterozoic to Mesoproterozoic convergent orogenic systems separated by extensional periods at ca. 1.46–1.23 Ga. These tectonic stages are preserved within various shear-bounded terranes composed of mostly felsic to mafic plutonic rocks and metasedimentary rocks. One such terrane (the Lake Melville terrane) occurs within a high-strain corridor over 300 km long and 20 km wide where pervasive high-temperature deformation is recorded at ca. 1.6 Ga with minor Grenvillian reworking at ca. 1.0 Ga. Revisiting the timing, magnitude, and continuity of this high-strain corridor is needed, since the discovery of the highly deformed and metamorphosed 1.3 Ga REE-hosting Fox Harbour bimodal volcanic belt (FHVB) suggests a more prominent role of Grenvillian deformation. This work aims to characterize the structural patterns that control the geometry of the FHVB and associated shear zones while also placing age constraints on deformation fabrics and anatectic metamorphism in order to unravel the tectonic history of this region. Detailed field observations combined with structural and microstructural petrographic analyses, were used with geophysical maps to establish the location of structural domains and bounding shear zones. We used U–Pb chemical abrasion LA-ICP-MS analysis on zircon to provide insights into protolith, depositional, and metamorphic ages within the study area. In situ titanite U–Pb petrochronology further constrains the timing of tectonic fabric development across the study area. We suggest that the Grenville-age high-temperature deformation (1.0 Ga) was pervasive across the study region in contrast to previously suggested narrow, low-temperature, locally mylonitic shears. Shortly after peak metamorphism, major bounding shear zones were active at ca. 1.0 Ga, facilitating the exhumation of the FHVB domain. This work highlights the necessity to combine detailed field observations with multiple petrochronometers in order to define ages of metamorphism and fabric development in polydeformed terranes.

BROAD-BAND TOTAL FIELD AIRBORNE NATURAL SOURCE ELECTROMAGNETICS: CAPABILITIES OF DETECTING AND IMAGING MINERAL RESOURCE SYSTEMS

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Utilizing an airborne approach to measure natural magnetic field variations in the air alongside electric field variations at a ground base station, the method known as

audio frequency magnetotellurics (a passive field method) significantly enhances the depth of investigation and broadens the resistivity detection range when compared to controlled-source primary-field methods. Field case studies of the MobileMT natural field system demonstrate its efficacy in various applications, including the exploration of unconformity uranium mineralization, along with associated minerals, epithermal gold, polymetallic bearing structures, porphyries, and pegmatite bodies. These case histories serve to highlight the capabilities of airborne natural electromagnetic field technology in reconstructing geoelectric models and identifying their distinct patterns.

LA-ICP-MS ANALYSIS OF TRACE ELEMENTS IN QUARTZ RELATED TO Mo–Cu MINERALIZATION OF LAKANG'E PORPHYRY Mo (Cu) DEPOSIT IN TIBET – IMPLICATIONS FOR THERMAL HISTORY AND FLUID CHEMISTRY

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The Lakang'e porphyry-type molybdenum (copper) deposit is located in the Gangdese metallogenic belt in Tibet and represents one of the youngest (Miocene) post-collisional mineralization events. Previous studies suggest that variations in temperature, pH, pressure, and redox are potential factors leading to Mo–Cu precipitation, but it remains unclear which of these variables is dominant. Laser ablation-ICP-MS analyses of trace elements in mineralization-related quartz were conducted to shed light on this problem. The studied quartz includes that in the unidirectional solidification texture (UST), A-vein (quartz–biotite–molybdenite–pyrite), B1-vein (quartz–molybdenite–pyrite–chalcopyrite), B2-vein (quartz–biotite–molybdenite–pyrite–chalcopyrite), and D-vein (quartz–pyrite–chalcopyrite–calcite). Cross-cutting relationships suggest a paragenetic sequence of UST–A–B1–D, but the relative timing of B2 is unclear. The determined Ti content in quartz gradually decreases from UST (avg. 69 ppm), through A (20 ppm), B1 (17 ppm), D (7 ppm), to B2 (2 ppm), corresponding to a decrease of temperature from 607°C to 361°C. In contrast, the Al content of the vein quartz is highly variable: UST (avg. 571 ppm), A (135 ppm), B1 (57 ppm), D (152 ppm), and B2 (219 ppm), likely indicating fluctuating fluid pH. The Ti and Al contents in quartz also decrease from the core to margin of a B1 vein, in which molybdenite postdates the quartz, suggesting that cooling and pH increase are main controls to Mo mineralization. On the other hand, the As, Sb and Ga contents of quartz in B2 are higher than in B1 veins, suggesting that the B2 vein may represent a distinct mineralization event. Furthermore, there is a spike in Ti and Al within B2, which coincides with quartz dissolution as revealed by cathodoluminescence (CL), indicating a thermal pulse. The trace elements in quartz from the Lakang'e deposit indicate a dynamic hydrothermal system with fluctuating temperature and pH parameters but with an overall trend of cooling and pH-increase.

INTERPRETING TEXTURES IN MINERALIZATION AT THE TORBRIT Ag DEPOSIT, DOLLY VARDEN PROPERTY, KITSAULT VALLEY AREA, NORTHWESTERN BRITISH COLUMBIA

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The Torbrit Ag–Zn–Pb–Ba deposit occurs in a trend of Ag deposits in the Kitsault Valley area, which are hosted by early Jurassic age (178.1 ± 2.2 Ma) intermediate volcano-sedimentary rocks of the upper Hazelton Group and deposited as part of a volcanic arc sequence within the Stikinia island arc terrane. Torbrit consists of a stratiform and stratabound series of mineralized pods, with mineralization styles varying from exhalative to epithermal-style veins. The primary ore minerals are Ag-sulphosalts and Ag-sulphides. Gangue minerals consist of quartz, jasper, barite, carbonate, Fe-oxide phases, and base metal sulphides. Samples from historic drill core were subjected to micro-XRF analysis and standard petrography. Bruker M4 Tornado micro-XRF element maps for twenty-five samples were acquired at a step size of 100 µm and a dwell time of 10 ms. An early Ag-bearing phase of mineralization shows exhalative textures (sinter-style banding and bedded exhalite), with later vein-hosted mineralization showing epithermal-style boiling and open space-filling textures (colloform or crustiform banding and bladed barite). Widespread brecciation occurred after Ag-bearing fluid flow had ended, with later breccia fill diluting the grade of preexisting mineralization. We propose that the Torbrit deposit formed in a shallow-water white smoker-dominant hydrothermal field setting, the subaqueous analogue of an epithermal system. This setting would explain the presence of coexistent exhalative and epithermal-style mineralization, as well as a relative lack of base metal sulphide minerals due to the proposed lower temperature of the system (< 200–250°C).

THE SOUTH PLATT PEGMATITE DISTRICT OF COLORADO: NEW INSIGHT INTO MINERALOGY, PETROLOGY, AND RARE EARTH ELEMENT FRACTIONATION

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Pegmatites associated with 'A-type' (anorogenic) ferroan granite, such as that in the South Platte pegmatite district of the 1.08 Ga Pikes Peak granite (PPG) batholith, are of particular interest. Many aspects of the formation of the South Platte pegmatite bodies are still unclear, specifically whether the REE-rich minerals in the pegmatite are the result of an already REE-enriched parental granitic magma, the result of extreme fractionation concentrating REE during pegmatite crystallization or derived from an influx of REE-rich fluids unrelated to the PPG. We address these questions at the example of a small (~5 m × 5 m × 5 m) concentrically zoned pegmatite. An Nd-isotope value of $\varepsilon Nd_{1.08\ Ga} = -1.6$ is within the range of $\varepsilon Nd_{1.08\ Ga} = -0.2$ to -2.7 of the host PPG, indicating that REE and other pegmatite constituents derived from the parental PPG magma. A calculation of total pegmatite composition based on whole rock chemistry reveals an overall composition similar to the PPG with respect to Si, Al, Na, and K, yet depleted notably in total REE compared to the PPG. Despite the abundance of different REE minerals, the lack of a net overall REE enrichment of the pegmatite compared to the PPG suggests that the pegmatite formed by the separation from the PPG magma of an H_2O-saturated silicate melt depleted in REE and HFSE. Homogenization temperatures of < 500°C are consistent with recent models of pegmatite petrogenesis leading to nucleation-controlled mega-crystal growth resulting from supercooling. We therefore postulate that the F-content of the melt controls the REE and HFSE, which have low solubility in F-poor silicate melts and aqueous fluids. We discuss the wider implications of this work on explaining the petrogenesis of the range of pegmatite in the PPG.

NEW AGE CONSTRAINTS FOR VOLCANIC AND PLUTONIC ROCKS SOUTHEAST OF WEKUSKO LAKE, MANITOBA

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New ID-TIMS dates of volcanic and plutonic rocks provide constraints on both stratigraphy and deformation southeast of Wekusko Lake. A sample of the Broad Bay pluton yielded an age of 1882.2 ± 1.2 Ma constraining a minimum age of the Puella Bay assemblage and n-MORB basalt of the South Weksuko assemblage. Dacitic tuff breccia on the northwest limb of the Herb Lake fold has an age of 1843.7 ± 1.1 Ma and is significantly older than the 1836 ± 1.3 Ma Chickadee Rhyolite in the core of the fold, supporting field observations that these volcanic rocks form a large-scale syncline. A crystallization age of 1833.9 ± 1.2 Ma for the Stuart Lake pluton provides minimum age for sedimentation and helps constrain deformation associated with the northeast-trending Herb Lake syncline and adjacent Stuart Lake anticline.

https://doi.org/10.12789/geocanj.2024.51.211

THE MAGMATIC LINEAGE OF THE LI-RICH PEGMATITE FROM THE CENTRAL IBERIAN ZONE: READING THE GEOCHEMICAL TRACERS AT BULK-ROCK AND MINERAL SCALES

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Aplite pegmatite bodies grouped in fields of some hundreds of dykes are relatively common in the Central Iberian Zone (CIZ) (Spain and Portugal). The most fractionated bodies of these fields may present high Li contents (often > 1 wt.% LiO_2), together with other incompatible elements such as F, Rb, Cs, Sn, Nb or Ta. The main Li-minerals in these aplite-pegmatite bodies are spodumene, petalite and lepidolite, with minor amblygonite–montebrasite. A mineralogically, chemically and texturally quite similar Li mineralization occurs much less frequently at the top of some leucogranitic cupolas. Field, geochemical, structural and geochronological data suggest that these Li-rich rocks are related to the important Variscan granitic magmatism that took place in the CIZ. However, it is challenging to decipher the petrogenetic relationship between Li-rich aplite pegmatite and the specific type of granitic series. With this purpose, detailed studies including bulk-rock and mineral geochemistry have been carried out to determine the potential linkage between Li mineralization and the different granitic series in the CIZ. According to the obtained results, an extreme fractionation of two different S-type, highly peraluminous, perphosphorus and Ca-poor granitic series seems the most plausible mechanism responsible for the origin of pegmatite. At bulk-rock scale, continuous evolution trends are observed from the less fractionated granitic units up to the most evolved pegmatitic facies, for major (e.g. Si, Al, Fe, Ca, Mg, Ti, P, Sr) and trace (e.g. F, Li, Ta, Cs, Rb and Sn) elements. At mineral scale, chemical fractionation trends in the same sense are observed for micas, feldspars, quartz and apatite. Combined bulk-rock geochemistry and mineral chemistry data are very useful for the exploration of Li in the CIZ, and also for other pegmatitic belts.

THE TAPPY, EAGLE AND F.D. NO.5 PEGMATITE FROM THE CAT LAKE–WINNIPEG RIVER PEGMATITE FIELD, SOUTHEASTERN MANITOBA

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This study investigates the geological features and petrogenesis of the Tappy, Eagle, and F.D. no.5 pegmatite bodies, which are Li-bearing pegmatite in the Cat Lake–Winnipeg River pegmatite field of southeastern Manitoba. Fieldwork over the summer of 2023 focused on observations and sample collection to provide preliminary insights into the dykes. More recently, thin sections of the sampled pegmatite have been prepared, followed by detailed petrography to establish mineral assemblage and paragenesis. Further petrography, complemented by geochronology on specific mineral phases is ongoing. The three studied dykes are broadly ascribed to the Li–Cs–Ta (LCT) class. The Tappy pegmatite is a roughly 50 m long by 3 m wide dyke hosted within the Winnipeg River pegmatite district. The Eagle and F.D. no.5 dykes are spatially related and are located in the Cat Lake pegmatite district. The Eagle pegmatite outcrops over multiple exposures trending east to west, while the F.D. no.5 dyke outcrops on one main hill to the northwest of the Eagle. Petrographic findings from polished thin sections indicate that all three of the studied dykes have undergone at least minor dynamic recrystallization. Bulging recrystallization of quartz and deformed feldspars are common and point toward a dynamic history. The main mineralogy is quartz, plagioclase, spodumene, and alkali feldspar along with minor columbite, muscovite, garnet, and apatite. The minor mineral phases will be used in upcoming geochronological studies. The findings of this study will contribute to a better understanding of pegmatite origin, enhancing geological and mineralogical knowledge in the region, and aiding future exploration efforts in southeastern Manitoba.

PRELIMINARY FAUNAL ANALYSIS OF THE HERSCHEL MARINE BONEBED (UPPER CAMPANIAN) NEAR HERSCHEL, SASKATCHEWAN

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The Herschel Marine Bonebed (HMB) is a multi-taxic marine fossil locality in the Dinosaur Park Formation (upper Campanian, Upper Cretaceous) near Herschel, Saskatchewan. The HMB is host to a collection of micro- and macro-vertebrate fossils, trace fossils, carbonized plant material, and amber. This locality is dominated by polycotylid plesiosaur specimens spanning a range of developmental stages. The fossils were deposited in what has been interpreted as a shallow marine barrier island system. We hypothesize that the high prevalence of juvenile specimens in a shallow, protected marine environment suggests the HMB was a plesiosaur nursery or calving ground. Analysis of previous and new fossil collections in combination with a review of the geological setting and the depositional environment will allow for a comprehensive description of the bonebed as a faunal assemblage. This approach enables evaluation of the site as a potential plesiosaur nursery. While there is a large amount of plesiosaur material, remnants of other large marine predators of the time (e.g. mosasaurs or sharks) are not as abundant as would be expected from a Campanian marine ecosystem. A protected, shallow marine setting with few large predators may have made the HMB an ideal setting for plesiosaurs to birth and raise their young, and provided a safe place for the juveniles to grow. Assessing this site as a nursery has significant implications for our understanding of polycotylid plesiosaur paleoecology, potentially providing insight into their life cycles, growth, development, and behaviour. This project, along with other ongoing work at the HMB, aims to improve our overall understanding of the palaeoecological dynamics of this unusual and thus far enigmatic Late Cretaceous fossil locality.

