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Hon. Mike Holland
Minister of Natural Resources and Energy Development

October 2022

Table of Contents

1 Rare-earth elements and yttrium (REY) mineralization in the Mount Pleasant (W-Mo-Bi) (Sn-Zn-In-Cu) deposits, southwestern New Brunswick: a preliminary study
S. Baghban Asgharinezhad[1], D.R. Lentz[1], and K.G. Thorne[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

2 U-Pb zircon dating in southern New Brunswick – an overview and update
S.M. Barr[1], D. van Rooyen[1], S.C. Johnson[2], J.L. Crowley[3], A.P. Escribano[1], and C.E. White[1]
[1]Acadia University; [2]New Brunswick Geological Survey; [3]Boise State University

3 Geochronology of shear zone-hosted gold mineralization at the Elmtree Deposit, northeastern New Brunswick
A.L. Bustard[1,2], D.R. Lentz[2], J.A. Walker[1], and A. Camacho[3]
New Brunswick Geological Survey; [2]University of New Brunswick; [3]University of Manitoba

4 An Alleghanian magmatic event in southern New Brunswick: exploring implications for correlations with other events in the northern Appalachians
A. Cardenas[1], D.R. Lentz[1], C.R.M. McFarlane[1], and K.G. Thorne[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

5 The potential for utilizing mine tailings for carbon sequestration in New Brunswick
L. Cheung
RPC Science & Engineering

6 3D Geological modelling of the southern Bathurst Mining Camp
D. Dahn[1], H. Ugalde[2], W.A. Morris[3], and J. Sorge[1]
[1]New Brunswick Geological Survey; [2]Brock University; [3]McMaster University

7 Petrological and geochemical characteristics of granitoids and clastic rocks in the Pokiok area: implications for mineralization
A. Gebru
New Brunswick Geological Survey

8 The New Brunswick Exploration Assistance Program
N. Hatheway
New Brunswick Geological Survey

9 Update from the Resource Development Branch and Mining Recorder's Office
A. Howland and J.P. Langton
New Brunswick Department of Natural Resources and Energy Development

10 Advancing a critical minerals project in Canada – the Sisson Tungsten Molybdenum Project
A. Ing
Northcliff Resources Ltd.

11 Updated bedrock geology of the eastern Caledonian Highlands, southern New Brunswick
S. Johnson[1], S. Rossiter[1], A. Gebru[1], A. Park[1], and S. Barr[2]
[1]New Brunswick Geological Survey; [2]Acadia University

12 Mineral prospectivity models of Williams Brooks gold property: integration and analysis of multiple geoscientific datasets
F. Mami khalifani[1], M. Parsa[1], D.R. Lentz[1], and J.A. Walker[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

13 Portable XRF-aided pattern recognition for characterization of gold mineralization in northern New Brunswick
F. Mami khalifani[1], M. Parsa[1], D.R. Lentz[1], and J.A. Walker[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

14 Exploration update in New Brunswick and Newfoundland
D. Martin
Great Atlantic Resources Corp.

15 Deformation of the Pennsylvanian Tynemouth Creek Formation, southern New Brunswick
A.F. Park and S.J. Hinds
New Brunswick Geological Survey

16 Late Devonian orogenesis in the Canadian Appalachians and critical mineral prospectivity
N. Rogers[1], N. Piette-Lauzière[2], D.A. Kellett[1], L.B. Harris[3], and K.P. Larson[2]
[1]Natural Resources Canada; [2]University of British Columbia Okanagan; [3]Institut National de la Recherche Scientifique

17 Till Geochemistry in the McDougall Lake and Rollingdam Areas
S. Rossiter, S. Allard, W. Gilmore, and T. Pronk
New Brunswick Geological Survey

18 The first evidence of terrestrial vertebrates from the Lower Mississippian Albert Formation of New Brunswick: Implications for the invasion of continental lacustrine ecosystems and biodiversity during Romer's Gap in Atlantic Canada
M. Stimson[1,2], O. King[1,2], R.A. MacRae[2], R. Miller[1], S. Hinds[3], A. Park[3], S. Lucas[4], and L. Allen[5]
[1]Saint Mary's University; [2]New Brunswick Museum; [3]New Brunswick Geological Survey; [4]New Mexico Museum of Natural History; [5]University of New Brunswick

19 Wildcat – Drilling defines molybdenum deposit
J.F. Wightman[1] and D. Black[2]
[1]Golden Kamala Resources Ltd.; [2]Geologist

20 Overview of the Devonian porphyries with adakitic affinities in the northeastern Appalachians and their potential for Cu±Au±Mo mineralization
F. Yousefi[1], D.R. Lentz[1], J.A. Walker[2], and K. Thorne[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

21 The middle Devonian Evandale porphyry Cu-Mo (Au) deposit: a review of exploration potential
F. Yousefi[1], D.R. Lentz[1], and K.G. Thorne[2]
[1]University of New Brunswick; [2]New Brunswick Geological Survey

22 Green Mining for the Green Mining Transition
J. Zinck
Nova Scotia Department Natural Resources and Renewables

RARE-EARTH ELEMENTS AND YTTRIUM (REY) MINERALIZATION IN THE MOUNT PLEASANT (W-MO-BI) (SN-ZN-IN-CU) DEPOSITS: A PRELIMINARY STUDY

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The Late Devonian granite-related Mount Pleasant deposits are located along the southwestern margin of the Mount Pleasant Caldara complex in southwestern New Brunswick. They are small-tonnage, high-grade deposits with three distinct ore zones; the Fire Tower Zone (W–Mo–Bi) has indicated resources of 13.5 Mt of 0.33% WO_3, 0.21% MoS_2, and 0.06% Bi, and the North Zone (Sn–Zn–In–Cu) has indicated resources of 4.9 Mt of 0.43% Sn, 0.67% Zn, 67.8 g/t In, and 0.11% Cu, and the comparatively small occurrence, as defined thus far, of the Saddle Zone (W-Sn-Zn-In).

The highly evolved Mount Pleasant granitic system is a polyphase suite and is composed of fine-grained equigranular granite (Gr-I) and aplitic to porphyritic granite (Gr-IIA and IIB), which caused W-Mo-Bi and Sn-Zn-In-Cu mineralization in the Mount Pleasant deposits, respectively. A barren, fine- to medium-grained, equigranular granite (Gr-III) cross-cuts these earlier granitic phases. This granitic system has extremely high concentrations of F (almost 1%), incompatible trace elements (Li, Rb, Cs, U, Th, Nb, Ta), and REE, with very low Zr/Hf, K/Rb, and Nb/Ta ratios, which suggest that fluid fractionation played an important role in late-stage magmatic differentiation. They exhibit highly fractionated, crustal A-type granite affinities. Lentz (2019) explained that the degree of fractionation is related to the presence of thermal anomalies associated with other magmatism in the region.

