Graduate Seminar Presentations

April 14, 2022, from 9:00 am to 12:30 pm

You are invited to join the Harquail School of Earth Sciences for the
Winter 2022 Graduate Student Seminars

The talks will be delivered in hybrid format:

In person: Executive Learning Centre (third floor of Laurentian University's Fraser Building)

Remote (via Zoom): (Meeting ID: 920 6704 2587 Passcode: 806255)
https://laurentian.zoom.us/j/92067042587?pwd=UzlkeFhqSkhoWEJlYVZmMGcrVzJrZz09

Session 1 - 9:00 - 10:40

9:00 – 9:20 - Derek Leung (PhD student)
Chromium and vanadium: Identical twins or sisters from another mister?

9:20 – 9:40 - Chaneil J. Wallace (PhD student)
Reconsidering an MVT model for the Scotia Mine (Nova Scotia, Canada)

9:40 – 10:00 - Funmilade Akinleye (MSc student)
Assessment and Validation of a Biological Polishing System at Boomerang Lake after 30 years

10:00 – 10:20 - Anthony Zamperoni (PhD student)
The application of three component transmitter electromagnetic systems and distributed array systems for detecting deep targets

10:20 – 10:40 - Christopher Mancuso (PhD student)
Joint gravity-seismic tomographic imaging of the South Sturgeon greenstone belt: preliminary results

Coffee Break: 10:40 – 11:00

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Graduate Seminar Presentations (Cont.)

Session 2 – 11:00 to 12:20 PM

11:00 – 11:20 - Shalaila Bhalla (MSc student)
Structural controls on mineralization at the Ormaque deposit, Val-d'Or, Quebec

11:20 – 11:40 - Ian Campos (MSc student)
Structural controls on gold mineralization, Magino gold mine, Wawa Subprovince, Northern Ontario

11:40 – 12:00 - Mohamed Farhat (MSc student)
The Stratigraphy of the Steep Rock Lake Greenstone Belt, Atikokan, Northwestern Ontario

12:00 – 12:20 - Théo Lombard (PhD student)
Val-d'Or: A typical Archean orogenic gold mining district (Literature review)

END: 12:20

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ABSTRACTS

Derek Leung

Chromium and vanadium: Identical twins or sisters from another mister?

Chromium (Cr) and vanadium (V) are multivalent transition metals that are neighbours on the periodic table. Green micas—*i.e.*, muscovite var. fuchsite and V-bearing muscovite—are coloured by Cr^{3+} and V^{3+}, respectively. Both occur in Au deposits: Cr-micas in ultramafic-hosted quartz-carbonate vein deposits, *e.g.*, Kerr-Addison (ON); and V-micas in alkalic epithermal deposits, *e.g.*, Porgera (PNG). These associations suggest that the geochemical behaviours of Cr and V reflect similar ore-forming processes. The properties of Cr and V (atomic number, ionic radii, and redox potentials)—which influence their natural abundance, substitution in minerals, and mobility in aqueous fluids—will be discussed. Chromium ($Z = 24$) is ~ 45x more abundant than vanadium ($Z = 23$) on earth. Ultramafic rocks have Cr > V, and intermediate to alkaline suites have Cr < V, which is dictated by their substitution in minerals. Octahedrally coordinated Cr^{3+} (0.615 Å) and V^{3+} (0.64 Å) substitute for Fe^{3+} (0.645 Å) and Al^{3+} (0.535 Å) in spinels, with Cr^{3+} being preferred over V^{3+}. However, V^{4+} (0.58 Å) substitutes for Ti^{4+} (0.605 Å) in ilmenite. These substitutions account for the geochemical differences between the two elements: Cr is compatible, whereas V is initially incompatible until ilmenite crystallizes. In hydrothermal fluids, Cr^{6+} and V^{5+} are soluble as oxyhydroxyl complexes, whereas Cr^{3+} and V^{3+} are immobile. However, V is more redox-sensitive than Cr and is more readily mobilized under oxidizing conditions. Thus, Cr and V are geochemically distinct, with host-rock geochemistry influencing the Cr *vs*. V content of the micas present. However, Cr^{3+} and V^{3+} behave similarly in minerals and fluids, so Cr- and V-micas likely formed under similar hydrothermal conditions in Au deposits (pH ~ 6, $\log fO_2 = -30$ to -35).