LITHOFACIES ATTRIBUTES OF THE MIOCENE MIXED CARBONATE-CLASTIC SUCCESSION OF THE GARA'AD COASTAL STRIP, CENTRAL SOMALIA

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The Oligocene–Miocene succession of central to northeastern Indian Ocean coastal strip of Somalia preserves carbonate strata that are collectively called the Hafun Group. Little sedimentologic and biostratigraphic studies were done, and no formation or member divisions were assigned for the group. Previous work was only in the form of regional mapping and brief description of two incomplete sections near the town of Eyl (~130 km northeast of Gara'ad). The sedimentary rocks along the Gara'ad coastal zone form the upper part of the southernmost outcrops of the Oligocene-Miocene series that stretches for ~600 km to the northeastern tip of the Somali Peninsula. The outcrops in the environs of Gara'ad Village expose carbonate-dominated, 40 m-thick Miocene strata. These rocks contain four lithofacies. Facies-1: peloidal, bioclastic packstone/grainstone: brown to orange, thickly bedded, bioturbated packstone to grainstone. Mollusc shells and large benthic foraminifera (Lepidocyclinids, Miogypsinids and Alveolinids) are present. Sandy packstone fills the burrows. Facies-2: sandy, pisolitic rudstone: it occurs in two discrete horizons of gravel-size, interconnected, rounded to elliptical pisoids. The cortices of the pisoid grains vary from brown to red laminae. Facies-1 and/or Facies-4 occupy the cores and inter-pisoidal spaces. Facies-3: algal mudstone to rudstone: it consists of white/beige/grey bioclastic mudstone, floatstone to rudstone. Calcareous algae, foraminifera, molluscs and bryozoans are present. This facies is locally intraclastic and peloidal with horizontal burrows and fenestral fabric. Facies-4: sandy, peloidal, bioclastic grainstone to calcareous sandstone: it consists of brownish orange (locally reddish), bioclastic and sandy grainstone (≅ sandy Facies-1); the sand components prevail locally changing to calcareous sandstone. The succession preserves metre-

scale shallowing-upward rhythmites defined by subtidal (Facies-3) to intertidal-supratidal deposits (Facies-1, Facies-4). The rocks contain extensive karst features (pedogenic Facies-2 pisoids, dissolution holes filled by sand- and gravel-size fragments, and the prevailing orange/reddish pigmentation) in different horizons, suggesting repetitive deposition-exposure cycles concomitant with the Miocene sea level fluctuations.

STRATIGRAPHIC EVOLUTION OF A SUBSIDING CARBONATE PLATFORM WITHIN A TECTONICALLY UNSTABLE REGION: THE MIDDLE EOCENE SEEB FORMATION OF THE BATINA COAST, NORTHERN OMAN

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The middle Eocene Seeb Formation is a very thick, carbonate-dominated lithostratigraphic unit that occurs along the Batina Coast of northern Oman. In the study area, previous work divided the formation into five informal limestone units (I-V). Recent excavations expose a more complete succession, including a previously unrecognized siliciclastic-rich unit. Lithostratigraphic re-evaluation allows division of the formation into four members: (A) lower limestone, (B) middle limestone, (C) mixed clastic-carbonate and (D) upper limestone-marl, in ascending order. The lower limestone member (140 m) encompasses units I to III of previous work and consists of three main lithofacies: sandy, peloidal bioclastic packstone to grainstone with herringbone, trough and tabular cross-beds, Skolithos ichnofossils, lateral pinch-outs and scoured surfaces. The middle lithofacies of the member consists of thickly bedded, bioturbated, bioclastic packstone/grainstone, whereas the upper lithofacies constitutes thin to thickly bedded peloidal bioclastic packstone to grainstone with hummocky and swaley cross-stratifications. Subordinate quartz sand- and granule-size clasts are locally scattered. The middle limestone member (47 m) includes medium to thickly bedded, nodular, bioturbated, Alveolina-rich wackestone to packstone. It forms metre-scale rhythmic units. The mixed clastic-carbonate member (~60 m) comprises thin to thickly bedded, bioclastic (discoidal Numulites and Assilina) marly/silty rudstone/packstone with bioclastic mudrock and calcareous sandstone (tempestite) interbeds. Nodularity increases upward. Normal grading, Skolithos, Planolites and Ophiomorpha ichnofossils are locally present. The upper limestone-marl member (~325 m) forms very thick, extensively bioturbated, nodular, profusely fossiliferous (foraminifera, echinoids, mollusc, algae) packstone to rudstone with fair amount of silty/clayey matrix. The upper part (~100 m) of the member comprises brown marls packed with larger benthic foraminifera. The sedimentary structures and fossil content of the formation suggest deposition under high-energy inner-ramp (member-A) through quiet (member-B) to storm-dominated (member-C) middle-ramp to proximal outer-ramp (member-D) environment. The formation's stratigraphic succession reflects a deepening-upward ramp that coincides with the middle Eocene sea-level rise and uplifted/exposed hinterland that provided the detrital influx.

PRELIMINARY CHARACTERIZATION OF PHOSPHATE MINERALS FROM THE BELVÍS DE MONROY GRANITE–PEGMATITE SYSTEM (SPAIN)

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The Belvís de Monroy granite–pegmatite system is located at the centre of the Central Iberian Zone of the Iberian Massif, in the southwestern part of the European Variscan belt. A dyke swarm of aplite–pegmatite bodies defines a U-shaped pegmatitic field of ~20 km² that, together with the granitic pluton, makes up the Belvís de Monroy granite–pegmatite system. The dykes have been classified into 5 different types of aplite and aplite–pegmatite and one type of quartz dykes. The two most abundant types are ones with phosphate minerals, some homogeneous, others heterogeneous aplite–pegmatite with abundant unidirectional solidification textures (UST). The granite and the different types of aplite–pegmatite both showcase apatite and a variety of Fe–Mn–(Al) phosphate minerals, forming complex mineral associations. In the granite, primary fine- to medium-grained fluorapatite, childrenite–eosphorite and gormanite–souzalite are observed. The homogeneous aplitic dykes exhibit a complex phosphate mineralogy, including primary fine-grained fluorapatite and amblygonite group minerals, which occur disseminated throughout the aplite. The secondary Fe–Mn phosphate minerals, such as alluaudite, heterosite–purpurite, rockbridgeite, jahnsite, childrenite–eosphorite, barbosalite, goyazite, cacoxenite and some unidentified secondary Fe–Mn phosphate phases appear as nodular aggregates up to 6 cm in diameter. In contrast, the phosphate mineralogy and textures in aplite–pegmatite with abundant UST are simpler. Primary fluorapatite is more abundant in the border zones, whereas fine- to medium-grained scorzalite–lazulite and gormanite–souzalite occur closer to the core zone. The FeO/(FeO + MnO) value of Fe–Mn phosphate minerals is used as an indicator of fractionation, with values decreasing as fractionation increases. Thus, the FeO/(FeO + MnO) values of the alluaudite and heterosite–purpurite (mean values of 0.66 and 0.74, respectively) from aplite may suggest an intermediate degree of fractionation. These complex Fe–Mn phosphate assemblages provide insights into the petrogenetic evolution of the pegmatite, as well as the metasomatic processes that these bodies underwent.

STRUCTURAL CONTROLS ON THE MARY RIVER IRON ORE DEPOSIT, NORTH BAFFIN ISLAND, NUNAVUT

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The Mary River Fe-ore deposits of northern Baffin Island are hosted in the Archean Mary River Group; Deposit 1 is the site of Canada's northernmost active mine. Greenstone belts of the Mary River Group form discontinuous, 1–10 km scale, variably deformed and metamorphosed panels within orthogneiss and granitoid rocks of the Rae Craton. Despite evidence for Archean deformation, two main tectonic events, including the Paleoproterozoic collisional Trans-Hudson orogeny and the Mesoproterozoic extensional events forming the Bylot basins were responsible for the distribution of Fe-ore. North–south shortening during the Trans-Hudson orogeny resulted in structural thickening of the primary Mary River banded iron formation (BIF), local metasomatic removal of chert layers, the development of foliated and lineated, specularitic hematite ore, and finally crenulation of the specularitic ore. Lineations and crenulations plunge regionally to the southeast across a series of synforms. The Mary River Group is structurally repeated along a series of steeply west- to southwest-dipping listric normal faults, best observed at Glacier Lake ~20 km east of the Deposit 1 Mary River mine. An appropriately oriented set of topographic lineaments evident in digital topographic images is likely the surface manifestation of the extensional faults. At Glacier Lake, development of normal faults was accompanied by local brecciation and facilitated fluid flow responsible for the metasomatic removal of chert and the formation of blocky ore, which locally overprints specular ore. The normal faults explain the consistent metamorphic grade across the region despite the consistent southeast structural plunge, the repetition of the Mary River Group stratigraphy, and the exposure of a series of synclines without intervening anticlines. The normal faults may be products of the Mesoproterozoic extensional event that gave rise to the more northerly Bylot basins.

IMPROVING 3-D NUMERICAL MODELS OF VOLCANOGENIC MASSIVE SULPHIDE ORE SYSTEMS USING CURVILINEAR COORDINATE SYSTEMS ILLUSTRATED WITH CASE STUDIES FROM THE FLIN FLON AND LALOR DEPOSITS, MANITOBA, CANADA

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Numerical grid models of volcanogenic massive sulphide (VMS) deposits traditionally apply geostatistical methods to estimate ore grade and tonnage using grids of rectangular cells. However, there is increasing recognition that these Cartesian grids can lead to gross inaccuracies when modelling complexly deformed deposits. More advanced methods developed by the hydrocarbon exploration industry employ

https://doi.org/10.12789/geocanj.2024.51.211

curvilinear grids with coordinate axes parallel to the 3-D geological structure of the deposit. Hence, the mapping of any categorical or continuous property on such a grid is conditioned by prior structural knowledge leading to 3-D geological models that are far more realistic and predictive. This contribution reviews case study examples to demonstrate that this method provided unprecedented insights into the 3-D lithofacies, hydrothermal alteration and ore metal zoning of the Flin Flon and Lalor VMS deposits. In addition, it will be shown how this method was exploited to develop 3-D physical rock property models of the Lalor deposit, which allowed computing its seismic, gravity and magnetotelluric responses of VMS deposit in support of geophysical exploration targeting.

NEW UNDERGRADUATE PROGRAM IN EARTH AND PLANETARY SCIENCE COMMUNICATION

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A new trans-disciplinary Bachelor of Arts and Sciences in Earth and Planetary Science Communication at Brock University was developed through partnerships between the departments of Earth Sciences, Geography and Tourism Studies, and Communication, Popular Culture and Film. The program is the only one of its kind in Canada; students enrolled take Earth Science courses to gain an understanding of geologic processes operating on Earth and other planets, as well as Communications courses to develop communication skill, all as part of a 4-year undergraduate degree. Graduates will take courses typical of an Earth Sciences program to understand the science behind important modern issues such as resource distribution, climate change, geohazards, and planetary exploration. They will also develop communication skills to participate effectively and successfully in the discussions and debates surrounding science in a variety of fields and industries. Relevant courses include Citizen Science, Indigenous Studies, and Social Media. A 4th year capstone project will involve novel approaches to communicating science and engagement with the general public. By combining storytelling and science, the program is designed to appeal to students with diverse cultural and academic backgrounds and voices. This program aims to train graduates to function as participants in discourses surrounding science and to increase the level of scientific literacy in Canada by training graduates who can take on diverse roles in the public communication of science to facilitate relationships between citizens and organizations, develop policy, and improve public scientific literacy. Potential careers open to graduates include science journalism and communicators for government agencies, NGOs, and private companies.

THE AGE AND PARAGENESIS OF PETALITE PEGMATITE AT ARCADIA, ZIMBABWE

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The global move to electric vehicles is leading to greatly increased demand for lithium, and particular interest in its main hard-rock source, lithium pegmatite. Zimbabwe hosts several economically important lithium pegmatite occurrences and is currently the only country in Africa with active lithium mining. The paragenesis observed in these pegmatite occurrences are often complex and highly variable; however, understanding these complexities is important for mineral processing and geometallurgy. In many African lithium pegmatite examples there is a clear 4-stage paragenesis: 1) magmatic Li-rich assemblage; 2) albitization; 3) greisenization; 4) lower-temperature alteration. At Arcadia, an Archean pegmatite in the Harare Greenstone Belt in Zimbabwe, the magmatic assemblage is dominated by massive petalite and quartz, with feldspar and white mica. Interestingly there is little evidence of widespread albitization or greisenization. However, there is evidence of localized replacement of petalite by spodumene–quartz intergrowth (SQI), or by eucryptite, clays (e.g. kaolinite) and zeolites (e.g. bikitaite). The presence of calcite, native bismuth and danalite is another interesting feature of the paragenesis, indicating there was introduction of a CO_3 and S-bearing fluid late in the paragenesis, similar to fluids in tin greisen. Carbonate, S, and Bi were ultimately derived from the melt source, which might include the carbonated, sulphide-bearing metavolcanic rocks of the Iron Mask Formation, which forms part of the Bulawayan Supergroup. This late-stage assemblage is not widespread nor is it uniformly distributed through the pegmatite; however, where present it does seem to lead to the complete replacement of primary petalite. Knowing how pegmatite at Arcadia fits in the regional context is key for understanding how geological processes might have contributed to the complexity of the paragenesis. To that end in situ U–Pb dating of ferro-tantalite was attempted, giving an imprecise date of ca. 2.54 Ga, suggesting the pegmatite formed around 100 Ma after the emplacement of outcropping granitoid plutons in the region.

