Highlights from Natural Resources Canada's Targeted Geoscience Initiative and Geo-Mapping for Energy and Minerals Program

Sunday, March 1, 2020 (08:00 to 17:00)
Room 206B, Metro Toronto Convention Centre (North building), 255 Front Street, Toronto, Ontario

Workshop schedule *(Chairpersons: Wouter Bleeker, Jan Peter, Patrick Mercier-Langevin, Geneviève Marquis)*

08:15 -08:20	**Wouter Bleeker**, GSC Ottawa	Introduction
08:20 - 08:40	**Michel Houlé et al.**, GSC Québec	Metal endowment of the 'Ring of Fire' region within the Superior Craton in Canada: Insights from a decade of geological research
08:40 - 09:00	**Lyal B. Harris**, INRS, Québec	Enigmatic hidden deep structures in the Superior Province - new data, tectonic models and exploration targets
09:00 - 09:20	**Gilles Bellefleur and Ernst Schetselaar**, GSC Ottawa	Seismic detection of hydrothermal alteration: a case study from the Lalor VMS deposit, Snow Lake, Manitoba
09:20 - 09:40	**Jean-Luc Pilote**, GSC Québec	Processes regulating gold endowment in carbonaceous argillite-hosted iron sulphides from the Timmins-Matheson gold corridor
09:40 - 10:00	**Ian Honsberger and Wouter Bleeker**, GSC Ottawa	Tectonic drivers of structurally controlled gold mineralization: examples from central Newfoundland
10:00 - 10:20	Coffee break	
10:20 - 10:40	**Dawn Kellett**, GSC Atlantic	Post-accretionary granites, fault reactivation and intrusion-related mineralization in space and time
10:40 - 11:00	**Beth McClenaghan et al.,** GSC Ottawa	New developments in indicator mineral and surficial geochemistry: examples from the Casino Cu-Au-Mo porphyry deposit
11:00 - 11:20	**Alain Plouffe**, GSC Ottawa	Epidote and zircon mineral chemistry: tools to detect the next porphyry Cu deposits in the Canadian Cordillera
11:20 - 11:40	**Michael Gadd & Jan Peter**, GSC Ottawa	Genetic and exploration models for northern Canadian hyper-enriched black shale Ni-Mo-Zn-PGE-Au-Re (metalliferous shale) deposits
11:40 - 12:00	**Matthew Leybourne**, Queen's University	Thallium isotopes as a tracer for genetic linkages between SEDEX mineralisation and alkaline magmatism
12:00 - 12:30	Questions and discussion	
12:30 - 14:00	Lunch break	
14:00 - 14:20	**Carl Ozyer**, GSC Calgary	Geo-Mapping for Energy and Minerals (GEM) - Unlocking mineral potential of the North through geological mapping: Results from 12 years of Northern Geoscience
14:20 - 14:40	**David Corrigan**, GSC Ottawa	Research highlights from the GEM-2 Hudson-Ungava project in the Southeastern Churchill Province, northeastern Quebec and Labrador
14:40 - 15:00	**Mary Sanborn-Barrie and Daniele Regis**, GSC Ottawa	GEM Boothia-Somerset: GEO-mapping to guide mineral exploration strategies
15:00 - 15:10	Coffee break	
15:10 - 15:30	**Roger Paulen**, GSC Ottawa	Deciphering the glacial history of the southern Mackenzie: a region with high potential for undiscovered Zn, Pb and Cu
15:30 - 15:50	**Eric Potter**, GSC Ottawa	Formation of unconformity-related uranium deposits: insights from integrated multidisciplinary studies of the Patterson Lake Corridor, northern Saskatchewan
15:50 - 16:10	**Mostafa Fayek**, University of Manitoba	Uranium solubility, source of uranium and fluid chemistry in the Athabasca Basin
16:10 - 16:30	**Jacob Hanley**, St. Mary's University	Revised model for the Eldorado five elements system in Port Radium with a focus on the importance of overlying basin evolution
16:30 - 17:00	Final questions and discussion	

Highlights from Natural Resources Canada's Targeted Geoscience Initiative and Geo-Mapping for Energy and Minerals program: presentation synopses