In a preliminary analysis of the rare-earth element and yttrium (REY) potential of the Mount Pleasant deposits, Lentz and Thorne (2019) showed that the REY content of the causative granitic suites is high. By utilizing multi-elemental µ-X ray fluorescence (µ-XRF) analysis, Baghban and Lentz (2022) showed that the fluorites from the Saddle Zone of the Mount Pleasant deposits have detectable amounts of REY elements and exhibit excellent chemical oscillatory zoning. According to petrography and µ-XRF analysis, monazite, xenotime, fluorite, rutile, apatite, and zircon are the main REY-bearing minerals within the mineralized zones. Based on the whole-rock geochemical analysis, REY concentrations are anomalously high in the mineralized zones. They are characterized by up to 2,620 ppm La, 4,870 ppm Ce, 553 ppm Pr, 2,180 ppm Nd, 454 ppm Sm, 434 ppm Gd, 863 ppm Dy, 206 ppm Ho, 680 ppm Er, 690 ppm Yb, and 5,444 ppm Y. Both the granitic system and the mineralized zones exhibit almost flat REE patterns with large negative Eu anomalies. Several key high-field strength elements (HFSE) are enriched in these two deposits. They include ~ 17,000 ppm Zr, ~ 9,000 ppm Ti, 472 ppm Hf, 387 ppm Nb, and 218 ppm Ta. Therefore, based on the rock types and previous studies, these deposits have a very high potential for REY and HFSE mineralization, which can probably be extracted as by-products. High fluorine was also detected in the mineralized zones (up to 7%) of these deposits, which is consistent with the shallow emplacement, low-pressure formation of the granitic suites.

Abstract for oral presentation.

U-PB ZIRCON DATING IN SOUTHERN NEW BRUNSWICK – AN OVERVIEW AND UPDATE

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U-Pb zircon dating using both laser ablation inductively coupled plasma–mass spectrometry and chemical abrasion isotope dilution thermal ionization mass spectrometry is providing new insights into the geological history of the numerous fault-bounded belts that comprise southern New Brunswick.

In the Avalonian Caledonian Highlands, dating is challenging because many rocks lack zircon or contain only sparse zircon, or the zircon isotopic compositions have been disturbed. The oldest dated rocks are ca. 690 Ma (Cryogenian) subduction-related plutonic rocks but evidence for older Tonian (ca. 730 Ma) magmatism is preserved in detrital zircon signatures. Because of similar rock types and overprinting by later deformation, the Cryogenian rocks are difficult to distinguish in the field from the more widespread early Ediacaran (mainly 620–615 Ma) Broad River Group and related plutons. The most voluminous igneous rocks preserved in the highlands are late Ediacaran volcanic rocks of the Coldbrook Group and associated plutons with the most reliable ages indicating rapid eruption and emplacement of the entire group and related plutons in 2.5 million years between 551.7 Ma and 549.2 Ma.

The New River belt is stratigraphically and structurally complex, and apparently includes both Ganderian and Avalonian components. The Seven Mile Lake mylonite zone, located along the Belleisle Fault that forms the boundary between the New River and Kingston belts, contains metasedimentary rocks that yielded detrital age peaks at 666 Ma and 693 Ma, indicating a maximum depositional age of about 666 Ma for the sedimentary protolith. A granitoid mylonite associated with the metasedimentary mylonite yielded an igneous crystallization age of 631.8 ± 0.5 Ma, similar to the age of the Lingley plutonic suite in the northeastern part of the New River belt, but older than the Blacks Harbour granite in the southwestern part of the belt. Quartzite in the Goss Point Formation in the southwestern part of the New River belt yielded a distinctive detrital signature dominated by Paleoproterozoic peaks at 2015 Ma and 2100 Ma, older Archean peaks at 2600–3000 Ma, and one grain dated by CA-TIMS at 1516 ± 1 Ma. Except for the ca. 1516 Ma grain, this signature is similar to that of The Thoroughfare Formation on Grand Manan Island. Dating in progress includes samples from previously undated granitoid plutons in the New River belt, as well as conglomerate from Gannet Rock and granite from White Ledge and Wallace Ledge in the Bay of Fundy south of Grand Manan Island.

Abstract for poster presentation

Funding: *Research agreements between the Geological Survey of the New Brunswick Department of Natural Resources and Energy Development and Acadia University and a Natural Science and Engineering Research Council of Canada Discovery Grant to S.M. Barr*

GEOCHRONOLOGY OF SHEAR ZONE-HOSTED GOLD MINERALIZATION AT THE ELMTREE DEPOSIT

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The Elmtree deposit of northeastern New Brunswick is the largest of several shear zone-hosted gold occurrences associated with regional-scale faults active during Salinic, Acadian, and Neoacadian orogenesis. Gold in the Elmtree deposit straddles a locally faulted Silurian angular unconformity that separates an accretionary wedge complex (Fournier Supergroup) from overlying synorogenic sedimentary clastic, carbonate, and minor volcaniclastic rocks (Quinn Point Group). Gold mineralization occurs primarily as wall rock replacement by arsenopyrite, pyrite, and pyrrhotite associated with quartz ± carbonate veins hosted in gabbro (West Gabbro Zone), and mafic dikes and clastic sedimentary rocks (South Gold and Discovery zones).

Sericite (muscovite) in veins associated with gold mineralization and sheared wall rock fabrics in the South Gold and West Gabbro zones were dated *in situ* by the ^{40}Ar-^{39}Ar method. Analyses of vein hosted sericite returned ages between ca. 398 and 386 Ma (n = 5), whereas sheared wall rock samples yielded ages between ca. 388 and 377 Ma (n = 5). Two samples of sheared sericite hosted in deformed veins yielded ages between ca. 381 and 391 Ma. These ages are younger than those in other gold systems in northern New Brunswick dated by the same method: Clarinda (417 ± 2 Ma and 418 ± 2 Ma), Williams Brook South (413 ± 3 Ma and 411 ± 2 Ma), and Grog Brook (410 ± 10 Ma). The ca. 388 to 377 Ma age of sheared wall rocks at the Elmtree deposit is consistent with the D_4 dextral transpressive deformational episode in the Brunswick Subduction Complex.

The timing of gold mineralization at the Elmtree deposit (ca. 390 Ma) is consistent with slab break off at the end of the Acadian orogeny ca. 400 Ma. Slab break off would have resulted in heating of the base of the crust by asthenospheric upwelling evidenced by the emplacement of granodiorite dikes along the Melanson Brook Fault at the Nigadoo Gold Property ca. 390 Ma, and felsic dikes with mantle differentiate signatures at the South Gold Zone. This is further supported by Pb isotope data for gold mineralization at the Elmtree deposit, with values consistent with mixing of upper crust and mantle sources (i.e., orogene) at ca. 400 Ma with average values of $^{206}Pb/^{204}Pb$ = 18.2, $^{207}Pb/^{204}Pb$ = 15.6, and $^{208}Pb/^{204}Pb$ = 38.2 (n = 6). The tectonic regime at the time of formation of the Elmtree deposit is compatible with both orogenic and intrusion-related models.