MUD, TIDES, AND CLAWS: CRAB TRACES ON THE TIDAL FLATS OF THE MIRA RIVER ESTUARY, PORTUGAL

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Crabs are some of the most common inhabitants of tidal flat and marsh environments, with their habitats ranging from continental clastic to marine carbonate situations. This study documents various crab-produced traces on the muddy tidal flats of the mesotidal Mira River estuary located in southwestern Portugal and accesses their preservation potential in the rock record. Atlantic shore crab *Carcinus maenas* was observed during the day hours roaming the tidal flats and marshes at neap low tide, hiding in burrows, crevices, and under the rocks. The type (morphology) and distribution of crab burrows vary along the tidal-flat profile as a function of the activity of the producer, its age, tidal cycles, tidal range, time of the day, substrate consistency, and marsh vegetation density. Special emphasis is placed on scratch marks left by crab chelae. These marks are currently unnamed and underrepresented in the scientific literature. They are interpreted to represent crab grazing and feeding activity, with an alternative interpretation of mating behaviour. Moreover, crabs produce tracks and trackways attributed to the ichnogenus *Coenobichnus*, representing crab locomotion. These are formed perpendicularly to the trackway axis by the crab pushing its appendages into a soft or semi-consolidated muddy substrate, leaving digit-like marks. Wide burrow entrances and exits are similar to *Psilonichnus*, *Thalassinoides*, and *Spongeliomorpha*, representing permanent to semi-permanent crab burrows. Ultimately, semi-consolidated muddy cylinders found on the Mira tidal flats are interpreted to represent crab fecal pellets (excrements). *C. maenas* is a very important agent of bioturbation in the environments it inhabits. This study provides further evidence that low-diversity assemblages, particularly those attributed to a single trace maker, could be associated with invasive species that out-compete autochthonous fauna. While crab traces typically have lower preservation potential, their likelihood of passing into the rock record increases under conditions of relative sea-level rise.

GEOLOGICAL ASSESSMENT OF UPPER CAMBRIAN SANDSTONE IN SOUTHWEST ONTARIO FOR CARBON CAPTURE AND STORAGE FEASIBILITY

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Sedimentary rocks can play a significant role in reducing humanity's carbon footprint and thereby help reduce our contribution to climate change. Porous and permeable sedimentary rocks can act as repositories for CO_2 emitted by point sources via carbon capture and storage (CCS). Southern Ontario, Canada's industrial heartland, has many significant point-source emitters, most of which are categorized as "hard-to-abate" sources meaning that CO_2 is generated as a by-product of the industrial process itself (e.g. conversion of limestone to lime for cement) or because low-carbon energy sources are either not available or prohibitively expensive (e.g. heat necessary to fuel blast furnaces in the steel-making industry). Unfortunately, the CCS needs, and storage options of southern Ontario have been largely ignored for the past 15+ years. We seek to develop predictive depositional models, via sedimentological and stratigraphic analyses of legacy oil and gas data, that will facilitate and

expedite the process to evaluate the site-selection process for potential CCS storage. We focus on Cambrian deposits of southwest Ontario because they appear to be the most suitable CCS candidates. Burial depths are > 800 m in most of the area, meaning injected CO_2 will remain in a supercritical state. The Cambrian section is overlain by a thick (> 500 m) succession of low permeability carbonate rocks and shale that will act as an effective seal, preventing the upward movement of injected gases. However, the Cambrian section is lithologically heterogeneous, consisting of variably feldspathic sandstone, dolomite, sandy dolomite and dolomitic sandstone, all of which are associated with differences in porosity and permeability. Sparse data control makes it difficult to predict these properties in undrilled areas. Our analyses to date suggest a shallow marine depositional setting for the Cambrian, with ongoing work focused on refining the predictive power of our depositional models, thereby reducing geologic risk at potential storage hub sites.

INVESTIGATING THE EVOLUTION OF THE LLEWELLYN–TALLY HO DEFORMATION CORRIDOR, YUKON, VIA IN SITU APATITE AND TITANITE PETROCHRONOLOGY

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The Llewellyn–Tally Ho deformation corridor comprises a network of plastic to brittle structures that extends over 200 km from southern Yukon into northern British Columbia, Canada. The deformation zone forms an important terrane boundary between Stikinia and Yukon-Tanana terranes and is associated with numerous hydrothermal ore deposits. Despite this, the role of this crustal-scale high-strain zone in regional tectonic and mineralizing events remains poorly understood, largely due to a lack of absolute timing constraints on deformation episodes. This project aims to characterize and directly date deformation along the Llewellyn–Tally Ho deformation corridor through a combination of field mapping, petrography, electron backscatter diffraction microstructural analysis and in situ U–Pb dating of key minerals via laser ablation-inductively coupled plasma-mass spectrometry. Within the deformation corridor, early ductile fabrics are developed in Late Triassic gabbro and related units. These are overprinted by later brittle fabrics that crosscut both the gabbroic units and otherwise undeformed mid-Cretaceous granodiorite. In the ductile high-strain zone, apatite and titanite exhibit broad ranges in texture and geochemistry and yield lower intercept dates between ca. 180 and 100 Ma, and ca. 215 and 130 Ma, respectively. Younger populations of apatite (ca. 135–100 Ma) and titanite (ca. 190–130 Ma) are interpreted to record episodes of late deformation- and fluid-induced (re)crystallization based on textural, trace element and microstructural analyses. Along zones of localized cataclastic deformation, brittlely deformed igneous apatite from the mid-Cretaceous granodiorite yields dates of ca. 105–95 Ma that overlap with those recorded by dynamically recrystallized apatite in the gabbro. This result indicates that pluton emplacement and cooling may have coincided with ductile shearing. The multiple deformation episodes these data have revealed will be investigated further in the context of the tectonic and mineralization history of the region.

HOST ROCK LITHOGEOCHEMICAL AND FLUID MOBILITY PERSPECTIVES OF LITHIUM-ENRICHED PEGMATITE DYKES FROM THE WEKUSKO LAKE PEGMATITE FIELD NORTH-CENTRAL MANITOBA

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There is a lack of investigations on the formation of chemical halos around pegmatite bodies in adjacent country rocks, despite the recognition of mobile elements, such as Li, Cs, U, Th, Ta, Sn, B, and F, as halos around pegmatite. Factors that affect the extent of the halo include fluxes from crystallizing pegmatite, pegmatite composition, and host-rock physical properties. Cost-effective lithogeochemical exploration across diverse geological contexts requires thorough investigations into fluid mobility and wall-rock alteration across different rock types. This study describes the dispersion halo of mobile elements (Li, Cs, Rb) and alteration of host rocks induced by aqueous fluids originating from lithium-enriched pegmatite within the Wekusko Lake District in north-central Manitoba. Two lithium-enriched pegmatite dykes emplaced in contrasting country rocks were selected for this study: Thompson Brothers in metasandstone and GRP009 from Sheritt-Gordon pegmatite dykes group in gabbroic diorite. Lithogeochemical data were obtained from 20–30 cm long country rock drill core samples, with a 1 m spacing for the initial 20 m from the pegmatite dyke, followed by a 3 m interval up to a maximum distance of 30 m for the Thompson Brothers dyke and 50 m for the GRP009 dyke. Lithogeochemical analyses reveal peak concentrations of Li (518 and 717 ppm in metasandstone and gabbroic diorite, respectively), Cs (21.6 and 23.1 ppm), and Rb (66.5 and 54.9 ppm) in the country rock within the initial 2–8 m from lithium-enriched pegmatite dykes. Beyond this distance, Li, Rb, and Cs concentrations decline with distance from the pegmatite. A more pronounced decrease was observed in the gabbroic diorite compared to the metasandstone. Elevated concentrations or spikes of Li, Cs, and Rb are evident in areas with heightened metasomatic alteration or strained zones within the country rock, suggesting a structural influence on metasomatic fluids in small discrete faults or shear zones.

INTEGRATING COASTAL ENVIRONMENTS INTO OUR UNDERSTANDING OF MAJOR MESOZOIC CARBON CYCLE PERTURBATIONS

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The Mesozoic witnessed several major carbon cycle perturbations associated with the deposition of organic-rich sediments in many locations worldwide. These episodes of environmental upheaval are commonly known as oceanic anoxic events (OAEs), often explained by drastic changes in carbon storage in the marine realm. However, there is a wide gap in knowledge concerning the response of coastal areas to the environmental drivers of OAEs and the impact of changing fluxes of carbon in and out of these depositional environments on the global carbon cycle. This presentation discusses the potential implications of terrestrial and coastal environments on global organic matter storage and atmospheric carbon feedback during the Mesozoic. The integration of our findings from both sides of the Atlantic margins with current modelling efforts will allow us to clarify the impact of coastal environments on climate, carbon cycle perturbations, and OAEs and provide a Deep Time perspective on the factors contributing to present-day issues of coastal anoxia expansion and tidal wetland loss.

OCEANIC DISSOLVED ORGANIC CARBON AND THE MESOZOIC GLOBAL CARBON CYCLE

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One of the most challenging aspects of studying past and present carbon cycle changes and predicting climate evolution concerns the roles and relative importance of oceanic organic carbon (OOC) and oceanic inorganic carbon in the global carbon cycle. Variations in the size and composition of the OOC reservoir can impact the atmospheric carbon pool and, therefore, climate and Earth System processes. In this talk, I examine the possible relationship between OOC (predominantly dissolved organic carbon – DOC), small-scale (periodic) carbon cycle perturbations, and climate change in the Bathonian–Callovian time interval. Provokingly, I hypothesize that the addition and removal of carbon from the OOC reservoir via orbitally forced processes (controlling, for example, weathering, organic productivity, and alteration of DOC by photodegradation) modulated atmospheric pCO_2 and the isotopic composition of carbon reservoirs during the Bathonian–Callovian transition. The hypothesis is tested by using a combination of detailed stratigraphic and geochemical studies with back-of-the-envelope mass balance calculations to broadly constrain the magnitude and rates of change in the size of the OOC reservoir necessary to explain periodic small-scale (0.5–2‰) $\delta^{13}C$ shifts in the Bathonian–Callovian.

https://doi.org/10.12789/geocanj.2024.51.211

SPECIATION OF ORE MINERALS IN GRANITIC PEGMATITES OF INDIA

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Granitic pegmatite of India constitutes a potential source for diverse types of ores of critical minerals. Mineralogical studies on ore minerals hosted in various pegmatite belts of India revealed a considerable speciation in ore minerals of Nb–Ta, Be, Li, Bi, Cs, W, Sn, Mo, U, Th, and rare earth elements (REE). Large speciation in Nb–Ta phases is noted in the pegmatite fields of India, with ubiquitous presence of beryl. Li minerals include spodumene, lepidolite, zinnwaldite and amblygonite, whereas occasionally Cs occurs as pollucite. At places, Bi (bismutite, bismite, and beyerite), U (uraninite and uranyl minerals), Th (thorite, uranothorite) and Mo (molybdenite) phases are also present. Interestingly, Sn (mostly as cassiterite) also occurs in association with Nb–Ta pegmatite. At places, W (as wolframite) is also recognized. Significantly, among rare earth phases, monazite and xenotime occur in granitic pegmatite of almost all the regions, with tritomite and chevkinite in certain belts. Restricted occurrence of bastnaesite is also noted in some granitic pegmatite. Ore mineral speciation reveals the common presence of 'rare earth' and 'beryl' types of pegmatite in most of the pegmatite belts. Furthermore, sub-types of 'complex pegmatite type' are 'lepidolite' sub-type (widespread), followed by 'spodumene' and 'amblygonite' sub-types. 'Spodumene' sub-type 'albite–spodumene' is restricted. Among the 'rare element' class of pegmatite, 'LCT' (lithium, cesium, tantalum) type pegmatite is restricted relative to 'NYF' (niobium, yttrium, fluorine) and 'mixed' pegmatite. Pegmatites of more than one family together point out the roles of more than one petrogenetic process in their formation.

INTEGRATED ROCK, SOIL, AND TREE GEOCHEMISTRY TO EXPLORE FOR LITHIUM PEGMATITE: PROMISING RESULTS FROM NORTHERN WISCONSIN, USA

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Glacial till, soil, vegetation, and swamp cover much of the surface of the potentially fertile Paleoproterozoic terrain in northern Wisconsin, USA and obstruct the discoveries of new pegmatite bodies. Pegmatite occurrences from the Florence County Pegmatite (FCP) field are highly fractionated, lithium–cesium–tantalum pegmatite emplaced in metavolcanic and metasedimentary rocks at the northernmost edge of the Wisconsin Magmatic Terrane, within a few kilometres from the E–W trending Niagara Fault Zone. We focused on four spodumene-bearing dykes and their host rocks. Although the mineral occurrences have been previously described, this pegmatite field is underexplored and offers an optimal setting for testing a multifaceted greenfield exploration methodology. Control samples were collected from post-tectonic peraluminous granite (the potential parent of FCP pegmatite), two simple pegmatite bodies, and their host rocks. Here we integrate traditional wet-chemical analysis with portable X-ray fluorescence (pXRF) and laser-induced breakdown spectroscopy (pLIBS) analyses of rock, soil, and maple and pine tree xylem samples, leading to three preliminary conclusions: 1) the emplacement of the 1–7 m wide, > 50 m long FCP pegmatite bodies created ~60 m wide cryptic Li-metasomatic aureoles in amphibolite and mica schist. During weathering and pedogenesis, 10–30 m wide soil anomalies were generated as demonstrated by ICP-OES data, with Li, Rb, and B concentrations enriched by a factor of 30x, 15x, and 14x respectively, compared to the control soils; 2) Random Forest machine learning algorithms successfully predict the Li-mineralization potential based on pXRF analysis of soil samples ($R2 < 0.88$ and RMSE < 65ppm); and 3) preliminary qualitative pLIBS data suggest that the tree xylem carries the geochemical signature of deeply buried pegmatite that may remain undetected based on soil geochemistry alone. Average Li (670.8 nm)/C (247.9 nm) intensity ratios (via pLIBS) for trees grown on known Li pegmatite exceed the ratios in control xylem by a factor of 1.9 (maple) and 2.6 (pine).

NATURE OF RESIDUAL MELTS INVOLVED IN THE ORIGIN OF Fe–Ti–P MINERALIZATION IN ANORTHOSITE SUITES IN THE CENTRAL GRENVILLE: NEW INSIGHTS FROM O–Hf ISOTOPES OF ZIRCON FROM GRANITIC PEGMATITIC POCKETS IN THE LAC-ST JEAN ANORTHOSITIC SUITE

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The Lac-St-Jean Anorthositic Suite (1157–1142 Ma) is part of the world's largest anorthosite–mangerite–charnockite–granite (AMCG) magmatic suite. It hosts numerous nelsonite (oxides and apatite) ore bodies but the nature of the involved Fe–Ti–P melts remains debated although experimental and petrological observations suggest that it is a residual silicate melt after anorthosite formation. Granitic pegmatite pockets represent more evolved, residual melt trapped in various anorthosite lithologies and is typically used to date the anorthosite suite. This study investigates the nature of the residual silicate melts, coexisting with common ore-hosting lithologies, using U–Pb geochronology, radiogenic Hf and in situ O isotopes of zircon from a variety of granitic pegmatite pockets from the southern and western margins of the Lac-St Jean Anorthositic Suite. The pegmatite pockets are hosted, from southeast to west, in leuconorite (Jonquière), leucotroctolite megadyke (Bégin) and anorthosite (Lac Perron). U–Pb dates of magmatic zircon grains (with identical zoning patterns) become progressively younger from southeast (1175 ± 6 Ma), south (1147 ± 4 Ma) and finally to the west (1101 ± 3; 1107 ± 1 Ma). Within this 100 Myr of magmatic activity, εHf values of zircon in the pegmatite pockets increase from +2–4 to +6–8 with decreasing age, reflecting continuing rejuvenation of the Grenville crust by significant contribution of mantle-derived melts. This is validated by a systematic change in $\delta^{18}O$ in zircon from crustal (6.4 ± 0.2‰) to mantle (5.6 ± 0.2‰) values. REE concentrations and oxygen isotope ratio of apatite from granitic pegmatite pockets and coexisting Fe–Ti–P ore bodies support increasing involvement of the mantle-derived melts with time. Our new data suggest a combination of mantle and crustal components played a crucial role in formation of final Fe–Ti–P melts. This study highlights investigation of mantle source as a potential mechanism to explain fertile melts forming Fe–Ti–P mineralization in anorthosite suites of the central Grenville Province.