Metal Endowment of the 'Ring of Fire' Region within the Superior Craton in Canada: Insights from a Decade of Geological Research

Michel G. Houlé[1,2,*], C. Michael Lesher[2], Riku T. Metsaranta[3], Anne-Aurélie Sappin[1], and Ernst M. Schetselaar[1]

[1]*Geological Survey of Canada,* [2]*Laurentian University,* [3]*Ontario Geological Survey*

During the last decade, the main characteristics of the orthomagmatic Cr-PGE, Ni-Cu-PGE, and Fe-Ti-V mineralization related to the mafic and ultramafic Ring of Fire Intrusive Suite have been investigated under the NRCan's Targeted Geoscience Initiative Program. This highly dynamic komatiitic magmatic ore system is composed of at least two separate but co-magmatic intrusions that coalesced over time to form the Cr and Ni-Cu-PGE-bearing Esker Intrusive Complex, one of the most important members of an increasingly important class of polymetallic magmatic ore systems. The exceptional metal endowment of the Esker Intrusive Complex highlights the likelihood of discovering additional mineral resources, not only within the McFaulds Lake greenstone but also elsewhere within the Superior Province and other frontier areas throughout the Canadian Shield.

Enigmatic hidden deep structures in the Superior Province: New data, tectonic models and exploration targets

Lyal B. Harris*

INRS, Québec

Long-lived deep crustal and upper mantle (SCLM) structures exert primary controls on cratonic architecture and mineralization. Enhanced aeromagnetic, gravity, and MT data for the Superior Province show a direct relationship between orogenic Au, porphyry, and magmatic Ni–Cu–PGE–Cr deposits; and (i) regional-scale faults and irregular competent mafic and felsic granulite blocks at high angles to mapped surface structures and (ii) concentric elliptical features up to ca. 185 km in diameter, preserved in the lower crust and SCLM. The new data and observations support a parautochthonous, plume-related rift model and generate new, unconventional exploration targets.

Seismic detection of hydrothermal alteration: A case study from the Lalor VMS deposit, Snow Lake, Manitoba

Gilles Bellefleur* and Ernst Schetselaar

Geological Survey of Canada

Footwall alteration of the Lalor VMS deposit is associated with an enhanced seismic reflectivity that can be tracked laterally and to depth on a 3-D seismic volume. Integrated analyses of seismic rock properties, lithogeochemistry, and SEM-EDS analyses of drill core samples show that the high reflectivity is due to a P-wave velocity increase caused by the high abundance of garnet, anthophyllite, and particularly cordierite. These minerals are constituents of amphibolite facies assemblages that are diagnostic of metamorphosed, intensely-altered footwalls of volcanogenic massive sulphide ore lenses. At Lalor, footwall rocks with enhanced reflectivity hosts disseminated gold-rich zones of the deposit that are not directly detected with seismic methods. Thus, areas with high seismic reflectivity have great exploration potential in the Snow Lake mining camp, especially when located in footwall rocks.

Factors regulating gold enrichment in carbonaceous argillite-hosted pyrite from the Timmins-Matheson gold corridor

Jean-Luc Pilote[1]*, Simon E. Jackson[1], Patrick Mercier-Langevin[1], Benoît Dubé[1], Christopher J.M. Lawley[1], Duane C. Petts[1], Zhaoping Yang[1], Ed van Hees[2], and Dave Rhys[3]

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This presentation examines the main characteristics of pyrite in carbonaceous argillites and other relevant volcanic sequences and ore zones within the Timmins-Matheson area of the southern Abitibi greenstone belt. Through robust statistical analysis of a large LA-ICP-MS dataset, geochemical fingerprints of diagenetic and epigenetic sulphides can be established and used to help understand factors controlling element uptake and classify or group certain unknowns. Also, results suggest that the degree to which certain diagenetic pyrite textures (e.g., nodules) are enriched in gold is mainly controlled by the petrogenetic nature of the source of the sediments. Metallogenic and exploration implications of these argillite-hosted sulphides are discussed.