Chaneil J. Wallace

Reconsidering an MVT model for the Scotia Mine (Nova Scotia, Canada)

Mississippi Valley-type (MVT) deposits are low-temperature, carbonate-hosted Zn-Pb sulphide deposits commonly assumed to form through delivery of metalliferous oxidised fluids to a site with reduced S. This study focussed on the Scotia Mine MVT deposit (Nova Scotia, Canada; reserves of 13.6 Mt at 2.0% Zn and 1.1% Pb) to evaluate this fluid model. Optical microscopy, SEM-EDS, and major- and trace-element content of host, gangue, and ore phases were used to determine the redox state of the fluid(s). Newly identified mineral phases include calcite pseudomorphs after pre-ore baryte and post-ore dolomite. Most carbonate REE patterns exhibit positive Ce and Eu anomalies. Two generations of sphalerite are present: earlier Pb-rich (to 2,600 ppm) and later Pb-poor (<500 ppm) sphalerites, with Tl concentrations positively correlating with Pb in both. Magnesium concentration in the fluid(s) varied over time, as indicated by pre- and post-ore dolomite with intervening calcite. High Fe and Mn in dolomite, along with positive Ce and Eu anomalies, suggest a reduced dolomitising fluid(s). Galena is replaced by Pb-rich sphalerite, suggesting that Pb and perhaps Tl concentrations in sphalerite resulted from mineral inheritance. The two sphalerite types precipitated at different times in the paragenesis; their variable metal content indicates either precipitation from different fluids or precipitation from a single evolving fluid. However, because reduced fluids cannot transport significant amounts of S and base metals together, the probable cause of base-metal precipitation was mixing of base-metal-rich fluids with a reservoir where reduction of S occurred on site. These paragenetic refinements affirm the traditional MVT model but importantly brackets S reduction to post early baryte.

Funmilade Akinleye

Assessment and Validation of a Biological Polishing System at Boomerang Lake after 30 years

About 1Mt of tailings containing ~45% pyrite and ~5% pyrrhotite from a nearby Cu/Zn mine discharged seepages into the 1Mm^3 Boomerang Lake. The site is located within the South Bay Waste Management Area (SBWMA), approximately 450 km northwest of Thunder Bay in Northwestern Ontario. Based on the pyrite content the tailings are expected to discharge metal-contaminated acid mine drainage (AMD) for 30,000 years. Boojum Research Ltd used the site to test ecological engineering measures with agreement from regulatory bodies in Ontario. Three different measures were implemented gradually from closure in 1981 for over 30 years. Biological polishing, tested previously in small field trials, was implemented in several steps, scaling up completely by 2000. Biological polishing removes contaminants from the water column, relegating them to a reducing organic-rich sediment. It is maintained by the growing biomass covering the sediment. Estimates of contaminant loadings retained at the bottom sediments when treatments had not commenced on the lake (1987-1994) were 1.9 t Cu, 345 t Fe, and 79 t Zn. In 1998, 2 t Cu, 468 t Fe and 51 t Zn. However, these loadings have not been quantified since then. The focus of the project is to compare newly collected data with historical data to document the changes in the biologically polished lake over time and allow a comprehensive assessment of the actual performance of the measures applied over the 40 years. These new results will allow conclusions on the applicability of the systems, the processes and the methodologies at the mine closure phase for other mine sites around the world.

Anthony Zamperoni

The application of three component transmitter electromagnetic systems and distributed array systems for detecting deep targets

Electromagnetic (EM) geophysical methods are used in mineral exploration for detecting conductors at depth, they are commonly capable of detecting large conductors at depths of 400 m and up to 800 m under ideal conditions. The ability of EM systems to detect conductors is partly dependent on the coupling of the target body with the primary magnetic field and the depth of the conductor. Traditional EM systems with one transmitter will often have poor coupling to the target body or lack the required signal to noise ratio (S/N) to detect conductor responses at depths greater than 800 m. This research aims to address these limitations by constructing a three-component transmitter system and deploying a large array of distributed receivers in a survey configuration known as a “distributed-array system”. The additional transmitter coils of the three-component system will provide improved coupling for deep bodies as co-orthogonal nature of the coils and resultant multiplicity of primary-field directions will ensure coupling for a wide range of target body orientations. The survey configuration will allow for the ability to move the system when the receivers are laid out, increasing the likelihood of achieving improved coupling of the transmitter (and receivers) to the target body and allowing the transmitters to be summed to improve the signal-to-noise ratio. Simple preliminary testing of the three-component transmitter has been completed to determine if the proximity of the transmitter loops would induce cross coupling and introduce noise to the data. Furthermore, EM modelling software Maxwell, is used to carry out modelling of a distributed array survey configuration and the results are compared to traditional EM survey configurations.