GEOLOGY AND MINERAL EXPLORATION OF "ALTO PATRIMONIO" PEGMATITIC BODY, BORBOREMA PROVINCE, BRAZIL

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Intrusive pegmatitic bodies in the supracrustal rocks of the Borborema Province, located in the northeastern region of Brazil, are of a complex nature, chronostratigraphically positioned in the Neoproterozoic era/Phanerozoic eon in which the "Brasilian Granitegenesis" occurred, where intense magmatic pulses permeated the Caico Complex and the Serido Group, generating large granitoid bodies, culminating in the crystallization of pegmatitic dykes and sills. The present work reports on the pegmatite "Alto Patrimonio", in the urban perimeter of the municipality of Pedra Lavrada, Paraíba, characterized by the development of giant crystals of quartz, feldspars and micas from the core to the edges, in a concentric way, forming almost regular zoning. Percolating late hydrothermal fluids promoted crystallization of beryl, tantalite, apatite, lepidolite, as well as phosphate minerals, with arrojatite being the most complex species. The body is embedded discordantly in biotite schist of the Seridó Formation of the Homonymous Group. Cenozoic volcanic magmatic pulses affected the entire sequence in the form of intrusive basalt dykes in the "Patrimonio pegmatite". As it is a heterogeneous pegmatite rich in minerals of economic interest, it has been mined as a small deposit in both an open pit and underground, supplying industry and the domestic and foreign market with gemstones. The environmental degradation in and around the mine caused by the disorderly practice of mining is worrisome, requiring mitigating standards for the return of the degraded site to conditions close to before mining.

EVALUATING THE MAGMATIC EVOLUTION OF ARCHEAN PORPHYRY AND VOLCANIC ROCKS FROM THE TIMMINS GOLD CAMP USING ZIRCON MINERAL CHEMISTRY AND HIGH-PRECISION CA-TIMS

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Magmatic systems consist of complex, overlapping plutonic and volcanic activity associated with the generation and emplacement of dykes, plutons, and volcaniclastic horizons. This complexity makes it challenging to determine meaningful ages due to the protracted nature of magmatism. This problem is compounded when considering Archean rocks, such as those found in the same district as prolific orogenic gold deposits within the Timmins mining district, Ontario, Canada. Three felsic porphyry examples (Paymaster, Crown Lake, and Carr) and one volcanic fragmental unit (Krist Formation) were studied to understand their evolution. Zircon grains were examined using cathodoluminescence (CL) imaging, followed by LA-ICP-MS (trace elements and preliminary U–Pb dating), and CA-TIMS (high-precision U–Pb dating). The CL imaging guided LA-ICP-MS analysis and identification of grains for CA-TIMS. The ages obtained in this study include 2687.09 ± 0.22 Ma (Paymaster, n = 5), 2687.59 ± 0.66 Ma (Crown Lake, n = 5), and 2687.46 ± 0.38 Ma (Krist volcanic rocks, n = 6). Zircon from the Paymaster, Carr, and Krist volcanic rocks have U/Yb–Nb/Yb systematics suggesting they crystallized from an arc-like magma, while the Crown Lake porphyry contains two zircon populations. The first have overlapping chemistry with the Paymaster, Carr, and Krist zircon while the second group of zircon has inherited cores. The U/Yb–Nb/Yb systematics suggest the inherited cores crystallized from a MORB-like magma compared to the arc signature of their rims and the other porphyries. This suggests that Crown Lake zircon with inherited cores shared a final magmatic environment with Paymaster, Carr, and Krist volcanic rocks. The evolution of these porphyry magmas is constrained by studying zircon core–rim chemistry, which tracks magmatic changes during zircon crystallization. The contrasting zircon chemistry of inherited versus magmatic grains, combined with new CA-TIMS age data, records a change in the tectono-magmatic setting during zircon crystallization. Complementary melt inclusion analysis will provide trace element and precious metal concentrations related to these periods of crystallization.

ASSESSING PROCESSES RELATED TO DIFFERENTIAL METAL ENDOWMENT IN THE ABITIBI GREENSTONE BELT USING ZIRCON MINERAL CHEMISTRY AND ISOTOPIC STUDIES

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The development of critical metal resources has become an important focus in geologic research. The Abitibi greenstone belt (AGB), Superior Province, Canada, hosts abundant volcanogenic massive sulphide (VMS) occurrences that are rich in critical metals (e.g. Cu, Zn, Pb, Ag, Au, Sn, Bi, etc.). Although the genetic model for VMS formation is well established, the processes related to the formation of well-endowed and poorly endowed greenstone belts is unknown. Zircon was chosen as a robust phase shown to withstand alteration and provide insights into magma petrogenesis of the early Earth. Therefore, zircon mineral chemistry and isotopic characteristics are used across several transects within the AGB to assess their variations in relation to VMS endowment and relationship to petrogenetic processes. Trace element, U–Pb, and Lu–Hf isotopic analysis of zircon from felsic intrusive and volcanic rocks from the Chibougamau, Rouyn-Noranda, Larder Lake, and Swayze greenstone belts were compared. Different tectonic settings can be determined using U/Yb–Hf–Y systematics, which are influenced during magmatic evolution. Zircon from the Chibougamau, Larder Lake, and Swayze regions fall within the continental (i.e. arc) zircon field, whereas the Rouyn-Noranda zircon have mainly an oceanic (tholeiitic, MORB) affinity. An evaluation of the U/Yb versus Nb/Yb ratios differentiates two signatures in these transects: zircon from the Chibougamau, Larder Lake, and Swayze regions has a magmatic arc affinity whereas Rouyn-Noranda zircon falls within both the magmatic arc and mantle-derived zircon fields. Despite geologic similarities between Archean greenstone belts, the processes related to differential VMS endowment remains poorly constrained. Further comparison of the U–Pb and Lu–Hf isotopic characteristics of zircon should lead to a better understanding of magmatic processes recorded in Archean zircon and its relationship to VMS formation.

NOT ALL S-TYPE GRANITES ARE CREATED EQUAL

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Sediment-derived melt and the detrital products derived therefrom have been present in the geologic record since the Hadean Eon. However, it is often assumed that melts of (meta)sedimentary material represent small volumes of melt compared to other felsic melts such as those formed in arc settings. Nevertheless, constraining the mode and volume of sediment assimilation plays a fundamental role in our understanding of the interplay between Earth's surface where sediment is formed and Earth's depths where surface-derived materials are melted. Recent work has demonstrated that changes in sedimentary compositions through time are reflected in the composition of sediment-derived melt. This means any detrital mineral proxy used to constrain the volume of sediment-derived melt through time will be a moving target. The clastic sedimentary record is also extremely diverse in its isotopic signatures and degree of maturity. This compositional diversity is reflected in sediment-derived melt that reflects specific isotopic features of various petrotectonic settings. Sediment-derived melt examples are present across the spectrum of orogenies from oceanic and continental arcs to continental collisions. Oceanic arc settings record sediment-derived melts with elevated $\delta^{18}O$, but depleted εHf, whereas collisional settings produce melts with elevated $\delta^{18}O$ and enriched εHf. In contrast to the end-member oceanic arcs and continental collisions, long-lived continental arc systems yield dramatic swings in isotopic signatures during the oscillations of retreating and advancing phases of arc magmatism. Ophiolites also host sediment-derived granite intruding peridotite that carries isotopic signatures akin to biogenic sediments, implying subduction and melting of deep marine sediment. Sediment-derived melts record plate tectonic-driven mass transfer and form a clear connection between evolving surface conditions and the deep Earth. These relatively low-volume granitoid rocks play an important role in understanding the long-term evolution of both the plate tectonic processes that form them and the sedimentary systems that provide the fodder for melting.

A PALEOBIOGEOGRAPHICALLY SIGNIFICANT LATE ORDOVICIAN BRACHIOPOD FAUNA FROM THE MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES

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Although the Ordovician brachiopod faunas of eastern North America are well-studied, there are still substantial gaps in our knowledge of the paleobiogeography of this group both worldwide and within the rest of North America. One of these gaps is in what is now northwestern North America but was then on the northern edge of Laurentia within the northern subtropics. Several stratigraphic sections in the Mackenzie Mountains were described in the 1970s. Samples taken as part of this work contained a well-preserved silicified fossil fauna including a diverse assemblage of brachiopods and trilobites. The trilobites were used to establish a detailed biostratigraphic scheme calibrated with conodont data, but the brachiopods have remained understudied with only a single paper focusing on a single brachiopod lineage ever being published. From current efforts to describe the fauna, we now recognize it to be distinct from other Late Ordovician brachiopod faunas in Laurentia in terms of composition and relative abundance of brachiopod taxa. This work fills an important gap in our paleobiogeographic dataset and reveals connections to a distant Scoto-Appalachian fauna on the other side of Laurentia and even as far away as Baltica, a continent that was located not only on the other side of Laurentia but also on the other side of the paleoequator in the mid-latitudes. These results have impor-

https://doi.org/10.12789/geocanj.2024.51.211

tant implications for our understanding of brachiopod dispersal and potentially can provide important information for the modelling of ocean currents and paleogeographic reconstructions.

CHEMICAL AND STRUCTURAL CONSTRAINTS OF SHEAR-ZONE HOSTED GOLD MINERALIZATION FROM THE ARCHEAN SHEBANDOWAN GREENSTONE BELT (SUPERIOR CRATON, NW ONTARIO)

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The Shebandowan Greenstone Belt in the Wawa Subprovince of the Superior Craton hosts large gold resources. Mineralization is mainly hosted in quartz–carbonate veins in brittle to ductile shear zones within Archean supracrustal rocks. The greenschist- to amphibolite-facies metavolcanic rocks and their plutonic equivalents (gabbro and diorite sills) were emplaced at about 2720 Ma and subsequently intruded by post-kinematic felsic rocks (ca. 2690 Ma). Here we combine whole-rock geochemistry, geochronology, metamorphic petrology, and (micro-)structural observations to constrain the poorly understood genetic link between Au enrichment and host rock geochemistry, deformation, and magmatic/hydrothermal activity. Geochemistry reveals two groups: 1) basaltic komatiite to high-Mg tholeiitic rocks with basaltic to rhyolitic compositions, and 2) tholeiitic to calc-alkaline rocks. REE patterns of Group 1 rocks are predominantly unfractionated, while Group 2 rocks show strong fractionation. High-grade Au occurs mainly in Group 1 with the highest grades in and near sheared diorite lenses. Gold correlates positively with Ag, S, Te, Bi, W, Cu, and Mo. Sulphide veins were ductilely deformed after 2708 ± 12 Ma (molybdenite Re/Os). P-T estimates show that deformation occurred at high temperatures and medium pressures (> 500°C, 3–4 kbar). The deformation is characterized by a steep and penetrative foliation and horizontal (dextral) or vertical stretching lineation in the NW and SE parts of the belt, respectively. The two orthogonal lineations indicate locally varying vorticity. Our observations suggest that primary Au mineralization depends on the style and intensity of ductile deformation and spatial interaction with suitable host lithologies and brittle structures. Enrichment occurs along rheological contrasts within Group 1 rocks that are strongly deformed in a ductile regime by simple shear. Because Au appears to concentrate along the intermediate strain axis along the margins of weakly deformed bodies, dilatational jogs may allow for vertical flow of metamorphic fluids leading to secondary gold enrichment.

CRUSTAL ANCESTRY OF THE ASSEAN LAKE COMPLEX, NORTH-CENTRAL MANITOBA, REVEALED BY COUPLED $^{147-146}Sm$-$^{143-142}Nd$ ISOTOPES

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Although crust likely existed on Earth prior to 4 billion years ago, nearly the entire geological record from the Hadean Eon has been lost. Beside scarce localities hosting detrital Hadean zircon grains and rare occurrences of > 3.6 billion year old rocks, Neo- to Mesoarchean felsic rocks from the tonalite–trondhjemite–granodiorite (TTG) series which dominate Archean cratons represent the oldest crustal remnants. These felsic rocks were likely produced by the melting of older mafic precursors and recent isotopic evidence suggests that Hadean basaltic crust was the source for the oldest TTG from the Slave, Superior and the Nain provinces. The ^{142}Nd isotopic tracer is well-suited for tracing the involvement of Hadean silicate sources in the generation of these Archean rocks; the short-lived parent isotope ^{146}Sm (half-life of 103 Myr) was functionally extinct by 4.0 Ga, and any variations in $^{142}Nd/^{144}Nd$ ratios require Sm–Nd fractionation during the Hadean. Post-4 Ga crustal reworking has no influence of the $^{142}Nd/^{144}Nd$ ratio, thereby preserving evidence of, and constraining the nature of, Earth's Hadean crust. The Assean Lake Complex, in north-central Manitoba is a 3.2 to 3.1 Ga block of gneissic tonalite to granodiorite, containing inherited zircon as old as 3.5 Ga. Nd model ages as old as 4.2 Ga suggest the involvement of an ancient component in the petrogenesis of these TTG bodies. To date, only four samples from the Assean Lake Complex have been analyzed for ^{142}Nd, yielding no resolvable ^{142}Nd anomalies, but given the age of these rocks and evidence for older crust inherency, further investigation is warranted. Here, we present new ^{142}Nd data for 15 Mesoarchean TTG samples from the Assean Lake Complex to better constrain the nature and age of their crustal precursor source(s) and investigate if the reworking of Hadean crust was recorded by some of the oldest rocks from the Western Superior Province.