Abstract for oral presentation

AN ALLEGHANIAN MAGMATIC EVENT IN SOUTHERN NEW BRUNSWICK: EXPLORING IMPLICATIONS FOR CORRELATIONS WITH OTHER EVENTS IN THE NORTHERN APPALACHIANS

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Rocks in the Cape Spencer area (15 km southeast of Saint John, New Brunswick) are dominated by thrusts, reverse faults, associated folds, and penetrative and/or spaced crenulated cleavages related to the alteration event linked to gold deposition, mainly restricted to illitized (illite-carbonate ± quartz ± pyrite ± chlorite ± specularite) rocks. Unfoliated leucocratic aplitic dikes intrude both the Millican Lake Granite and the Cape Spencer Formation and occur both parallel and cross-cutting the dominant foliation in the host rocks; they are uniformly quenched based on textural consistency. Whole-rock major- and trace-element geochemistry, especially immobile high field strength elements, shows they are a highly evolved, low-temperature I-type granitic suite.

In situ U-Pb zircon and monazite geochronology was conducted on the aplitic dike samples. Most samples contained metamict zircons that manifest effects of a high degree of radiation damage due to high U and Th concentrations (i.e., a decrease in zircon crystallinity). Two separate small clusters were identified and yielded weighted average $^{206}Pb/^{238}U$ ages of 273.4 ± 4.2 Ma and 348.5 ± 3.1 Ma for the two youngest populations, in addition to older, concordant dates interpreted as xenocrystic components that date back to ca. 650 Ma. Monazite occurs as subhedral to anhedral very fine grains ranging up to 40 µm in diameter; U-Pb analyses of monazite resulted in a spread of data probably due to mixing between two different age domains. By performing an anchored Tera-Wasserburg regression, an age of 273.7 ± 1.3 Ma is determined corresponding to the youngest end-member age population, whereas 340 ± 18 Ma would be the oldest possible anchored regression.

Initial εNd values (calculated for 274 Ma) define a negative range from -9.2 to -5.7, with depleted mantle model ages (TDM) for the aplites ranging from 1.3 Ga to 1.6 Ga, and εHf values (-1.0 to -1.8) indicating that a combination of an isotopically evolved component (mantle-derived material?) and preexisting continental crust must have been involved in their petrogenesis. These aplitic bodies constitute the first known evidence for Alleghanian magmatic events in southern New Brunswick, since widespread Permian (300–265 Ma) granitic rocks (including pegmatites, e.g., Topsham, Maine, dated at 273 ± 1.5 Ma, U-Pb monazite) are documented in New England and Maine (United States), and the Alleghanian German Bank pluton (300 ± 1) in Nova Scotia (Canada), along with widespread thermal events (340–300 Ma) restricted to shear zones are also documented.

Abstract for oral presentation

THE POTENTIAL FOR UTILIZING MINE TAILINGS FOR CARBON SEQUESTRATION IN NEW BRUNSWICK

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RPC is New Brunswick's provincial research organization and a not-for-profit independent contract research and development and technical services organization with locations in Fredericton, Moncton, and St. George, New Brunswick. They have been working on several applied research and Cleantech projects focused on repurposing tailings and waste material as well as technologies that could circumvent waste creation.

One such example would be the Baie Minerals asbestos tailings located in Baie Verte, NL. These tailings could potentially be converted into various high demand magnesium and silica products while remediating the tailings. One of the magnesium products could potentially be utilized for carbon sequestration, which could be applied to reduce CO_2 emissions in coal fire power plants. The technology, once proven, would mineralize the CO_2 into stable magnesium carbonate. Through incorporating CO_2 capture technologies in New Brunswick, the life of coal fire power plants could potentially be extended, and locally sourced raw materials could potentially be utilized.

Other Cleantech projects that are currently being conducted at RPC in the mining sector will be discussed. The projects are aimed to improve the supply of critical minerals and the circular economy.

Abstract for oral presentation

3D GEOLOGICAL MODELLING OF THE SOUTHERN BATHURST MINING CAMP

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Previous geological mapping in the southern part of the Bathurst Mining Camp has constrained surface distribution of the main lithologies and major faults; however, the geometry of geological units at depth is not well-constrained or understood. Recent 1:20 000 scale geological mapping, limited areal extent, and the structural separation of the Sheephouse Brook Group from the remainder of the Bathurst Supergroup make this area an ideal test case for 3D modelling.

This project will integrate geophysical data sets, observations from surface outcrops, drill log data and petrophysical properties to produce a 3D geological model. To date, over 500 samples have been collected from surface outcrops and drill cores from across the study area (approximately 20 samples from each lithology). These samples were measured for several physical rock properties, including: magnetic susceptibility, conductivity, density, chargeability, and DC-resistivity. Descriptive statistics of physical rock property measurements were analyzed to better understand the variability and distribution among rock types from different units.

Following the evaluation of petrophysical measurements, a series of 29 geological cross-sections from across the study area were used to provide constraints on the geometry of contacts and thrust surfaces. Cross-sections were transferred into the gravity and magnetic modelling software where each polygon within the model was assigned physical rock properties as per the statistical distributions measured for each unit. Subsequently, the geometry and depth of the bodies were adjusted iteratively until a good fit was achieved with the magnetic and gravity data

Ongoing work includes additional geological mapping and sampling to address shortcomings identified in 2021, specifically: a) the possibility of remanent magnetization; b) variability (non-uniform distributions) of physical properties for many lithologies; and c) inconsistencies between the geological map and geophysical data.

Integrating the new petrophysical data will allow for completion of the model cross-sections, as well as improved constraints from the gravity modelling initiated in 2021. The final product will be a comprehensive 3D geological model of the area based on the geological cross-sections, reinterpretation of all the geophysical data available, structural information, and new constraints from bedrock mapping. It is hoped that this model will be a useful guide to industry conducting mineral exploration in the area.

Abstract for oral presentation

PETROLOGICAL AND GEOCHEMICAL CHARACTERISTICS OF GRANITOIDS AND CLASTIC ROCKS IN THE POKIOK AREA: IMPLICATIONS FOR MINERALIZATION

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There are two main types of granitoids in the Pokiok area. The medium-grained leucocratic Allandale Granite and coarse-grained to megacystic Hawkshaw Granite. The Hawkshaw Granite is further divided into two types based on colour: a light grey granite and a light pink granite to pink granite of variable shades. The bulk of the rock is biotite granite with or without varying proportions of muscovite and amphibole.

The Hawkshaw and Allandale granites do not show a pronounced degree of compositional variation in their major element geochemistry, although the latter contains slightly higher SiO_2, lower TiO_2, MgO, FeO_t, CaO, and a distinct SiO_2-P_2O_5 trend. The Allandale Granite is characterized by low Ba, Th, V, Y, Zr, Sc, Co, Ga, Sb, Ba, Sr, Hf, Cs, and REE relative to the Hawkshaw Granite. Barium and REE clearly differentiate the two types of granitoids. Relatively higher values of Ca and Al tend to differentiate the pink and grey varieties of the Hawkshaw Granite. Compared to the Hawkshaw Granite, the Hartfield Tonalite has a granodiorite composition and higher values of MgO, CaO, FeOt, TiO_2, and Al_2O_3.