Tectonic drivers of structurally controlled gold mineralization and its preservation: Implications for Paleozoic gold potential of central Newfoundland

Ian Honsberger[1]*, Wouter Bleeker[1], Sandra Kamo[2], Hamish Sandeman[3], and Dave Evans[4]

[1]Geological Survey of Canada, [2]University of Toronto, [3]Government of Newfoundland and Labrador, [4]Antler Gold Inc.

A predictable sequence of structural and tectonic processes involving early imbrication, lithospheric extension, synorogenic sedimentation and magmatism, and thick-skinned re-imbrication has recurred throughout Earth's history to form economic gold deposits. Fieldwork and high-precision U-Pb geochronology carried-out in central Newfoundland between 2017 – 2019 demonstrates that the emerging Paleozoic gold district bears strong similarities to the world-class Archean Abitibi greenstone belt with respect to scale, geology, structure, and process rates. Results of this study indicate that footwall blocks buried below thrusts, within an overall west-verging, crustal-scale fault system that cuts through Neoproterozoic basement granitoids in central Newfoundland are highly prospective for economic gold mineralization.

Post-accretionary granites, fault reactivation and intrusion-related mineralization in space and time

D.A. Kellett[1]*, N. Piette-Lauzière[2], N. Mohammadi[3], L. Bickerton[4], N. Rogers[1], D. Kontak[4], and K. Larson[2]

[1]Geological Survey of Canada, [2]University of British Columbia-Okanagan, [3]University of New Brunswick, [4]Laurentian University

Devonian post-accretionary granitoids of the Canadian Appalachians are an important polymetallic metallotect (e.g.., Sn, W, Mo, Au, In) that includes significant resources such as New Brunswick's Sisson and Mount Pleasant deposits and Nova Scotia's East Kemptville deposit. Accretionary orogenic systems like the Canadian Appalachians tend to involve multiple magmatic episodes over a protracted period. The question remains why the Devonian post-accretionary magmatic event was particularly metalliferous. The temporal and spatial distribution of granitoids and metals are in part controlled by both the structural framework and tectonic history of the orogen. Thus, it is critical to situate granitoid emplacement in the context of active structural pathways and tectonic drivers. Towards this end, we review the Devonian intrusive record across the Canadian Appalachian orogen, including several new datasets collected under the Geological Survey of Canada's Targeted Geoscience Initiative (TGI) program. We compare its distribution and duration with new (TGI) and existing constraints on the regional-scale Devonian reactivated fault network.

New developments in exploration geochemistry for porphyry Cu deposits

M.B. McClenaghan[1], C.E. Beckett-Brown[2], M.W. McCurdy[1], M.E. Leybourne[3], A.M. McDonald[2], and S.G Casselman[4]

[1]Geological Survey of Canada, [2]Laurentian University, [3]Queen's University, [4]Yukon Geological Survey

GSC has recently tested new indicator mineral and surficial geochemistry methods on the undeveloped Casino porphyry Cu-Au-Mo deposit in the unglaciated southwest part of the Yukon. Results show that modern multi-element stream sediment geochemistry is still an effective exploration tool. Stream water chemistry combined with isotopic analysis are also useful vectoring tools. Indicator mineral methods, rarely applied in this part of the Yukon, detect obvious porphyry signatures in stream sediments around the deposit. The chemistry of tourmaline, a common mineral in some porphyry systems including Casino, can enhance indicator mineral vectoring to porphyry systems in both unglaciated and glaciated terrains.

Tools to detect new porphyry Cu deposits in the Canadian Cordillera: Epidote and zircon mineral chemistry

A. Plouffe[1]*, R.G. Lee[2], I.M. Kjarsgaard[3], D.C. Petts[1], and T. Ferbey[4]

[1]Geological Survey of Canada, [2]University of British Columbia, [3]Mineralogical Consultant, [4]British Columbia Geological Survey

The demand for conductors like Cu keeps increasing with the electrification of transport systems and the transition towards green technologies. To fulfil the growing need for Cu resources in Canada, new porphyry Cu deposits will need to be discovered. In the Canadian Cordillera, these new deposits are likely to be covered by glacial sediments or to reside at shallow depth in the crust. To overcome this challenge, we have identified the composition of epidote, a mineral common in alteration zones that surround porphyry systems, and zircon, a primary mineral present in the magmatic host rocks of mineralization, that are diagnostic of fertile porphyry systems. These minerals recovered from rocks or detrital cover sediments will be used to vector towards the next porphyry Cu deposits that will fulfill the needs of future generations.