FORMATION OF REE-RICH SEGREGATIONS BY SILICATE–FLUORIDE MELT IMMISCIBILITY IN THE LONGS PEAK-ST. VRAIN SILVER PLUME GRANITE, NEAR JAMESTOWN, COLORADO (USA)

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Globally unique REE-rich (40–46% REE, 3.7–4.8 wt.% P_2O_5, and 5–8 wt.% F) mineralization within the anorogenic 1.4 Ga Longs Peak-St. Vrain granite near Jamestown, Colorado, has long drawn attention, yet defied a petrogenetic interpretation. Up to several decimetre-sized REE pods in aplite, consist of zoned assemblages dominated by a core of fluorbritholite-(Ce), with monazite-(Ce), fluorite, and minor quartz, surrounded by a rim of allanite-(Ce). Bastnaesite-(Ce), törnebohmite-(Ce), and cerite-(Ce) define an intermediate zone between core and rim. Both textural features and geochemical data suggest that the aplite and REE-rich globular segregations co-existed as two co-genetic liquids prior to their crystallization, suggesting that they are formed by silicate–fluoride + phosphate (+ S + CO_2) melt immiscibility following ascent, cooling, and decompression of what was initially a single homogeneous magma. Although monazite-(Ce) and uraninite U–Th–Pb microprobe ages for the segregations yield 1.420 (± 25) and 1.442 (± 8) Ga, respectively, they suggest a co-genetic relationship with their host granite, average $\varepsilon Nd_{1.42\ Ga}$ value of –3.9 for granite and related granitic pegmatite, differ from the average value of –1.6 for both aplite and REE-rich segregations. Furthermore, granite and pegmatite have (La/Yb) N < 50 with significant negative Eu anomalies, which contrast with higher (La/Yb) N > 100 and absence of Eu anomaly in both aplite and segregations. This implies that the aplite dykes and the REE-rich segregations are co-genetic but derived from a source different from the granite. The higher $\varepsilon Nd_{1.42\ Ga}$ values for aplite and REE-rich segregations suggest that the magma from which they separated had a more mafic and deeper, dryer and hotter source in the lower crust or upper mantle, compared to the quartzofeldspathic upper crustal source proposed for the Longs Peak-St. Vrain granite. We discuss implications of this work and the broader role of fluid and melt immiscibility in REE and pegmatite petrogenesis.

NEODYMIUM ISOTOPE MAPPING OF POLYGENETIC TONALITE-TRONDHJEMITE-GRANODIORITE (TTG) BATHOLITHS: FAILED BACK-ARC RIFTING IN THE CENTRAL METASEDIMENTARY BELT, SW GRENVILLE PROVINCE

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Fifty-five Nd isotope analyses are presented for plutonic orthogneiss from the Grimsthorpe domain in the marble-rich segment of the Grenvillian Central Metasedimentary Belt (CMB) to test the back-arc aulacogen model for its origin. Nd isotope analyses from the Weslemkoon batholith, Elzevir batholith, Lingham Lake complex, and Canniff tonalite are used to probe the crustal formation age of their source rocks. Despite its concentric foliation, the Weslemkoon batholith displays a complex isotopic pattern consisting of several northeast-trending domains with older source rocks, which are surrounded by juvenile domains. The new Nd isotope results, coupled with geochemistry for the Weslemkoon and Elzevir batholiths, depict the fragmentation of a block of old crust that formed a screen between en echelon segments of a mid-Mesoproterozoic back-arc rift zone. The isotope boundaries identified within the Weslemkoon batholith delineate magma pulses sampling two distinct sources, interpreted as Laurentian basement and juvenile basaltic underplate. Underplating could be attributed to slab rollback under the pre-Grenvillian

continental margin arc. The intensification of rift-related magmatism in the CMB is demonstrated by its bimodal petrological character. A modern analogue for the tectonic context of the CMB is the Gulf of California, where subduction-related magmatism has transitioned to rift-related magmatism. However, the Gulf of California exhibits more transcurrent motion than is evidenced by the geometry of the CMB rift. A geometrical analogue for the break-up of the Elzevir block between two rift segments is provided by the Danakil block of the Red Sea, which is currently undergoing similar tectonic fragmentation.

INSIGHTS INTO THE TECTONIC SETTING OF PALEOPROTEROZOIC OROGENIC GOLD IN THE PINE LAKE GREENSTONE BELT, NORTHEAST GLENNIE DOMAIN, REINDEER ZONE, TRANS-HUDSON OROGEN

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The Pine Lake belt hosts numerous economic gold occurrences, including SSR Mining's now exploited main Seabee mine and the more recently discovered highly Au-endowed deposits along the Santoy shear zone, a splay of the Tabbernor fault zone. Geochemical and isotopic studies indicate that volcanic rocks of this belt's two main assemblages are juvenile and record an evolution from primitive arc tholeiites (Assemblage A) to evolved calc-alkaline rocks (Assemblage B). Within Assemblage A, the 'Carruthers Lake basalt' has characteristics in common with island-arc tholeiite, whereas the 'Santoy Lake basalt' has signatures indicative of proximal back-arc or rifted arc settings. The Pine Lake belt thus originated (~1920–1875 Ma) as a juvenile island arc and accompanying back arc basin in the ancient Manikewan ocean. Convergence of oceanic plates (~1875–1860 Ma) led to collision and thrust intercalation of arc and back-arc components. Subsequent crustal thickening (~1860–1840 Ma), uplift and erosion drove deposition of the Pine Lake conglomerate at the base of Assemblage B; during this stage, thrusts were reactivated as normal faults, focusing conglomerate deposition along pre-existing (D1) faults. Continued or renewed subduction produced a second phase of (successor) arc magmatism (~1840–1810 Ma). Uplift, sedimentation and deformation (D2) continued as the Sask craton impinged upon the arc complex with final assembly (< 1820 Ma) driven by terminal collision of all bounding cratons. Notable concentrations of gold accumulated along the Santoy shear zone during the latest stages of D3 folding and strain localization/fluid migration along the crustal-scale Tabbernor fault zone. While clearly 'late-orogenic', gold mineralization represents the end-product of a protracted history of tectonic activity in fluid-rich environments (i.e. volcanic arc). All told, gold in the Pine Lake belt likely underwent significant recycling, being initially concentrated along D1 thrusts and potentially re-concentrated in D2 structures; with final migration into suitable structural sites during latest compressional–transpressional (D3) deformation.

HIGH-RESOLUTION DRONE MAGNETICS PROVES AN EFFECTIVE DRILL TARGETING TOOL AT THE DEPOSIT SCALE FOR THE BIG MACK PEGMATITE PROJECT

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High-resolution magnetic data obtained from a sufficiently precise and low flying unmanned aerial vehicle (UAV) magnetic survey at the Big Mack property presents a cutting-edge approach in the search for lithium within the Separation Lake Greenstone Belt (SLGB) of northwestern Ontario. The property's geological setting, characterized by significant petalite mineralization within lithium–cesium–tantalum (LCT) subtype rare-metal pegmatite, hosted in intrusive and volcanic mafic rocks, presents a compelling case for the use of high-resolution magnetic data in delineating exploration targets. This portable, non-invasive technique has successfully identified magnetically low features that show strong correlation with substantial, drill-proven mineralized zones, leading to the identification of six primary drill target areas proximal to known mineralization. Three-dimensional modelling of the magnetic data has defined target zones to depth, and when combined with historical mapping and recent geochemical sampling data, has improved the understanding of subsurface trends across the property, allowing for a strategic focus on exploring the areas with highest potential. The precision offered by the UAV survey is evident in the clear definition of the Big Mack deposit as well as other known pegmatite bodies in the SLGB. The current drill program, guided by the EarthEx 'exMAG' survey magnetic data, has been designed to validate the modelled extensions of known mineralized zones, and explore the depth and true potential of identified targets. This innovative technique has not only refined the exploration strategy at Big Mack by significantly de-risking drill-holes, but also set a benchmark for exploring similar granite pegmatite deposits that are hosted in greenstone belts. The ability to non-invasively map subsurface features accelerates the preliminary exploration phase, thereby reducing environmental impact and focusing resources on the most promising targets. These findings emphasize the importance of integrated geophysical techniques in modern mineral exploration, offering an early stage template for future studies in similar geological settings.

LOOKING THROUGH LITHIUM-TINTED RETROSPECTACLES: HOW CAN THE UNDERSTANDING OF RARE METAL PEGMATITE IN RESEARCH AND THE MINERALS INDUSTRY BETTER INFORM EACH OTHER?

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The recent exploration "rush" for lithium has generated much new data relating to LCT pegmatite occurrences from intensified exploration and mine development activity, especially in Archean terranes in Western Australia and Canada. This new exploration poses some challenges and questions to existing and established paradigms for ore models and genetic theories for rare metal pegmatite occurrences. However, much new data produced has mostly not been subject to systematic analysis, with current detail in the public domain usually limited to stock exchange announcements tailored to an investor audience. At a regional scale, a question is the applicability of proposed anatectic models of pegmatite genesis in exploration, as opposed to 'traditional' models of fertile granite. To the author's knowledge, these granite-related models continue to be used in all exploration to date. The relevance of a minerals systems approach to pegmatite exploration appears increasingly valid, not least as ore systems of other commodities occur in close proximity to significant rare metal pegmatite bodies. In an exploration targeting context, attention is drawn to distal geochemical dispersion haloes of Li–Rb–Cs in host rocks as an under-utilized tool. At a deposit scale, the common image of near concentric zoned pegmatite intrusions persists, with little or no relevance to the substantial sheeted Li mineralized bodies being mined and explored for. Do existing and proposed classification systems adequately account for these bodies? The term 'fractionation' is commonly used in discussing the degree of geochemical specialization and extent of concentration of rare elements in relation to more common ones, but most public reference data sets developed over the years relate to minerals and not whole rock geochemistry. The latter is the norm in exploration, where mineral mixtures are dealt with, especially in percussion drilling. In the latter case, refinement of geochemical data is required, particularly where mineral species are not identified accurately.

ADVANCES IN ISOTOPIC CHRONOLOGY OF PALEOPROTEROZOIC BANDED IRON FORMATIONS IN THE NORTH CHINA CRATON

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The world's super-large iron deposits are mainly Precambrian banded iron formations (BIFs), with > 70% of global Fe being formed in the Siderian (2.5–2.3 Ga). The BIFs with size exceeding 105 Gt were mostly formed in the Siderian and belong to the Superior type. However, the BIFs in North China Craton (NCC) have been commonly believed to be Archean Algoma type, rather than Paleoproterozoic (especially Siderian) Superior type. In this contribution, the authors collect and reassess the zircon U–Pb age data of the BIFs in NCC, and conclude that the BIFs in the Wutai, Wuyang, Lushan, Jining and Daqingshan terranes were formed in the Sider-

https://doi.org/10.12789/geocanj.2024.51.211

ian, and those in the Jiaobei and Huoqiu terrains formed in late Siderian or the transition from Siderian to Rhyacian. The BIFs in Lvliang terrane were formed in Rhyacian, and those in the Songshan Group in Henan and the Wanzi Group (Fuping) in Hebei were formed in the Orosirian. The BIFs in the Wutai Group belong to Algoma type, whereas the other Paleoproteroic BIFs are Superior type. In the early Paleoproterozoic, microbial processes and biological photosynthesis were remarkably enhanced, the ocean changed from reducing to oxidic or sub-oxidic, and meanwhile, a large amount of Fe^{2+} was oxidized to Fe^{3+}, and subsequently deposited as global BIFs. Detrital zircons from the BIF-bearing strata in NCC recorded three significant magmatic and continental crust accretion events at 2.54, 2.76, and 2.99–2.94 Ga, respectively. The crustal accretion event at 2.54 Ga is the most intense. The instability of the NCC in late Neoarchean and early Paleoproterozoic made it difficult to form large-scale cratonic basins and may be the main reason for the low reserves and grade of Siderian BIFs in China.

THE PETROGENESIS OF MAGMATICALLY-DERIVED GELS

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Pegmatite melts are generated from the mobilization of intergranular fluids along the margins of hydrous igneous intrusions. Tectonically nduced fissuring opens voids in the mostly brittle parts of these crystal mushes, allowing the fluids to form dikes and segregations both internally and externally from the intrusions. The fissuring causes an extreme drop in pressure that initiates a process known as flash boiling atomization of the residual hydrous intergranular melt, which spontaneously boils and forms melt droplets in a front propagating into the mush until repressurization occurs. The atomization produces spherical nanoparticles after the melt droplets are further broken up and rounded by impacting the crystals that line the networks of interconnected pores within the mush when the boiling melt is transported down the pressure gradient towards fissures. The resulting fluid becomes much cooler than the crystal mush due to the expansion of the exsolved phase during depressurization, which undercools the entrained melt droplets. This low-viscosity two-phase fluid (i.e. undercooled melt nanospheres dispersed in their exsolved aqueous-carbonic fluid) is then sprayed into fissures and channeled along them to rapidly fill the voids, analogous to drawing fluid into a syringe. Once fissures are filled and the pressure re-equilibrates while excess hydrous fluids in the dikes and segregations diffuse into their surrounding host rocks, the melt/glass nanospheres in fissures become packed and stick together through short-range attraction, then undergo spinodal decomposition and crosslinking to form a particle gel from which crystallization of mostly alkali aluminosilicates occurs. Contact metamorphism of external granitic pegmatites is limited to metasomatism (e.g. biotitization, tourmalinization) and the formation of mostly hydrous minerals that indicate pegmatitic fluid emplacement, gelation, and crystallization temperatures of 400°C and below. The crystallization of massive quartz-rich units — silica gel remnants that define the granitic pegmatite solidi — is known to occur as low as 260°C and below.

PALEOPROTEROZOIC TECTONIC INSIGHTS FROM THE WESTERN CANADIAN SHIELD USING U–Pb + Hf ISOTOPIC ANALYSIS IN DETRITAL ZIRCONS

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This study examines the early Paleoproterozoic history of supracrustal rocks in the western Canadian Shield to better inform the geological events that formed Laurentia. Samples were collected for detrital zircon U–Pb geochronology and Hf isotopes from the Rae province, Taltson magmatic zone, and the Great Slave Lake shear zone in order to assess depositional ages, provenance and geodynamic significance accompanying the detrital systems. Samples from the Rae province were deposited at about < 2.1 Ga in a broadly extensional regime and were derived from western Rae province sources. Samples from the Taltson magmatic zone were deposited at about < 2.0 Ga in a contractional regime and also were derived from western Rae sources, but differ in that they have a significant 2.2 to 2.0 Ga detrital source of relatively juvenile material. The 2.2 to 2.0 Ga detritus may have been derived from reworked ca. 2.3 Ga crust or from rocks (currently unknown exposures) with an enriched mantle source. A sample from the Great Slave Lake shear zone was deposited at about < 2.0 Ga in a contractional regime and was derived from Slave Province crust. Our data support extension along the western Rae margin at ca. 2.1 Ga and distinct histories of the Rae and Slave provinces prior to their collision at ca. 1.95 Ga. The Rae province may have initially been attached to the Slave province, North China Craton or various Indian cratons prior to 2.1 Ga, but further work is required to make more robust linkages. This study helps show the utility of detrital zircon U–Pb + Hf analyses to help resolve geodynamic settings and tectonic reconstructions in polydeformed and metamorphosed terranes.