The Hawkshaw and the Allandale granites are weakly to moderately and moderately peraluminous, respectively. The megacrystic grey Hawkshaw Granite is calc-alkalic, whereas the pink Hawkshaw Granite and Allandale Granite are alkalic-calcic. All the granitoids are magnesian. Rocks of the Hawkshaw Granite plot within the VAG field, very close to the WPG and Syn-COLG boundaries, whereas the Allandale Granite plots on the Syn-COLG and VAG boundary, near the WPG field. All rocks belong to the high-K calc-alkaline magma series. The high Th/Yb and Nb/Yb values indicate their continental arc affinity.

Within the Pokiok Batholith, Cu-Zn-Pb-Ag-Au mineralization is related to zones of silicification and chloritization, and epidotization controlled by brittle deformation. Tungsten mineralization in the northern part of the batholith is generally related to quartz veining and calc-silicate alteration within the Burtts Corner Formation, whereas Be mineralization occurs as disseminations in greisenized and fracture zones of granites of various compositions, in quartz veins and as coarse crystals intergrown with silicates in unaltered granitic rocks. Outside the known Pokiok Au-Ag-Cu-Zn-Pb mineralization uncovered by StrikePoint Gold's 2010 drilling, granitoid grab samples analyzed in this investigation yielded up to 0.14% Cu and 0.5 g/t Au; up to 0.8% W in quartz veins within the Burtts Corner Formation; and up to 18% Fe_2O_3, 8% MnO, and anomalous values of Sb, Te, B, As, and Bi.

Abstract for poster presentation

THE NEW BRUNSWICK EXPLORATION ASSISTANCE PROGRAM

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The New Brunswick Exploration Assistance Program (NBEAP) is offered by the Department of Natural Resources and Energy Development to help fund selected mineral exploration projects in the province. The program encompasses the New Brunswick Prospectors Assistance Program, the Prospector Promotion Program, and the New Brunswick Junior Mining Assistance Program. The NBEAP budget for 2022–2023 is $852,000.

The New Brunswick Prospectors Assistance Program provides financial support to prospectors searching for metallic or industrial minerals (except aggregates) in the province. This year, forty-six prospectors received grants ranging from $1,000 to $15,000 for their exploration projects.

The Prospector Promotion Program is intended to facilitate the process of optioning New Brunswick mineral prospects to mining companies. This program supports promotional activities for prospectors at the Prospectors and Developers Association convention in Toronto and the Mineral Exploration Roundup in Vancouver. Twenty-five thousand dollars ($25,000) is budgeted for prospector support for travel to these conventions.

The New Brunswick Junior Mining Assistance Program provides financial assistance to junior mining companies working in the province. This program provides 50% of eligible costs up to a predetermined maximum, for mineral exploration projects. This year, twenty-two projects were supported under this program with individual grants ranging from $10,000 to $35,000.

The New Brunswick Exploration Assistance program has been very successful in helping to locate and enhance mineral exploration targets throughout the province, and in promoting these properties locally and nationally. Consequently, the program is highly regarded by the New Brunswick Prospectors and Developers Association and the mining industry in general.

Abstract for poster presentation

UPDATE FROM THE RESOURCE DEVELOPMENT BRANCH AND MINING RECORDER'S OFFICE

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The global focus on reducing carbon-emissions is driving an increased demand for so-called 'green-metals' and other critical minerals by industries that are moving towards electrification. This has put the mineral exploration sector into overdrive, as reflected by the recent upsurge in staking and exploration activity in the province.

The Mining Recorder's Office (MRO) is responsible for administering subsurface mineral rights in New Brunswick as they pertain to mineral tenure, mineral exploration, and the rights and obligations of individual prospectors and exploration companies, pursuant to the *Mining Act*.

As part of its administrative responsibilities, the MRO generates monthly updated claim maps, which are publicly available, and maintains annual and year-to-date claim statistics.

The amount of new staking has seen a sharp and steady rise since 2015, peaking in 2020. A slight drop in new staking since 2020 is likely a reflection of the dwindling availability of 'prospective' ground. Current claim holdings comprise an all-time high of almost one million hectares and permit applications for proposed exploration programs in 2022 are nearing 100 for the year to date. As at the end of September, recorded exploration expenditures for 2022 by prospectors and exploration companies totalled over $8.3 million.

The MRO continues to liaise with public, industry, and government stakeholders to improve permitting application review, report-of-work guidelines, and exploration data collation for those active in the mineral exploration sector in the province.

Abstract for oral presentation

ADVANCING A CRITICAL MINERALS PROJECT IN CANADA – THE SISSON TUNGSTEN MOLYBDENUM PROJECT

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Critical Metals are metals and minerals that are considered vital for the economic well-being of the world's major and emerging economies, yet whose supply may be at risk due to geological scarcity, geopolitical issues, trade policy, or other factors. Among these important minerals are metals and minerals used in industry (all industries across all supply chain stages), modern technology (e.g., mobile phones, flat screen monitors, and many other high-tech applications), and the environment (e.g., wind turbines, electric cars, and solar panels).

The industries and economies of many countries, including the United States, Japan, Republic of Korea, United Kingdom, and the European Union, are reliant on international markets to provide access to important raw materials that are produced and supplied by other countries. The supply of many critical raw materials is highly concentrated. The USGS estimates that China is the world’s largest supplier and consumer of tungsten.

Tungsten and molybdenum are both listed as critical minerals in Canada and other countries, hence the importance of the advanced stage Sisson W-Mo Project, which Northcliff Resources Ltd. (TSX: NCF, “Northcliff”) is advancing toward development in New Brunswick, Canada. Recent research has shown that tungsten has the potential to replace cobalt in the anode of lithium-ion batteries, with faster charging, higher input power density, longer durability, and improved safety, further strengthening the market for and the importance of tungsten.

Northcliff holds an 88.5% controlling interest in and is the operator of the Sisson Project. The Sisson Project has the potential to become a near-term critical metal producer, providing new primary supply tungsten and molybdenum to North American, European, and Asian markets.

The current focus is to secure construction and operating permits, off-take agreements and project financing for the Sisson Project, as well advance discussions with the Centre of Excellence for Critical Minerals (Natural Resources Canada) and the Defense Production Act Title III (US Department of Defense).