New insights into the genesis of and exploration for hyper-enriched black shales in Yukon

Michael G. Gadd* and Jan M. Peter

Geological Survey of Canada

Polymetallic (Ni-Mo-Zn-PGE-Au-Re) hyper-enriched black shale deposits in northern Yukon are geographically widespread, but poorly understood. There is significant potential for further discoveries, but the lack of understanding of their genesis hampers exploration for them. To address this, we applied multiple investigative methods to determine the origin and nature of these metal-rich shales. Geochronology and biostratigraphy indicate that mineralization is syn-sedimentary and coeval at the basin-scale. Elemental enrichment is derived from ambient seawater, which is supported by Os, Mo and Tl isotopic data. The presence of up to three discrete mineralized layers within the stratigraphic succession suggests mineralization may be cyclic.

Clastic sediment-hosted Pb-Zn mineralization in the Selwyn Basin, Yukon, Canada and the relationship to alkaline magmatism

Emma J. Scanlan[1], Matthew Leybourne[1]*, Daniel Layton-Matthews[1], Alex Voinot[1], and Nancy van Wagoner[2]

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The Selwyn Basin in the Yukon Territory, Canada, is host to several Pb-Zn clastic sedimentary-hosted districts with contemporaneous magmatism. Collected samples from the Anvil District and MacMillan Pass are alkaline basalts and basaltic volcaniclastics. Volcanism in MacMillan Pass was more explosive than Anvil District, where pillow lavas and lapilli tuffs represent periods of effusive and explosive subaqueous volcanism, respectively. Thallium isotopes values from MacMillan Pass samples have a more negative ε^{205}Tl range (-3.2 ± 1.8 to -14.2 ± 3.2) than those from the Anvil District (-0.9 ± 1.9 to -6.4 ± 1.2), with both ranges overlapping with those measured at the Howard's Pass Pb-Zn deposit (-2.6 to -3.6). The range in isotopic values most likely reflects hydrothermal perturbation of magmatic Tl ratios, with the MacMillan Pass samples showing a greater degree of hydrothermal alteration. Understanding the influences of alteration on the primary magmatic ε^{205}Tl is essential for evaluating any thermal and chemical input of Tl to the SEDEX system from magmatic sources.

Geo-Mapping for Energy and Minerals (GEM)—Unlocking mineral potential of the North through geological mapping: Results from 12 years of Northern Geoscience

Carl Ozyer*

Geological Survey of Canada

An overview of GEM results and key outputs summarizing highlights of the last 12 years (2008-2020), with focus on areas of high potential for gold, Ni-PGEs, Cu, REE, base metals, and diamonds will be presented. The GEM program represents a significant investment ($200 million dollars), providing modern, public geoscience knowledge of Canada's North. The program has significantly increased publicly available geoscience information, setting the stage for long-term decision making related to land-use and resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and is utilized by the public and private sectors in Canada and around the world, helping mineral exploration companies reduce their risks and exploration costs, in turn leading to job creation and encouraging economic development in the North.

Research highlights from the GEM-2 Hudson-Ungava project in the Southeastern Churchill Province, northeastern Quebec and Labrador

David Corrigan*

Geological Survey of Canada

High-resolution airborne aeromagnetic surveys, targeted bedrock mapping, high-precision U-Pb geochronology and other bedrock and surficial geology techniques were used to advance our understanding of the tectonic evolution and economic mineral prospectivity of the Southeastern Churchill Province. A protracted history of rifting, accretion and extrusion in a transpressional regime is emerging, providing additional context for the formation of a variety of base, precious, and strategic metal mineralization in the area. This presentation provides an overview of the principal findings including new models for the formation of the Core Zone and tectonostratigraphic/tectonomagmatic evolution of the Labrador Trough.