ANATOMY OF AN ARCHEAN TERRANE BOUNDARY: STRUCTURAL ANALYSIS OF THE BOUNDARY BETWEEN THE QUETICO AND WAWA SUBPROVINCES (SUPERIOR PROVINCE)

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Archean plate tectonics are poorly understood due to poor preservation of tectonic features, a higher geothermal gradient, and multiple younger tectonic events overprinting original tectonic fabrics. To dissect the evolution of Archean tectonics, we study the structural, metamorphic, and strain spatial patterns across the terrane boundary between the Quetico and Wawa Subprovinces of the Superior Province. The SW-NE striking subprovince boundary separates metasedimentary rocks (Quetico Subprovince) from metavolcanic rocks of the Shebandowan Greenstone Belt (Wawa Subprovince). The lithological contrast is believed to represent either an Archean erosional contact, a strike-slip fault, or a paleo-subduction zone. We test the potential formation processes by characterizing changes of orientation of ductile deformation and the patterns of both intensity and geometry of strain. Furthermore, models of phase equilibria, based on the whole rock geochemistry and mineral compositions from SEM-BSE analyses, constrain the metamorphic gradients across the boundary. Our initial findings suggest that the subprovince boundary has a strong strike-slip ductile overprint as indicated by a consistent subhorizontal stretching lineation. In the Quetico Subprovince, strain intensity decreases towards the boundary. The Shebandowan Greenstone Belt, in contrast, has a complex pattern of localized high strain and simple-shear dominated zones separating pure-shear dominated zones of varying strain intensities. P-T estimates and field observations show a change from lower greenschist-grade rocks to higher-grade, migmatitic paragneisses in the Quetico Subprovince indicating a high lateral temperature gradient whereas the temperature gradient is significantly lower in the Shebandowan Greenstone Belt. The high lateral thermal gradient of the Quetico Subprovince could be characteristic of a subduction zone. Nevertheless, the strong strike-slip overprint may have obliterated original subduction related fabrics.

150 MILLION YEARS OF PLUME-ASSISTED CONTINENTAL RIFTING TO FORM THE PALEOPROTEROZOIC MAGMATISM OF THE SOUTHERN DOMAIN, CAPE SMITH BELT, NUNAVIK, QUÉBEC

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Characterization of the diverse magmatic phases within Precambrian orogenic belts is crucial to understand their tectonomagmatic evolution and the geodynamic regimes controlling their assembly. The Southern Domain of the Cape Smith belt (Nunavik, Québec), part of the Paleoproterozoic Trans-Hudson orogenic belt, consists of three magmatic phases previously described as representing a time and space transition from continental rift, to passive margin, to ocean basin opening. The ca. 2038 to 1991 Ma Beauparlant Formation comprises pillow basalts and massive basaltic flows and is interpreted as a large igneous province (LIP) intruding the rifting Superior craton margin. The ca. 1960 to1950 Ma Cecilia Formation is composed of bimodal massive flows and subaerial volcanoclastic rocks and is inferred to have

formed from hot-spot magmatism intruding a passive margin. Finally, the ca. 1882 to 1870 Ma Chukotat Formation, composed of differentiated basaltic flows and sills which demonstrate in the field a transition from ultramafic cumulates to komatiites to pillow basalts, has previously been interpreted to be ocean crust and more recently as a second mantle-plume driven LIP. Preliminary whole rock lithogeochemical data of basaltic rocks from each formation indicate that the Beauparlant Formation plots mainly as Fe-Tholeiite but includes alkali basalt of E-MORB affinity. The Chukotat Formation spans an array of Fe-Tholeiite to Komatiitic basalts with some preserving an alkaline signature. The Chukotat Formation basalts range from N-MORB to E-MORB affinity. The Cecilia Formation displays the greatest alkalic component and yields an E-MORB to OIB affinity. All units yield clear evidence of crustal contamination with incompatible element enrichments in LILE, U, Th, Pb, and LREE compared to the primitive mantle. This suggests that the basin never reached a mature rifting phase. Our results indicate that plume-assisted continental rift magmatism was located and punctuated at the thinned margin of the Superior Craton for over 150 million years in the Southern Domain.

SPECTROSCOPIC STABILITY ANALYSIS OF Mg AND Ca CARBONATES UNDER MARS SURFACE AND HIGH VACUUM CONDITIONS

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The purpose of this study was to analyze biogenic magnesium-carbonate-rich samples from fluvial-lacustrine and playa environments on Earth including the Atlin playas, British Columbia, Canada, Clinton Creek, Yukon, Canada, Lake Alchichica, Puebla State, Mexico and, Lake Salda, Turkey. The goal was to advance the ability to detect and characterize different Mg-carbonates on Mars using VISIR reflectance spectroscopy. The nine samples from these sites were subjected to 85 days of Mars surface conditions including ~5–7 millibars of CO_2 and ambient temperatures. On Day 85 the pressure was lowered to 4 x 10^{-7} mbars, for a high vacuum, low-pressure experiment until the end of the run on Day 104. Spectral changes were assessed in terms of significant changes in band depth, shape, position, overall spectral slope; X-ray diffractometry was used to interpret any spectral changes. From the initial results, the hydromagnesite-bearing samples did not exhibit any significant changes within the experimental run. The Mg and Ca mixture samples lost adsorbed OH/H_2O, resulting in some shift in spectral band positions. The addition of a high vacuum does not seem to have affected the sample spectra except for one of the Clinton Creek samples which exhibited several spectral changes over the course of the experiment. No additional significant dehydration or band minima position changes occurred for the other samples in high vacuum. From this study, we determined that biogenic hydromagnesite and aragonite are stable under Mars and high vacuum conditions, and that adsorbed water, but not structural water, is evolved from these samples. This has implications for Martian stability, habitability, and biogenic carbonate preservation under atmospheric pressure variations, and on icy bodies such as Enceladus and Europa.

PETROGRAPHIC, GEOCHEMICAL AND STRUCTURAL ANALYSIS OF PEGMATITE-HOSTED REE MINERALIZATION IN THE FORGET LAKE AREA, NORTHERN SASKATCHEWAN

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Numerous REE deposits and showings, including those associated with pegmatites in Precambrian rocks, have been found in northern Saskatchewan in recent years. This study examines one of the showings in the Forget Lake area, north of Lake Athabasca. The area is located in the Beaverlodge Domain, which consists mainly of Archean to Paleoproterozoic metamorphic/plutonic rocks. The study area is part of a North-South-trending regional polyphase megafold, which hosts the multiple low- to high-grade REE occurrences associated with pegmatites at Alces Lake. Based on grid field mapping of a 20 x 25 m outcrop and petrographic examination of samples collected from the outcrop and drill core, seven lithologic units were distinguished, including two varieties of pegmatite. The pegmatite bodies of both varieties are irregular in shape, with many occurring in the form of augenitic lensoid pods. The host rocks are strongly foliated gneisses; the average foliation orientation is 184°/79°. Petrographic and Raman spectroscopic analyses show that monazite-(Ce) is the main REE-mineral in the pegmatites and is concentrated in biotite-rich zones. A pegmatite situated along a ca. 5 m-wide biotite-rich shear zone contains the most abundant monazite. Whole-rock geochemical analyses indicate that both the pegmatites and the host rocks have LREE-enriched REE patterns, but the pegmatites are more enriched in LREE and have higher total REE than the gneisses. In particular, mineralized pegmatites appear to have higher total REE and more significant Eu depletion than other pegmatite types. The geological characteristics of the pegmatites documented so far, especially their irregular shapes, appear to support a low degree of anatectic partial melting in the genesis of the pegmatites and REE mineralization. However, more detailed geological and geochemical studies are warranted to better understand the conditions and processes of the mineralization, which will have implications for further exploration in the region.

METAMORPHISM IN THE NORTHEASTERN MEGUMA TERRANE; LOCAL HIGH HEAT FLOW METAMORPHISM AND COMPLEX RELATIONSHIPS

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The Meguma terrane in Nova Scotia consists mainly of Cambrian to Ordovician metasedimentary rocks intruded by peraluminous granite and minor diorite–tonalite–granodiorite bodies intruded between 380 Ma and 360 Ma. The metasedimentary rocks were variably metamorphosed to greenschist to amphibolite facies during the Early Devonian. South of the West River St. Marys Fault, metasedimentary rocks of the Goldenville and Halifax groups were intruded by mainly granitic and minor diorite–tonalite–granodiorite plutons. The pelitic rocks contain garnet and staurolite as idioblastic porphyroblasts and fabric relationships suggest that amphibolite-facies metamorphism was coeval with regional deformation. P-T estimates indicate peak metamorphic conditions were at least 550–620°C and 4–6 kbar. A new garnet Lu–Hf age of 372.7 ± 1.4 Ma constrains the timing of amphibolite-facies metamorphism. This age is indistinguishable from the published U–Pb zircon emplacement age of 375.0 ± 4.6 Ma for the mylonitic Kelly Brook pluton which intruded these rocks. The pluton has a 369.0 ± 1.2 Ma $^{40}Ar/^{39}Ar$ muscovite cooling age indicating rapid cooling. In nearby rocks associated with the Trafalgar Plutonic Suite, cordierite + andalusite ± biotite assemblages indicate peak metamorphic conditions of similar temperatures but lower (2.5–3.5 kbar) pressures, suggesting different intrusive depths for plutons. As the leading edge of the collision between the Meguma terrane and Avalonia, the northern part of the eastern Meguma terrane represents an active tectonic environment in the late Devonian. The regional-scale deformation, metamorphism, and contact metamorphism overlapped in time and space, and was followed by rapid exhumation of the Meguma terrane.

APATITE, A PIECE OF THE CARBONATITE-NIOBIUM PUZZLE

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The St Honoré carbonatite complex is the site of one of three niobium mines and, in all of them, the niobium mineralization is intimately associated with apatite. Three rock units host this mineralization (pyrochlore) at St Honoré; an apatitite, an apatite-bearing biotitite and a magnetite-biotite rock. The apatitite, however, contains the bulk of the niobium. Cathodoluminescence mapping and trace element analysis revealed a striking difference between the apatite in the apatitite and biotitite. Apatite began crystallizing in the biotitite from a carbonatitic magma that was interacting with an adjacent K-rich syenite. This was interrupted by the exsolution of an aqueous fluid, which caused recrystallization of the apatite cores. The apatite rims, there-

https://doi.org/10.12789/geocanj.2024.51.211

fore, crystallized from a magma that was depleted in fluid-mobile elements. In the apatitite, crystallization commenced after fluid exsolution and was followed by fluid-induced recrystallization of the rims of the apatite. This difference in crystallization history reflects the different origin of the two units. The biotitite formed as a result of the interaction of the carbonatitic magma with K-rich syenite, during which Mg and OH were removed from the magma to crystallize biotite. This enriched the interstitial liquid in Ca, and P (and Nb) saturating it in apatite (and pyrochlore). In contrast, the apatitite crystallized from an evolved residual magma that accumulated at an advanced stage of biotitization, after the crystallization of considerable calcite and the resulting onset of aqueous fluid exsolution. The resulting enrichment in Ca, P and Nb saturated this magma in apatite and pyrochlore to form the apatitite-bearing pyrochlore ore that forms the bulk of the deposit. Our study shows that, as is the case for pyrochlore, crystallization of apatite was closely related to biotitization, crystallization of calcite and fluid exsolution, and that these processes controlled the evolution of the niobium ore-forming system at St Honoré.

A CLIMATE RECONSTRUCTION FOR THE PAST 5000 YEARS IN SOUTHERN SASKATCHEWAN BASED ON OSTRACOD STABLE ISOTOPES AND TRACE ELEMENT ANALYSES

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Sediment cores from Deep Lake and Pond-1 of the St. Denis national wildlife area in southern Saskatchewan provide insights regarding climate change in the northernmost part of the Great Plains over the last 5000 years. Chemical proxies for environmental and climate reconstructions including oxygen and carbon stable isotope ratios were determined for *Fabaermiscanona obtusa* (Deep Lake), and laser ablation ICP-MS trace elements analyses were performed on shells of *F. obtusa*, *Candona acutula* and *Cypridosis vidua* (St. Denis). Preliminary results show a total of nine and five ostracod species in the cores from Deep Lake and St. Denis, respectively. Chemical proxies in both records show remarkable excursions at 60 cm in Deep Lake and at 14 cm in St Denis: $\delta^{18}O$ and $\delta^{13}C$ values become more negative whereas the ratios of Mg/Ca, Sr/Ca, U/Ca, Mn/Ca, Fe/Ca and U/Th increase. This change is dated at ~3000 Cal yr BP in Deep Lake. *Cypridosis vidua* was found in both records, *C. acutula* is absent in Deep Lake, whereas *F. obsuta* is present in Deep Lake, and below 37 cm of the St. Denis' record. At this depth, *C. acutula's* shells display a change from light to darker colours up core. Future analyses will focus on dating and interpreting chemical and stratigraphic changes using statistics to reconstruct past variations in temperature, evaporation to precipitation ratio, and water chemistry of these watersheds.

DEPOSITION OF THE MOBLAN LITHIUM-CESIUM-TANTALUM PEGMATITE DYKE SWARM: FROM MELT EMPLACEMENT TO LATE-STAGE PROCESSES (QUEBEC, CANADA)

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Many issues of lithium-cesium-tantalum pegmatite genesis are the subject of ongoing debate, notably the source of the magma, the role of H_2O and the conditions of crystallization. Preliminary results for the Moblan lithium pegmatite dyke swarm in the Archean Frotet-Evans greenstone belt, Québec, address some of these issues. The swarm consists of two groups of dykes, one oriented East-West emplaced in ductile to brittle structures, and a second group oriented North-South, controlled by brittle structures. Whole-rock geochemical signatures (K/Cs, K/Rb, Nb/Ta) indicate that the N-S pegmatites are more evolved than the E-W pegmatites. These differences are also evident within a single dyke. The Moblan Main dyke comprises two parts with different elemental signatures separated by a layered aplite; the upper part is more evolved. This likely records multiple injections of magma to form the main dyke rather than the in-situ differentiation of a single magma. A feature of the dyke is that several minerals are intergrown with quartz: potassic feldspar, albite, garnet, and spodumene. Spodumene-quartz intergrowths are very common in the dyke, although spodumene also occurs as euhedral crystals free of quartz. Based on textural evidence, the intergrowth is interpreted to reflect co-crystallization of the two minerals rather than the breakdown of petalite, and to have been the result of a large degree of undercooling. The emplacement of the Moblan pegmatites terminated with hydrothermal alteration of the previously crystallized minerals. Most significantly, spodumene was locally altered to alkali feldspar and/or fine-grained mica. These minerals crystallized from fluids of higher pH or temperature and lower pH or temperature respectively, that propagated through cracks and along cleavages in the spodumene, eventually replacing the latter completely. The study highlights the complex history of the Moblan pegmatites and the important role that multiple injections of magma, undercooling and aqueous fluids played in their genesis.