Abstract for oral presentation

UPDATED BEDROCK GEOLOGY OF THE EASTERN CALEDONIAN HIGHLANDS

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The Caledonian Highlands comprise over 3800 km^2 of mainly Neoproterozoic volcanic, volcanosedimentary, and plutonic rocks and Cambrian shallow marine siliciclastic rocks. Early mapping was conducted at a relatively detailed one inch to ¼ mile scale, and without the aid of modern geochronology, the differences in lithological assemblages were attributed to facies changes within one group of rocks named the Coldbrook Group. Later regional-scale mapping utilizing petrological studies and limited U-Pb zircon dating showed that the complex suite of rocks in the eastern highlands was older, regionally metamorphosed and deformed; hence, the highlands were divided into a late Ediacaran (ca. 560–550 Ma) Coldbrook Group and related plutons, exposed mainly in the western highlands, and an early Ediacaran (ca. 620 Ma) Broad River Group and related plutons, exposed mainly in the eastern highlands. Determining stratigraphic relationships in the eastern highlands is hampered by intense ductile and brittle deformation, and an expanding database of high precision U-Pb zircon ages has revealed that some intrusive rocks emplaced into the Broad River Group are Cryogenian age (ca. 690 Ma). This relationship indicates that rocks hosting the Cryogenian plutons are much older than the Broad River Group; therefore, a cryptic boundary must be present within the group as it is currently mapped. Accordingly, the eastern highlands (parts of NTS 21 H/11E, 21 H/15, and 21 H/10) have been the focus of our recent mapping campaigns.

Additional data has also been acquired on new roads constructed for logging, wind farming, and the Fundy Trail Parkway and connector routes, which has greatly improved access to this large area. Mapping conducted thus far has resulted in improvements to the current geology maps and provided insight into the stratigraphy that will result in major revisions to the geology of the highlands.

Abstract for poster presentation

MINERAL PROSPECTIVITY MODELS OF WILLIAMS BROOKS GOLD PROPERTY: INTEGRATION AND ANALYSIS OF MULTIPLE GEOSCIENTIFIC DATASETS

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The Williams Brook gold occurrence, located in the northwestern part of the Chaleur Bay Synclinorium in northern New Brunswick, is hosted by Early Devonian, felsic volcanic and-sedimentary rocks of the Wapske Formation (Tobique Group). Gold mineralization is attributed to a low-sulfidation epithermal style system, occurring in the flow-layered K-feldspar porphyritic rhyolite and sulphide-bearing quartz veins cross-cutting these felsic units. Preliminary investigation suggests that Early Devonian dextral movement along the Rocky Brook – Millstream fault system (i.e., Acadian orogenesis) exerts substantial control over gold mineralization regionally. The mineral systems components relating to the gold endowment of the Williams Brook area (i.e., source, transport, and trap) are translated into a suite of predictive variables (E1, E2, …, En) using multiple data layers (i.e., geological, geochemical, and geophysical) that can vector toward gold mineralization. The data layers are augmented and enhanced when they are integrated with other geo-exploration data layers, thereby delineating more reliable mineral exploration targets. First, aeromagnetic, and radiometric data were used to determine the geophysical signature of host rocks related to gold mineralization. Then, we demonstrate that the mineralization-related features, recognized through interpretation of geophysical data, can be integrated with alteration types and geochemical signatures of mineralization to delimit reliable exploration targets. Determination of the geological features, (i.e., faults, shear zones, and geological contacts), alteration types and intensity, and geochemical and geophysical anomalies provide valuable pieces of information about the gold mineralizing system. The study area was divided into cells of equal size. For each unit cell a fuzzy-logic-based framework was employed to quantify the probability of discovering mineralization – $Pj = f(E1, E2, ..., En)$. Further to estimating the probability of discovering gold mineralization in individual cells, uncertainties were quantified using the Monte Carlo-based simulation that weighs and prioritizes individual predictor variables, Ei. A Gaussian probability function was considered for each Ei assigning 100 simulated weights in individual iterations. This, in turn, generates multiple scenarios for prospectivity modelling in the Williams Brook area, allowing for uncertainty quantification. Plots of uncertainty versus prediction are used to delineate exploration targets. Ground-truthing was conducted for validating the effectiveness of delineated exploration targets and point to reliable performance.

Abstract for poster presentation

PORTABLE XRF-AIDED PATTERN RECOGNITION FOR CHARACTERIZATION OF GOLD MINERALIZATION IN NORTHERN NEW BRUNSWICK

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Northern New Brunswick hosts some very significant quartz vein-hosted gold deposits/occurrences. These systems can be challenging exploration targets as there are few if any useful indicator minerals associated with this type of mineralization. Herein, the portable X-ray fluorescence (pXRF, Olympus Vanta™) spectrometer in conjunction with micro-X-Ray Fluorescence (μ-XRF) Energy Dispersive Spectrometer was applied to selected core intervals from five gold occurrences, namely: Dalhousie Road, Simpson Field, McKenzie Gulch, Mulligan Gulch, and McIntyre Brook. All five of these occurrences are spatially related to major splays of the Rocky Brook – Millstream Fault system (i.e., the McCormack Brook, Ramsay Brook, and McKenzie Gulch faults). The McCormack Brook and Ramsay Brook occurrences are associated with fine- to medium-grained mafic intrusions cutting clastic sedimentary rocks of the Simpsons Field and Free Grant formations. At both, mafic dikes are carbonate altered and gold occurs with hematite and chalcopyrite. At McIntyre Brook gold is associated with hematite and sulphide-bearing quartz veins within potassically altered feldspar phyric rhyolite. The McKenzie Gulch Cu-Ag deposit is hosted by garnet-diopside skarn and hornfels and calc-silicate-altered rocks peripheral to a series of north-northeast-striking, porphyritic felsic-intermediate dikes of the McKenzie Gulch Porphyry. The Mulligan Gulch Porphyry is a feldspar (± quartz) phyric hypabyssal felsic body emplaced in upper Silurian sedimentary rocks. In this study, pXRF-based multi-element datasets were created from these selected core intervals for each occurrence/deposit. Compositional-based multivariate techniques (i.e., variation array analysis, compositional biplots, and correlation analysis) were applied to these geochemical datasets. Biplots derived from the Dalhousie Road Mulligan Gulch, and McIntyre Brook databases show that Au, Sb, As, and Ag are closely associated, whereas a strong relationship between Au and As is recognized in the Simpson Field and McKenzie Gulch databases. These shed light on the mineralogical composition and geochemical signatures of gold-bearing zones. In addition, a thorough mineralogical study was conducted on the polished thin sections generated from these core intervals. Gold-bearing minerals were further identified by μ-XRF analysis, revealing that gold mostly occurs in close association with pyrite, chalcopyrite, and arsenopyrite. These results agree with those derived by pXRF analysis and allow definition of a suite of indicator minerals for each occurrence. In addition, mineralogical studies further indicate that silicification, chloritic and sericitic alteration with sulphides are associated with gold-bearing quartz (-carbonate) veins.

Abstract for oral presentation

EXPLORATION UPDATE IN NEW BRUNSWICK AND NEWFOUNDLAND

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Great Atlantic Resources Corp., a public company based in Vancouver, B.C., is focused on mineral exploration in Atlantic Canada. The Company has eighteen projects in New Brunswick and Newfoundland. This presentation will focus on the Keymet, Glenelg, and Golden Promise Projects.