GEM Boothia-Somerset: GEO-mapping to guide mineral exploration strategies

Mary Sanborn-Barrie* and Daniele Regis

Geological Survey of Canada

With a mandate to update geoscience knowledge of the frontier western Rae craton, the GEM Boothia Peninsula-Somerset Island project has discovered a region *atypical* of Rae. Its formation and evolution, from ca. 2.56 to 2.44 Ga, reveals a history distinct from Rae and from much of the Canadian Shield. Mapping, geochemical and isotopic data establish it may constitute a distinct terrane with affinity to the China craton. This discovery holds critical implications for stakeholders in that mineral deposits typical of Rae (i.e., Meadowbank gold, Mary River iron) are not appropriate exploration targets. Rather, new mineral exploration strategies pertinent to this terrane and to correlative rocks are required.

New potential for undiscovered Zn, Pb, Cu and kimberlites in the southwest NWT

R.C. Paulen[1]*, I.R. Smith[2], S.J.A. Day[1], and S.J. Piercey[3]

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Quaternary geology and mineralogical studies of till and stream sediments were undertaken in the southwestern region of Great Slave Lake from 2017-2019. No previous surficial mapping or surficial heavy mineral data existed for this region. Heavy minerals were subjected to trace element geochemical and isotopic analyses to elucidate potential mineralization source types, and eliminate known sources. Results from this project bring considerable new insights into the glacial history and indicate a strong potential for undiscovered Zn, Pb, and Cu mineralization as well as kimberlite emplacement occurring in bedrock concealed beneath Quaternary sediments in the region.

Formation of unconformity-related uranium deposits: Insights from integrated multidisciplinary studies of the Patterson Lake Corridor, northern Saskatchewan

Eric G. Potter[1]*, Victoria Tschirhart[1], Jeremy Powell[1], Colter Kelly[1], Morteza Rabiei[2], Dillon Johnstone[2,3], Sally Pehrsson[1], Sarah Mount[4], Guoxiang Chi[2], and Kathryn Bethune[2]

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Studies of the Patterson Lake Corridor highlight the role of the Clearwater granitic intrusions in formation of the uranium deposits. Multiple lines of evidence support a linkage between the Clearwater intrusions, Hudson intrusive suite and Rimbey Arc, forming a ~1500 km prospective belt that extends from southeastern Alberta to central Nunavut. High radiogenic heat production from these intrusions may have developed a prolonged, elevated geothermal gradient capable of forming hydrothermal cells as recorded in thermal modelling. Brittle fault reactivations focused oxidized basin brines into the basement rocks, where fluid boiling and fluid-rock interactions caused precipitation of the metals.

The source of uranium and fluid chemistry in the Athabasca Basin

Mostafa Fayek* and Brandi Shabaga

University of Manitoba

The objective of this research is to identify the potential sources of U in the Athabasca Basin. To achieve this goal, we examined the stability of zircons, monazites, and apatites in acidic and neutral fluids. Mineral grains (~1 mm in size) were reacted with fluids at temperatures that prevailed in the Athabasca Basin during U deposit formation. The grains were examined periodically using high-resolution SEM to determine their rate of corrosion. Results from this project provide considerable new insights regarding the fluid chemistry and source of U in the Athabasca Basin.

A revised model for the Eldorado five-element system at Port Radium with a focus on the importance of overlying basin evolution

Jacob Hanley[1]*, Corwin Trottier[1], Zoltan Zajacz[2], Mostafa Fayek[3], Ryan Sharpe[3], Eric Potter[4], and Bill Davis[4]

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The present study has integrated stable and radiogenic isotope, fluid inclusion and geochronology methods to provide new constraints on the formation conditions, metal and fluid source, and timing of the high-grade Eldorado U-Co-Ni-As-Ag-Bi mineralization. A revised absolute age of arsenide-stage mineralization (SHRIMP U-Pb dating from xenotime), combined with evidence for the incursion of evaporated seawater from single fluid inclusion LA-ICPMS analysis, highlight the importance of a thick sequence of overlying intracratonic sediments as a prerequisite for ore formation.