ULTRAHIGH TEMPERATURE METAMORPHISM RECORDED IN MAFIC GRANULITES FROM THE PIKWITONEI GRANULITE DOMAIN OF THE NORTHWESTERN SUPERIOR PROVINCE

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Ultrahigh temperature (UHT) metamorphism is generally preserved in Al-rich and Iron-rich pelitic granulites with a temperature above 900°C at 7–9 kbar. We report here a UHT mafic granulite recognized in the Pikwitonei Granulite Domain, the northwestern margin of the Superior Province. These mafic granulites can be subdivided into groups I and II, according to whether granulite includes garnet or not based on the petrographic examination. Both groups of mafic granulites experienced three metamorphic stages: prograde assemblages of amphibole + plagioclase + quartz were preserved in the pyroxene (Group I) and clinopyroxene + plagioclase + quartz were preserved in the garnet core (Group II), respectively. Peak metamorphic stage is defined by coarse-grained clinopyroxene, orthopyroxene, spinel, with or without garnet. Late development of amphibole and the symplectite of garnet + quartz marked the post-peak assemblage of groups I and II, respectively. Phase equilibria modelling in NCKFMASHTO system for two groups of granulites yield consistent peak P-T conditions of 1050–1160°C, 8.4–9.4 kbar and clockwise P-T path, indicating a decompression heating process. SHRIMP U–Pb dating on the metamorphic zircons from Group I and II yielded weighted mean $^{207}Pb/^{206}Pb$ ages at 2624 ± 17 Ma and 2680 ± 11 Ma, respectively. This exhibits a timing gap of ca. 50 Myr between two groups of UHT mafic granulites, suggesting that this UHT event lasted for at least ca.50 million years. These results combined with available data indicate that this UHT metamorphism was formed in a post-orogenic collisional setting during the amalgamation of the Superior Province.

CHARACTERIZATION OF SEDIMENT SOURCE CONTRIBUTIONS TO EARLY CRETACEOUS SEDIMENT-ROUTING SYSTEMS IN THE CENTRAL AND SOUTHERN SECTORS OF THE ALBERTA BASIN

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Provenance studies of sedimentary units offer insight into the long-term development of large-scale sediment-routing systems. Lower Cretaceous units in Alberta record the evolution of several large-scale sediment-routing systems in the Alberta Basin over 25 million years. While the provenance of these units is well-constrained in northeastern Alberta and in the Rocky Mountain Foothills, provenance studies on time-equivalent units in central and southern Alberta are limited. Since Early Cretaceous sediment-routing systems in central and southern Alberta may have been connected to coeval systems in other areas, study of sedimentary units in central and southern Alberta is required to fully characterize Alberta's Cretaceous landscapes. In this study, we examine new and published U–Pb detrital zircon dates (total number of samples = 14; total number of dates = 2788) from the Lower Cretaceous Man-

nville Group in central and southern Alberta. The study objective is to document U–Pb date populations in these units to enable comparison with coeval units and examine connectivity between adjacent sediment-routing systems through time. U–Pb date populations were identified and analyzed using probability density plots and MATLAB-based mixture modelling approaches. Results show that studied units contain five notable date populations that are also observed in coeval units elsewhere. Populations include: (1) a Paleoproterozoic group (2300–1800 Ma); (2) a Mesoproterozoic-Neoproterozoic group (1250–950 Ma); (3) a Paleozoic group (500–260 Ma); (4) a Jurassic group (201–145 Ma); and (5) a Cretaceous group (< 145 Ma). Modelling results suggest that date population proportions in studied units differ significantly from those in adjacent areas during the Aptian but resemble those in adjacent areas during the Albian. This suggests that connectivity between Alberta's large-scale sediment-routing systems was restricted during the Aptian and less restricted during the Albian. These results help constrain basin evolution in Early Cretaceous Alberta and can assist with predicting sediment provenance in overlying units.

NIOBIUM ORE GENESIS IN A CAPSULE

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A problem that has hindered the development of a model for the genesis of carbonatite-hosted niobium deposits is that the solubility of niobium minerals in carbonatitic magmas is extremely high, yet pyrochlore, the main ore mineral, is an early crystallizing phase. Based on the close association of the niobium mineralization with glimmerite (biotite) in the Araxa and St Honoré, carbonatites (responsible for > 90% of global niobium production), we propose that niobium saturates in the magma because of the prior consumption of much of the magma due to its reaction with K-feldspar fenite to form glimmerite. To test this hypothesis, we reacted a niobium- and fluorine-doped hydrous carbonatitic liquid of dolomitic composition with a K-feldspar prism containing trace albite; the experimental conditions were 800 ^{O}C and 200 MPa. The result of the reaction was the production of a rind (on the prism) of fine-grained phlogopite, and subordinate calcite that increased in proportion outwards to form a zone of fine-grained calcite. We interpret the rind to represent the metasomatic replacement of K-feldspar by the liquid via the reaction: $3CaMg(CO_3)_2 + KAlSi_3O_8 + H_2O = KAlMg_3Si_3O_{10}(OH)_2 + 3Ca(CO_3) + 3CO_2$. A domain containing books of phlogopite and coarse calcite, which we interpret to represent the residual liquid from the reaction, formed adjacent to the rind. Beyond this, the starting liquid crystallized to calcite, magnesite and minor dolomite. As predicted, pyrochlore crystallized in the experiments and did so towards the edge of the fine-grained phlogopite zone, in the fine-grained calcite zone and in the adjacent coarser-grained phlogopite-calcite domain. The results of these experiments support the hypothesis that the metasomatic alteration of K-feldspar fenite by carbonatitic magmas of dolomitic composition leads to the saturation of pyrochlore. This, in turn, explains the close spatial association of niobium ores with glimmerites in carbonatite complexes.

MINLIB BIBLIOGRAPHY - DEVELOPMENT AND APPLICATIONS

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There are about 50 years of personal history here, in this description of a powerful Earth-sciences bibliographic database (MINLIB), which has a substantial companion (WORLD) of geopolitical bent. The origins lie back in 3rd-year undergrad, a scrawling of boxes full of index cards in the library. The digital equivalent, MINLIB, arose later, in 1983, using a word-processor routine on a mainframe computer. Since 1988, MINLIB has been hosted on ever-faster PCs. The basic anatomy of each record is inevitable: author, title, reference, year. Beyond the mere citation, the essential feature is 1-30 lines of keyword-heavy text. Some 90 logical (yes/no) fields add versatility to queries: current flags include select geographic descriptors, mineral deposit type, chemical elements, lithological environments (e.g. pegmatites, skarns), gemstones and meteorites, environmental issues, and techniques (e.g. petrography, ore textures, (micro-)structural geology, isotopes). MINLIB currently exceeds 92,000 searchable records, and WORLD an extra 25,000. It is a broad yet finite sampling of the literature. with thematic and regional strengths, such as igneous rocks, economic geology, the Indian subcontinent, meteorites. It is backed up by a physical library and geological samples but can stand alone as and when it can be upgraded to modern software (it runs on an old but durable flat-file model). Three intensive public applications illustrate the utility of MINLIB, which has been used for 40 years in research and consulting projects. 1) The History of Geochemistry and Cosmochemistry of the late R.W. Boyle of the Geological Survey of Canada: volume 1 is in press (early 2024), updated from 1987 to 2023 using MINLIB input. 2) The Mineralogy of Meteorites, a reference work on extraterrestrial occurrences of minerals, in collaboration with J. de Fourestier and R.K. Herd, projected completion date 2025. 3) A whimsical, indexed "Rock of the Month" feature on www.turnstone.ca, now with 270-plus samples.

REASSESSING THE CLASSIFICATION OF GRANITIC PEGMATITES USING STATISTICAL ANALYSIS VERSUS VISUAL INSPECTION OF MINERAL ASSEMBLAGES

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Granitic pegmatites are among the world's most mineralogically diverse and complex rock types. Their mineralogical composition can consist simply of rock-forming quartz, feldspars and micas and may also include dozens of mineral species, many of which occur as accessory phases typically resulting from the moderate to advanced fractionation of lithophile, high-field strength or rare-earth elements of the parental pegmatite melt. Mineralogy has long been important in the classification of granitic pegmatites, serving as one of the principal criteria for separating pegmatites into different geochemical categories. The most popular classification scheme currently in use relies on the assumption that pegmatites can be grouped into distinctive families, classes, types, and subtypes by a finite number (~15) of accessory mineral species. A new pegmatite classification proposed in 2022 relies heavily on the presence of a more extensive suite of primary minerals (~30) to distinguish three distinct pegmatite groups that are not defined by metamorphic conditions, tectonic settings, level of emplacement, physical or textural features. The more comprehensive suite of minerals used in the new classification scheme allows for the inclusion of pegmatite types that were omitted in previous classification schemes. To assess the validity of the new classification groupings, a dataset consisting of 117 pegmatite localities, each represented by a distinct assemblage of essential and accessory minerals, was subjected to the statistical methods of cluster analysis and discriminant analysis. The cluster analysis method produced a solution that shows three mineralogically distinct pegmatite groups similar to the groups described in the newly proposed classification. The three-pegmatite group model is also validated by discriminant analysis which revealed high rates of correct classification for each of the three groups. The results were used to construct a discrimination diagram which can be extremely useful for classifying a broad range of granitic pegmatite types with high confidence.

EVALUATING FRACTIONATION LEVELS IN GRANITIC PEGMATITES BY HANDHELD LASER-INDUCED BREAKDOWN SPECTROSCOPY: EXAMPLES FROM THE OXFORD PEGMATITE FIELD, MAINE, USA

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Laser-induced breakdown spectroscopy (LIBS) is a technology uniquely suitable for mineral exploration that can provide rapid, compositional analysis and high-resolution imaging in both laboratory and field settings. LIBS has a particular sensitivity to the light elements (i.e. H, Li, Be, B, C) that cannot be readily analyzed by many other analytical methods. Handheld LIBS analyzers are highly versatile tools capable of real time *in situ* analysis of pegmatite materials in the field, either for elemental detection or abundance quantification. In this study, we used a handheld LIBS analyzer to acquire K, Rb and Li data on muscovite separates from granitic pegmatites in the

https://doi.org/10.12789/geocanj.2024.51.211

Oxford pegmatite field of southwestern Maine to determine the degree of pegmatite fractionation and assess the rare-element enrichment of pegmatites as part of a regional pegmatite exploration program. The Oxford pegmatite field is populated by mineralogically and chemically primitive to fractionated pegmatites that are generally characterized by a Group 1/(LCT)-type mineralogical-geochemical signature. K/Rb and Li analyses of muscovite determined by the LIBS analyzer generally corroborate the style of rare-element mineralization as observed in the field. Muscovite samples with > 500 ppm Li generally occur in pegmatites with elbaite, spodumene or petalite as the main Li mineral. Common and beryl-bearing pegmatites lacking Li mineralization usually host muscovite with < 500 ppm Li. Fractionation levels of Maine pegmatites, as expressed by the K/Rb LIBS data for muscovite range from ~125 to 40 for poorly fractionated, Li-poor pegmatites to ~40 to 10 for moderately fractionated, Li-enriched pegmatites. While the K/Rb-Li systematics of some muscovite samples may not always correctly correlate to the degree of pegmatite fractionation or style of rare-element mineralization, the ability to rapidly garner a large number of chemical analyses using a handheld LIBS analyzer is indispensable in supporting the evaluation of individual pegmatites to large pegmatite populations.

HYDROTHERMAL SOLUBILITY OF FLUORITE IN CONCENTRATED ELECTROLYTE SOLUTIONS: IMPLICATIONS TO FLUORITE MINERALIZATION AND NUCLEAR WASTE-FORM DEVELOPMENT

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Fluorite with a chemical formula of CaF_2 occurs in numerous geological environments and is an important host-phase for rare earth elements. For instance, fluorite can occur in greisen pockets of granites, in skarns, and in hydrothermal deposits such as Mississippi Valley Type Pb-Zn deposits. In nuclear waste management, fluorite provides versatile wasteforms that can accommodate a wide range of nuclear wastes. The nuclear wastes that fluorite-type wasteforms can accommodate include fluoride molten salt wastes, actinides, fission products such as Cs-135, Cs-137 and Sr-90, etc. The molten alkali fluoride salts [e.g. (Li, Na, K)F] have been used as coolants in the next generation of nuclear reactors. The fluorite wasteforms are a strong candidate for immobilization of such alkali fluoride salts contaminated by fission products. Additionally, fluorite itself is a critical mineral according to USGS definition. In this work, we have conducted solubility measurements on fluorite at 25°C and 60°C. Based on our experimental results and solubility data from the literature, we establish a thermodynamic model describing solubilities of fluorite in various media with high ionic strengths at elevated temperatures. In the modelling, we use the Specific ion Interaction Theory (SIT) for activity coefficient calculations. Based on our model, solubilities of fluorite under various geological conditions can be calculated. Our model can also be used to predict stability of fluorite wasteforms in terms of its solubility under various conditions.