The Keymet Project, located within northeast New Brunswick, hosts base metal-and silver-bearing veins and gold mineralization. Great Atlantic intersected the Elmtree 12 polymetallic vein system (northwest region of the project) during 2015–2021 diamond drilling programs, including (core length) 16.68% zinc over 1.80 m; 7.67% zinc over 4.95 m; and 9.04% zinc, 9.19% copper, and 1158 g/t silver over 3.00 m. A 2017 drill hole intersected 0.70 g/t gold over 15.48 m core length in this area. A 2021 drill hole intersected 3.17 g/t gold over 0.70 m core length, being a new discovery (Debler Zone).

Great Atlantic identified gold soil anomalies during 2021 within the central region of the Keymet Project. Sixty of ninety-one soil samples within one area returned anomalous gold values exceeding 0.005 ppm gold (up to 0.067 ppm gold). Prospecting and rock/soil geochemical sampling is in progress, the work supported through a New Brunswick Junior Mining Assistance Program grant.

The Glenelg Project is located within southwest New Brunswick. A 2018 outcrop grab sample from the Bocabec Gabbro Complex returned 0.18 percent vanadium (0.33% V_2O_5). Great Atlantic discovered an antimony-bearing quartz vein this year within the southern region of the property, a 1.8 kg grab sample returning 23.4% antimony. Other samples from float returned anomalous values for gold and antimony.

The Golden Promise Project, located within central Newfoundland, hosts gold-bearing quartz veins. Great Atlantic reported a 43-101 compliant Inferred mineral resource estimate for the Jaclyn Main Zone, in late 2018, of 119,900 oz of gold averaging 10.4 g/t gold (uncapped). Diamond drill intercepts (core length) from Great Atlantic's 2021 programs include 238 g/t gold over 0.40 m, 56.8 g/t gold over 0.75 m and 57.1 g/t gold over 0.65 m at the Jaclyn Main Zone; 30.6 g/t gold over 0.41 m at the Jaclyn North Zone; and 4.95 g/t gold over 0.50 m (core length) at the Otter Brook gold showing. Prospecting and rock geochemical sampling are in progress. Great Atlantic applied for a diamond drilling permit this year for the Jaclyn Zone.

Abstract for oral presentation

DEFORMATION OF THE PENNSYLVANIAN TYNEMOUTH CREEK FORMATION, SOUTHERN NEW BRUNSWICK

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Along the coast of southern New Brunswick between Black River and Quaco Head, the Tynemouth Creek Formation consists of coarse- to fine-grained siliciclastic sedimentary rocks considered to represent proximal to distal deposits of an alluvial fan complex. Analysis of macroflora and miospores indicates a Langsettian (Lower Pennsylvanian) age. The western contact with the West Beach Formation is the Emmett Creek Fault, to the east at Quaco Head, basalts considered to be West Beach Formation (but undated) lie unconformably beneath the Tynemouth Creek Formation with Mabou and Windsor Group rocks preserved. At Roger's Head, the basalts are thrust over Tynemouth Creek Formation. Inland, an unconformity on the Ediacaran rocks of the Caledonia Highlands is poorly exposed. Folds and sporadic cleavage(s) are observed in the Tynemouth Creek Formation within well-exposed outcrops along the Fundy coast from Emmett Creek to Quaco Head. Morphology of folds can be complicated by layer-parallel slip and strain features accommodated in layered sandstone-conglomerate-shale intervals containing channel-forms: namely original layering is not strictly parallel. Three distinct phases of deformation features such as folds and cleavage exist but are not uniformly developed. The earliest phase of folding, only seen around Dickson Point and Reeds Beach, relates to extension. Two phases succeed this earliest phase, most extensively developed between Reeds Beach and Quaco Head, and both involve shortening: open to tight and overturned folds with a southwest trend and shallow plunge (SW and NE) between Wallace Cove and Robinson Point show a southeastward vergence. This second phase is then overprinted by steeply plunging, open to tight, asymmetric folds only seen east of Gardner Creek. Between Tynemouth Creek and Quaco Head large-scale folds share the southeastward vergence in part, but also relate to the Rogers Head thrust, with its northwestward vergence.

Vergence changes for compression-related folds in the Tynemouth Creek Formation are consistent with these folds being related to a flower structure rooted in the offshore strike-slip Cobequid-Chedabucto Fault. This is comparable to late Pennsylvanian structures seen at Cape Spencer and west as far as Maces Bay – also known as the Maritime Coastal disturbance. The degree of shortening represented by these folds may be of the order of 40%, but the only basement rocks faulted into the Tynemouth Creek Formation are the undated basalts at Quaco Head. This suggests the Tynemouth Creek Formation is underlain by a more ductile sublayer, itself overlying the Caledonian Ediacaran rocks. Windsor Group evaporites are one possible candidate.

Abstract for oral presentation

LATE DEVONIAN OROGENESIS IN THE CANADIAN APPALACHIANS AND CRITICAL MINERAL PROSPECTIVITY

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The Canadian Appalachians incorporates multiple generations of overlapping mineralizing events that formed in response to progressive accretionary orogenesis. This has resulted in a spectrum of ore deposits (representing magmatic, hydrothermal, orogenic, and hybrid ore systems) that are both spatially and temporally heterogeneous. As the driving accretionary tectonics were largely non-orthogonal and influenced by indentures and promontories, mineralization is often also diachronous with repeated sequences of processes occurring at different places at different times. Furthermore, as some types of mineralization are controlled by environmental conditions, the deposit distribution is additionally in part transgressive. The sequencing and interactions of earlier orogenic events are believed to control the prospectivity of Siluro-Devonian, post-orogenic granitoid-related mineralization that produces a wide array of critical minerals, including antimony, beryllium, bismuth, copper, fluorite, indium, molybdenum, REE, tin, tungsten, and zinc. Much of this mineralization is also exogranitic, and as such has little to no alteration footprint. Consequently, precise tectonostratigraphic plate reconstructions, incorporating the full sequence of ore forming processes presented in time and space, will greatly facilitate predictions of where critical mineral deposits are likely.

When considering the progressive accretion of oceanic arcs and terranes to the composite Laurentian margin, it is often difficult to constrain the tectonics controlling the deformation inboard of the active suture zone. This is illustrated by the regional deformation occurring during the Late Devonian oblique collision of Meguma leading to the Neoacadian Orogeny. Structural models are tested using shear zone kinematics, deformation ages, and regional $^{40}Ar/^{39}Ar$ cooling ages. These show that between the Late Devonian and Mississippian, regionally extensive northeast-southwest and east-northeast west-southwest oriented shear zones, such as the Cobequid-Chedabucto suture, Hermitage Bay-Dover shear zone and Catamaran fault, were formed or reactivated with dextral strike-slip kinematics forming a large-scale C-C' system. Magnetic and gravimetric depth slices indicate that several of these structures are listric, forming a lateral succession of transpressive and transtensive segments cross-cut by antithetic shear zones. At the apex of Meguma terrane collision with the composite Laurentian margin of New England, cooling ages highlight large regions of focussed Neoacadian cooling and exhumation corresponding to an area of contemporaneous high elevation flanked by the opening of the Maritimes and Catskills basins.

Abstract for oral presentation

TILL GEOCHEMISTRY IN THE MCDOUGALL LAKE AND ROLLINGDAM AREAS

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During the field seasons of 2017 and 2018, staff with the New Brunswick Geological Survey collected “C-horizon” basal till samples at 464 locations across the McDougall Lake (NTS 21G/07) and Rollingdam (NTS 21G/06) map quadrangles in southwestern New Brunswick in the vicinity of the Mount Pleasant (Sn-W-Mo-Bi-In) and Clarence Stream (Au-Sb) deposits. Basal till samples were also previously collected at 558 locations across these quadrangles on an evenly spaced grid. All samples from these investigations were prepared and submitted for commercial geochemical analysis by Sodium Peroxide Fusion - Inductively Coupled Plasma Mass Spectroscopy and Optical Emission Spectroscopy. This talk will discuss the geochemical results obtained from this submission within the context of bedrock geological setting, glacial dispersal and sedimentology, and documented mineral occurrences and deposits. A Principal Component Analysis of the data was used to enhance interpretations and delineate areas that warrant further exploration.

Abstract for oral presentation

THE FIRST EVIDENCE OF TERRESTRIAL VERTEBRATES FROM THE LOWER MISSISSIPPIAN ALBERT FORMATION OF NEW BRUNSWICK: IMPLICATIONS FOR THE INVASION OF CONTINENTAL LACUSTRINE ECOSYSTEMS AND BIODIVERSITY DURING ROMER'S GAP IN ATLANTIC CANADA

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Romer's Gap marks the start of a critical divergent point in the history of life, as tetrapods transitioned from solely aquatic to terrestrial ecosystems. This expansion into dry environments set the stage for the radiation of all terrestrial life on Earth, including all of the crown groups of tetrapods, yet it is one of the least understood intervals of Earth's history. The exact timing for the radiation of tetrapods and other terrestrial biota into inland continental environments is poorly understood due to a lack of continental body fossils or ichnofossils from terrestrial deposits. New discoveries of body and trace fossils from sites in Scotland, England, and Nova Scotia, represent rare exceptions offering a glimpse into terrestrial ecologies during Romer's Gap; however, these sites have evidence for an open-water connection suggesting a coastal paleogeographical position. Lower Mississippian sediments deposited in the Moncton subbasin of southern New Brunswick are interpreted to represent freshwater, and intra-continental conditions (lacustrine, wetland, fluvial, alluvial settings). Within the Moncton Subbasin, a horizon in the Tournaisian-aged Hiram Brook Member of the Albert Formation, and another within the Bloomfield Formation exposed near Norton, NB, have yielded abundant tetrapod footprints. Preliminary assessments of these trackways suggest at least four ichnogenera are preserved including: *Amphisauropus, Characichnos, Matthewichnus, Paleosauropus*, and *Batrachichnus*. Footprints range in size from 1 cm to 3 cm, suggesting that tetrapods were smaller than those documented from time-equivalent sites in Nova Scotia, but are comparable in size to skeletal remains described from Scotland that could be considered possible candidate trace makers. These footprints are interpreted to be preserved on the margins of small channels associated with dense wetland forests dominated by *Lepidodendropsis* lycopods and *Aneimites* ferns preserved in their ecological context. The large sample size of tetrapod footprints, in addition to previously studied invertebrate traces, suggests that a community of tetrapods were present and part of a diverse ecosystem, adapted to terrestrial and semi-aquatic continental environments in the Early Mississippian (early Tournaisian). Additional trackways from younger redbed alluvial plain or playa lake deposits in the Sussex Group (Stilesville Formation) and Mabou Group (Maringouin Formation) suggest tetrapods were venturing into semi-arid continental environments during the late Tournaisian through the latest Visean, similar to those described from the Mauch Chunk Formation of Pennsylvania. All Mississippian stratigraphic localities in New Brunswick and those described in literature from Pennsylvania, England, and Nova Scotia, show little ichnotaxonomic variation despite paleogeographic and allostratigraphic position.

Abstract for oral presentation

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WILDCAT – RECENT DRILLING DEFINES MOLYBDENUM DEPOSIT

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The Wildcat discovery is situated along strike, 9 km east of the Mount Pleasant Sn-Mo-W-Zn-In deposit. The deposit is located in a package of Ordovician-Silurian sediments (Kendall Mountain, Digdeguash, and Sand Brook formations) between the Jake Lee Mountain Granite, to the north, and the Magaguadavic Granite, to the south. These granitic units have a strong positive magnetic response and can be traced throughout the district based on this distinctive magnetic signature. By comparison, the sediments are magnetically neutral. What drew attention to this area was the presence of a small, isolated magnetic high several hundred metres north of the granite contact. This magnetic high indicated the possibility of a satellite granite pluton or cupola intruding the sediments in this area.

Float samples gathered during initial exploration efforts assayed up to 0.65% MoS_2 and 0.11% WO_3 in greisen-quartz veins. Distal to these veins, Pb/Zn mineralization occurs as veins and cavity infilling in brecciated, indurated wacke to the north, south, east, and west of the discovery area. Analysis of the wolframite returned up to 13.93% WO_3 (more commonly 0.12% WO_3) while typical quartz-sulphide boulders averaged 0.055% MoS_2. The galena-sphalerite float boulders returned up to 25% Zn, 15% Pb, 32 g/t Ag, and 450 ppm Indium.

It was determined that large quartz stockworks with attendant greisenization exist around the magnetic high. The magnetic high represents pyrrhotite-pyrite-magnetite mineralization peripheral to a buried granite or porphyritic body from which the quartz vein swarms are derived. The base-metal tungsten-indium mineralization represents zoned mineralization distal to the main molybdenum mineralization. While Sn has not yet been intersected in the shallow (< 200 m) drilling to date, it is a potential target as deeper (> 250 m) drilling probes for the top of the porphyry intrusion.

A molybdenum-bearing porphyry dike was intersected in drilling in 2009 and 2010. It occurs in a mineralized, greisenized, quartz stockwork porphyry dike zone 800 m in strike and 80 m in width. Gravity and IP geophysics surveys conducted in 2016 and 2017 have broadened the target zones of distal mineralization to the north and east. Trenching in 2016 discovered new Pb/Zn mineralization on IP anomalies. An IP survey conducted in 2017 extended the potential Zn-In-Pb-Ag distal zone over 1 km to the northeast.

In 2020, a 9-hole, 1,500 m drill program hit a porphyry zone of high-grade Mo (> 0.88%) over 20 m in hole WC-20-06, as spotted by Don Black. Step-out drilling of 3 diamond-drill holes all crossed similar intersections of ore grade Mo (> 0.1%) over an average of intersections > 20 m at depths < 100 m.