CRITICAL MINERAL RESOURCE POTENTIAL IN HEAVY MINERAL BEACH-PLACER SANDSTONE DEPOSITS IN NEW MEXICO

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The demand for critical minerals (CMs) could grow over 450% by 2050. As larger and economical mines will be soon exhausted, smaller deposits, such as placer deposits, provide alternate important resources. Beach-placer sandstone deposits are accumulations of heavy and resistant minerals formed by gravity separation during sedimentary processes on upper regions of beaches or in the long-shore bars in a marginal-marine environment. The heavy minerals in beach-placer sandstone contain high concentrations of titanium, zirconium, and rare earth elements (REEs), which are important CM resources. Heavy mineral deposits have several advantages over other types of mineral deposits: 1) beneficiation process is relatively simple, only requiring density to separate out heavy minerals, and 2) remediation is also relatively simple because corresponding restoration methods are also physical. In this work, we focused on the Cretaceous beach-placer sandstone from Farr Ranch (Star Lake) in San Juan Basin, New Mexico. The sandstone deposit is layered in mineral compositions alternating from dominantly quartz and feldspar with almost no zircon to ilmenite + anatase rich layers with abundant zircon. The main heavy minerals present are zircon, ilmenite, hematite, anatase and monazite. These mineralogy variations are accompanied by different concentrations of CMs. For example, the ilmenite- and anatase-rich layer have total REE ~2.85% whereas the quartz and feldspar layer has less than 2000 ppm. Due to the similar heavy densities, zircon, ilmenite, anatase and hematite are co-existing, leading to high concentration of CMs other than REEs, such as 1.2% Ni and 0.7% Zr. Leaching tests using environmentally friendly reagents show that significant amount of CMs, > 60%, can be extracted, thus making the beach-placer deposits economically promising to mine.

LOCATION, LOCATION, LOCATION: MONAZITE BEHAVIOUR DURING ULTRA-HIGH TEMPERATURE METAMORPHISM

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Monazite is a robust mineral for recording the suprasolidus evolution of high-temperature metamorphic rocks, including migmatites and granulites. However, monazite commonly has diverse compositions and yields variable age dates from a single sample; understanding the controls on monazite behaviour and composition during partial melting and melt crystallization is not always straightforward. Here, in situ monazite petrochronology from sapphirine-quartz granulites in the Arequipa Massif in Peru is integrated with an equilibrium model of monazite behaviour. Monazite from leucocratic microdomains — inferred to represent crystallized remnants of melt — is generally older and enriched in Th relative to monazite in melanosome (i.e. residual) microdomains. Enrichment and depletion of Y are unrelated to the presence or absence of garnet in these samples. An equilibrium model of monazite crystallization accounts for the decrease in Th content in monazite with decreasing age but cannot reproduce the wide range of Y concentrations and europium anomalies (Eu/EU*) in monazite in the sapphirine-quartz granulites. The microstructural setting of monazite is a dominant control on trace element composition and that whole-rock equilibration of Eu/Eu* and Y (and the HREE) is unlikely. Monazite proximal to the dominant sources and sinks of Y (garnet) and Eu (feldspar) may serve as a monitor of the behaviour of these minerals whereas monazite distal from these minerals is a monitor of evolving melt composition during crystallization. Monazites have similar ages to zircons from the same rocks, but monazite in melanocratic domains can be younger than zircon and this monazite may have been affected by dissolution-reprecipitation in the presence of melt whereas monazite in leucosome was not. Although in situ analysis of monazite is crucial for linking trace element compositions and age dates to the metamorphic evolution of samples, there are important limitations of a whole-rock equilibrium approach to understanding accessory mineral growth and compositions in anatectic systems.

PETROLOGICAL CONTROLS ON Ce AND Eu ANOMALIES IN ZIRCON

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Trace element compositions in accessory minerals are commonly used as proxies to understand Earth's long-term changes. An increased use of big data sets of detrital, igneous, and metamorphic zircon trace element compositions can elucidate secular changes in plate tectonic processes, lithospheric redox conditions, and crustal growth. However, the underlying petrological mechanisms that contribute to the trace element signatures preserved in accessory minerals are rarely considered. Here, I discuss the variables that affect redox-sensitive rare earth element (Ce and Eu) anomalies in zircon during crustal growth and differentiation using numerical modelling that couples thermodynamic modelling of igneous and metamorphic systems with the solubility of accessory minerals and trace element partitioning. Formulations are developed that separate substitution of trivalent cations from divalent (for Eu) and quadrivalent (Ce) cations in major and accessory minerals. Variations in oxygen fugacity during the evolution of metamorphic and igneous systems due to inter-

nally buffered reactions play an important role in controlling Eu and Ce behaviour, but other variables are also significant (e.g. melt composition, mineral modes, pressure, temperature, Zr concentration). I explore the dominant variables that control Ce and Eu anomalies in zircon and then discuss the limitations and opportunities of using these anomalies in the zircon archive to understand Earth's evolution.

ADAKITE-LIKE GRANITOID INTRUSIONS IN THE PALEOPROTEROZOIC LYNN LAKE GREENSTONE BELT, NORTHWESTERN MANITOBA, CANADA: IMPLICATIONS FOR GEODYNAMIC SETTING AND GOLD MINERALIZATION

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Adakite-like granitoid intrusions (AGI) in the Paleoproterozoic Lynn Lake greenstone belt are represented by the ca. 1854 Ma Farley Lake quartz diorite stock, 1857 Ma Burge Lake pluton, 1849 Ma Motriuk Lake pluton, 1847 Ma Dunphy Lakes batholith, and 1831 Ma Fox mine intrusion. The AGI rocks are characterized by the presence of amphibole, and vary from diorite, quartz diorite, tonalite to granodiorite, although more primitive and/or evolved varieties are evident. They are medium- to coarse-grained, massive, equigranular and locally porphyritic, displaying weak to no foliation. They are mostly magnesian, calcalkaline, and metaluminous to slightly peraluminous, with Mg# ranging from 49 to 60, high Sr/Y (> 40) and La/Yb (> 20) ratios. These rocks show strongly enriched REE patterns without significant Eu anomalies, and pronounced Nb (Ta) and Ti negative anomalies. The Farley quartz diorite displays εNd_T values of +3.5 to +3.6, slightly higher than those (+2.9 to +3.2) of Dunphy Lakes tonalite, suggesting that they were derived from depleted mantle source(s). The former yielded depleted-mantle model ages of 2.07 to 2.05 Ga, similar to the latter of 2.09 to 2.06 Ga. The AGI rocks inherited arc signatures may have been derived from partial melting of subducted slab and/or partial melting of prior metasomatized sub-arc lithospheric mantle due to slab rollback/break-off during accretionary orogenesis and/or terminal ca. 1.83–1.80 Ga terrane collision. They are known as important host rocks for some orogenic Au, and porphyry Cu deposits. Intra-arc extensional settings represent favourable geological environments for Au concentration as late to postorogenic magmatism heated the crust and drove circulation of hydrothermal fluids. Nevertheless, the adakite-like intrusions predate timing of earlier generation of auriferous veins by tens of millions of years. It is likely that auriferous fluids may have been focused along faults or pathways that reactivated the same structural architecture exploited by adakite-like intrusions.

FLUID INCLUSION ANALYSIS OF ORE FORMING FLUIDS OF THE MAW ZONE REE DEPOSIT - INVESTIGATION OF POTENTIAL GENETIC LINK BETWEEN UNCONFORMITY-RELATED URANIUM AND REE MINERALIZATION IN THE ATHABASCA BASIN

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Rare earth elements (REE) encompass a crucial group of critical metals, and while most mineralization is related to carbonatites or granites, Proterozoic sedimentary basins have also been shown to host a significant concentration of these elements. The Athabasca basin, Canada, is known worldwide for its rich endowment in unconformity-related uranium (URU) deposits, many of which contain elevated concentrations of REEs. The Maw zone is a REE deposit without accompanying U mineralization in the Athabasca Basin and provides a unique opportunity to investigate the potential relationship between U and REE mineralization. Despite previous studies, great uncertainties and even contradictions exist regarding the concentrations of metals in the ore-forming fluids as well as their sources. Fluid inclusions within drusy quartz occupying the same paragenetic sequence as mineralization provide samples of ore-forming fluids for compositional, geochemical, and pressure/temperature analysis. Synchrotron x-ray fluorescence analysis of fluid inclusion assemblages showed detectable concentrations of REEs and U in inclusions, which will be confirmed with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analysis of individual inclusions and ICP-MS analysis of bulk fluid inclusions. To quantify LA-ICP-MS elemental analysis, salinity was first determined from microthermometric analysis; however, to overcome the common challenges caused by metastability, salinity was also determined through Raman spectroscopic analysis. SEM-CL analysis revealed complex sectored zoning suggesting dynamic precipitation conditions. These results will be compared to background unmineralized sandstone samples to investigate the fluid histories and potential genetic link between REE and URU mineralization, especially the potential sources, fluid pathways and chemical traps responsible for REE and URU mineralization in the basin.

MAGNETITE COMPOSITIONAL SYSTEMATICS IN OXIDIZED I-TYPE GRANITOIDS IN NEW BRUNSWICK: A KEY FERTILITY INDICATOR FOR Cu-Mo-Au PORPHYRIES

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Magnetite forms as a widespread accessory mineral in many different geologic settings and host rocks. The magnetite grains within the Devonian oxidized I-type granitoids of New Brunswick (NB) vary in size between 20 and 200 µm. They exhibit euhedral to subhedral shapes, and in SEM-BSE images notably lack oscillatory zoning. These magnetite crystals are often mantling magmatic hornblende and biotite, with quartz, titanite, apatite, and feldspars, implying equilibrium and a magmatic origin with these rock-forming minerals. Various textures in NB magnetites imply ongoing re-equilibration processes. Different environments yield magnetite with varied assemblages and concentrations of trace elements, offering potential clues to its genesis and associated magmatic to magmatic hydrothermal mineral deposits. Using scanning electron microscopy (SEM), magnetite grains from various intrusions in NB, which are spatially and temporally associated with porphyry Cu-Mo-Au deposit systems, were examined. Further detailed analysis was conducted through electron probe microanalysis (EPMA) with long integration times. EPMA analysis reveals high SiO_2 (0.029–3.66 wt.%) and Al_2O_3 (0.02–2.44 wt.%) concentrations that are higher than the value of secondary magnetite, and low MgO (0.01–0.61 wt.%) in these magnetite grains. EPMA also confirms variable Mn (0.01 to 0.85 wt.%), Fe (58.56 to 80.35 wt.%), Ti (0.002 to 8.83 wt.%), Cr (0.043 to 7.04 wt.%), and V (0.01 to 2.91 wt.%) concentrations. Abundant trace elements, like Ti, V, Ni, Cr, and Mn, in magnetite distinguish various deposit systems. Most of the magnetites derived from I-type granitoids in New Brunswick plot within the porphyry field. When comparing Ti + V with Al + Mn concentrations in magnetite crystals, all samples exhibit similar crystallization temperatures (> 500ºC). However, Blue Mountain Granitoid Suite and the Gaspe Mine samples exhibit moderately lower temperatures, yet remain within the range of over 500°C. The range of magnetite compositions is governed by magmatic composition, exsolving volatiles, reequilibration processes, temperature, cooling rate, fO_2, and fS_2.

IN SITU APATITE AND ILMENITE U–Pb DATING FOR THE DONGKENG OROGENIC GOLD DEPOSIT, YUNKAI MASSIF, SOUTH CHINA

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Measurement of precise ages for orogenic gold deposition is essential for understanding the linkages between mineralization and tectonic, metamorphic and magmatic events, but minerals for accurate dating are often lacking in these mineralization systems. In this study, we carried out in situ LA-ICP-MS U–Pb dating of syn-mineralization apatite and ilmenite to constrain the age and genesis of the Dongkeng orogenic deposit, Yunkai Massif, South China. The Yunkai Massif is located in the southwestern part of the Qin-Hang Metallogenic Belt between the Yangtze and Cathaysia blocks. As one of the important gold clusters in China, the Yunkai Massif has an estimated resource of gold exceeding 600 t. A series of NE-trending crust-scale deep faults, including the Wuchuan- Sihui and Luoding -

https://doi.org/10.12789/geocanj.2024.51.211

Guangning faults, are developed in the area. The Dongkeng gold deposit (> 10 t @5.68 g/t) is located in the central part of the Yunkai massif, west of the Wuchuan-Sihui fault. The orebodies are hosted by metamorphic rocks of the Proterozoic Yunkai Group and are located in a NW-trending brittle-ductile shear fault, which is regarded as a secondary fault of the NE-trending Wuchuan-Sihui fault. Two phases of apatite were distinguished in the host rocks and ores. The early apatite (Ap1) was found in muscovite quartz schist, while the late apatite (Ap2) is associated with biotite, coexisting with ilmenite and Au. The Ap1 yielded Discordia U–Pb ages of 235.80 ± 4.5 Ma (MSWD = 1.3, n = 106); the Ap2 and ilmenite associated with Ap2 yielded Discordia U–Pb ages of 209.40 ± 2.6 Ma (MSWD=1.2, n=68) and 219 ± 32 Ma (MSWD = 1.2, n = 48), respectively. Collectively, the age data suggest that the Dongkeng gold deposit may have formed from two mineralization events during the Triassic, with the second event being the dominant one.

TECTONIC MODEL OF THE PALEOPROTEROZOIC WESTERN TRANS-HUDSON OROGEN

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The Canadian Precambrian Shield southwest of Hudson Bay is dominated by the Paleoproterozoic western Trans-Hudson Orogen, a collisional land mass that evolved to form the core of North America from rocks as old as 3.1 to 1.77 Ga during 150 million years (1.92–1.77 Ga) of tectonic activity. This presentation uses the concept of rotation, on Euler poles, of three Archean cratons (Hearne, Superior and Sask) bordering two seaways (the Manikewan ocean and Neomanikewan backarc sea) separated by a single volcanic arc. Published U–Pb ages, geochemistry and Nd–Sm isotope data are used to correlate and differentiate lithotectonic map domains. These line up as remarkably similar, coeval terranes, like a Phanerozoic arc-backarc transect. Detrital zircon modes establish provenance, interrelationships and likely past relative positions. The evolution to the present geography is modelled in eight stages 1) tightening of the originally curved volcanic arc during subduction and slab retreat with the opening and elongation of the Neomanikewan backarc; 2) collision of the arc with Rottenstone domain, built on the Hearne craton margin and the adjacent Southern Indian domain, followed by a subduction flip; 3) local slab failure, upper-plate rebound, erosion and filling, from the arc, of the Neomanikewan forearc, trench and beyond; 4) local arc magmatism and widespread slab-failure magmatism with tightening of the basin (Kisseynew) built on the Neomanikewan ocean floor; 5) collision of Superior craton with the internal zone, during final arc magmatism, uplift, extensional block faulting, and change to nonmarine deposition; 6) underthrusting by Sask craton with final slab failure; 7) delamination of the Kisseynew oceanic basement and mantle with rising asthenosphere and high-grade metamorphism during bivergent expulsion of the migmatitic sediments; 8) sinistral transpression of the Superior craton with renewed northwest shortening throughout the orogen.

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ABSTRACTS **63**
GAC-MAC-PEG 2024 Brandon Meeting: Abstracts, Volume 47

2024 VOLUME 51 GSCNA7 51 63-130
PRINT EDITION ISSN 0315-0941
ONLINE EDITION ISSN 1911-4850