In 2021, a 4,300 m, 36-hole program expanded the ore zone to 200 m along strike to the west-southwest and down dip 175 m to the north-northwest. Drill intersections through this tabular mineralized zone range from about 10 m to over 50 m. Assays for the 2021 drilling confirm a very high grade (> 0.6 % Mo) core zone surrounded by a lower grade (> 0.01% Mo) resource of > 1 Mt at an average grade of ~ 0.40% Mo. Numerous, narrow, high-grade tungsten veins are found, normally within quartz veins, above the Mo mineralization, with grades up to 17% W over 50 cm.

In 2022, a further 1100 m, 6-hole program further defined the limits of the ore zone. To date a resource of over 8 million pounds of molybdenite has been defined.

The exploration completed on this property since 2006 supports a geological deposit model similar to the nearby Mount Pleasant deposit or the Henderson orebody in Colorado (from Kirkham and Sinclair, 1988).

Abstract for oral presentation

OVERVIEW OF THE DEVONIAN PORPHYRIES WITH ADAKITIC AFFINITIES IN THE NORTHEASTERN APPALACHIANS AND THEIR POTENTIAL FOR CU±AU±MO MINERALIZATION

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The term “adakite” was first used in 1978; the significant geochemical characteristics of these rocks and magmas are high concentrations of Sr (≥ 400 ppm), low contents of Y (≤ 18 ppm) and Yb (≤ 1.9 ppm), high La/Yb (≥ 20) (high ratios of LREE to HREE), high Sr/Y (≥ 20), Ni (≥ 20 ppm), Cr (≥ 30 ppm), SiO_2 ≥ 56 wt.%, and Al_2O_3 ≥ 15 wt.%. Adakitic rocks have geochemical characteristics similar to the tonalite–trondhjemite–granodiorite series. Research from northern New Brunswick, and Gaspésie, Québec, reports intrusive rocks with geochemical signatures within the range of adakitic rocks. Mines Gaspé in Québec and the McKenzie Gulch dikes in New Brunswick are among those with adakitic affinities. However, based on recent studies in northern New Brunswick, some intrusive complexes such as Benjamin River South (Blue Mountain Granodiorite Suite), Sugar Loaf Mountain, Squaw Cap Mountain, Patapédia, and Nicholas Denys also show adakitic features and are similar to intrusive rocks at Rivière-Verte, Quisibis, and Watson Brook in the northwestern New Brunswick. This classification is primarily based on major- and rare-earth elements, in particular Y (≤ 18 ppm) and Sr/Y (≥ 20). The overall composition of these intrusions tends to be heterogeneous and ranges from granodiorite through monzogranite, monzodiorite, diorite, to tonalite with a calc-alkaline to shoshonitic affinity. Based on A/CNK versus A/NK, these adakitic rocks plot across the peraluminous and metaluminous fields, although their peraluminousity is susceptible to the effects of even cryptic alteration.

These Devonian adakitic rocks in northern New Brunswick have a close connection to base-metal mineralization and hypabyssal porphyritic rocks. It is well known that high level porphyries having high La/Yb and Sr/Y formed in arc settings and have a high potential as precursors to porphyry Cu-Au-Mo mineralization. These mineralized adakitic porphyries are typically inferred to form from oceanic slab melting and (or) slab failure (breakoff). In comparison to intrusions with similar geochemical characteristic elsewhere, the adakitic rocks in northern New Brunswick may be considered fertile for porphyry Cu-Mo-Au deposits. The Pb isotope values of the intrusions in northern New Brunswick and Québec are low relative to southern New Brunswick and adjacent Maine, thus suggesting that these magmas were generated by mixing mantle-derived and crustal materials.

Abstract for oral presentation

THE MIDDLE DEVONIAN EVANDALE PORPHYRY CU-MO (AU) DEPOSIT: A REVIEW OF EXPLORATION POTENTIAL

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Porphyry deposits are considered the world's most significant source of Cu, Mo, and Au. Statistics reported in Canada show that they account for more than 40% of Cu, total Mo, and approximately 10% of Au production. Research shows that porphyry deposits are mainly related to porphyritic oxidized intermediate I-type granitoid intrusions and porphyry Cu-Mo-Au deposits occur in high-temperature (300–700°C) magmatic hydrothermal systems. The western regions of North and South America have been the focus of many porphyry-type deposit studies, consequently relatively little research has been devoted to porphyry Cu-Mo-(Au) system evolution of the granitoid rocks that comprise the Eastern North American orogenic belts.

An example of these porphyry intrusions in eastern North America is the 390.4 ±1.5 Ma (U-Pb on zircon) Evandale Granodiorite located in south-central New Brunswick. This Middle Devonian polyphase I-type granite intrudes through the deformed Silurian sedimentary and mafic volcanic rocks of the Mascarene Basin. Based on studies, this pluton is divided into two phases that range from (1) a calc-alkalic coarser phase ranging from medium- to coarse-grained, seriate to porphyritic granodiorite to monzogranite with metaluminous to peraluminous features, and (2) the alkali-calcic finer later stage layered aplitic phase ranging from a monzogranite to syeno-granite with peraluminous characteristics. Geochemical analyses indicate that both phases of the Evandale Granodiorite show a high concentration of Cu (108 ppm) and Au (33 ppb) associated with the presence of pyrite, chalcopyrite, and arsenopyrite in the aplitic dike samples. Up to 6 ppm Mo was contained within the granitic phase, whereas lesser amounts of Mo were confined to the aplite phases.

Microprobe analyses of biotite, as both phenocrysts and groundmass, shows 0.55 avg. wt.% Cl and 0.21 avg. wt.% F, which are relatively concentrated compared to other high-grade deposits. In these granitic rocks, transportation of metals (Cu and Au) is greatly affected by Cl and F fugacity of the magma. Hydrothermally altered rocks, veins, and sulphides in the porphyry systems result where rising magmatic-hydrothermal fluids from a deeper intrusion cool, depressurize, and react with the host rocks. Wall-rock reactions with host minerals change not only the rock composition, but also the fluid composition as mineralization-alteration elements are transported between rock and fluid. Based on the thermometry and geobarometry of hornblende, the crystallization temperature and pressure of the Evandale coarse-grained granite and aplite are 642°C, 0.7 kb and 600°C, 2.1 kb, respectively. Also, zircon saturation temperatures of the granites and aplite are 736°C and 787°C, respectively.

Abstract for poster presentation

GREEN MINING FOR THE GREEN MINING TRANSITION

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Countries around the globe have committed to net zero carbon emissions by 2050. As we transition from carbon-based energy systems to renewables, the demand for minerals and metals will increase exponentially. By 2040, raw mineral requirements will be 4 to 6 times higher than current day and some minerals such as lithium closer to 40 times today's demand. Adding to this challenge is the fact that mining is an energy and water intensive industry and a major contributor to global emissions. With the increase in demand for metals and minerals and the reduction in ore quality, there is a need for a more efficient extraction and processing of minerals and metals. Greening the mineral resource sector globally is essential to reduce emissions and other environmental impacts while industry ramps up production of critical minerals. There is an ongoing effort to reduce the environmental impact of mining operations, but progress has been slow. The presentation will explore green mining options, examples, and best practices at various stages of application.

Abstract for oral presentation