Christopher Mancuso

Joint gravity-seismic tomographic imaging of the South Sturgeon greenstone belt: preliminary results

The brittle, heterogeneous upper crust can be a challenge to image and interpret. This is due to the limitations of individual geophysical methodologies in the face of complicated geology. For seismic reflection methodologies, steep angle reflectors and high velocity contrasts over relatively small distances are problematic. In these settings, there are diffractors, thus the simple application of Snell's law can result in significant errors. This is a particular problem in regional fault zones such as those at the South Sturgeon Greenstone Belt in the Western Wabigoon sub-province, Ontario. Joint inversion of complementary gravity and seismic refraction data sets can help overcome these difficulties by facilitating the construction of a common Earth model comprising velocity and density distributions. This research utilizes Metal Earth and legacy wide-angle seismic data from the surrounding area. Structural similarities between the physical property models were measured using the cross gradients technique. The gradients were then applied to coerce the data to fit to both seismic and gravity inversions as a unified model. This provided improved depth constraints on resulting density anomalies and higher resolution of lateral features in the velocity model compared with the single property inversion results. In these preliminary findings, the joint models appear to have provided a more accurate estimation of the weathering layer velocities. This was confirmed by performing statics corrections with the joint results, which demonstrated a higher signal to noise ratio following the stacking of reflections. Thus, combining seismic and gravity data into a single inverse problem appears to improve the recovery of sub-surface features in a hard-rock exploration setting.

Shalaila Bhalla

Structural controls on mineralization at the Ormaque deposit, Val-d'Or, Quebec

The Ormaque deposit is a new gold discovery by Eldorado Gold Corporation within the renowned Val-d'Or mining camp in the Archean Abitibi greenstone belt, Quebec. Ormaque is located 2 km N of the Larder Lake-Cadillac Fault, 1.5 km S of the past-producing Sigma mine, and 1 km E of the Lamaque mine, where the fault-valve model for orogenic gold deposits was first proposed. Ormaque is hosted by a porphyritic diorite (C-Porphyry) intrusion emplaced within volcaniclastic supracrustal rocks of the ca. 2706 Ma – ca. 2700 Ma Val d'Or Formation. The C-Porphyry consists of amphibole, epidote, chlorite, and plagioclase phenocrysts in a quartz-feldspathic matrix. Three sets of veins are present at Ormaque based on cross-cutting relationships, vein morphology, textures, and orientations: (1) early quartz-carbonate-chlorite (QCC) veins and veinlets, (2) mineralized quartz-tourmaline-carbonate veins (QTC), and (3) late barren quartz-ankerite (QA) veins. The early QCC veins predate mineralization and ductile deformation. The mineralized QTC veins occur as deformed veins within steeply S-dipping shear zones cutting through the C-Porphyry and as extensional flat-lying veins oriented roughly perpendicular to the shear zones. The late QA veins are flat-lying perpendicular to the shear zones and postdate mineralization and ductile deformation. The shear zones are north-side-up ductile faults with the same orientation as regional foliation. They overprint and offset QCC and QTC veins. Primary alteration associated with both deformed and extensional QTC veins is characterized by tourmaline, carbonate, pyrite, chalcopyrite, and gold, and the late alteration is characterized by chlorite and muscovite which postdates foliation development. This study provides new information on the geometry and attitude of the QTC veins and shear zones at the Ormaque deposit.

Ian Campos

Structural controls on gold mineralization, Magino gold mine, Wawa Subprovince, Ontario

The Magino gold mine is located approximately 40 km northeast of the town of Wawa, within the Michipicoten greenstone belt of the Archean Wawa subprovince. It is a past-producing underground mine being redeveloped as a large tonnage open pit gold deposit with proven and probable reserves of 2.4 Moz of gold at a grade of 1.15 g/t Au. Gold mineralization at Magino is primarily hosted in the Webb Lake stock, a steeply-dipping 2724.1 ± 4.3 Ma tabular trondhjemitic body which intrudes steeply-dipping 2738 ± 9 Ma felsic metavolcanic rocks of the Wawa assemblage. The Webb Lake stock and Magino deposit underwent three episodes of ductile deformation and two pre- to syn-tectonic auriferous alteration events (Au_1 and Au_2; respectively). Gold mineralization occurs in two settings: 1) massive sheeted to stockwork-style, steeply-dipping pre-tectonic quartz veins with primary auriferous quartz-white mica-pyrite selvages (Au_1, pre-D_1); and 2) steep to flat-lying fibrous quartz-carbonate/tourmaline veins with secondary auriferous iron carbonate-fuchsite/paragonite/ albite-pyrite selvages (Au_2, syn-D_1). The pre-tectonic quartz veins are transposed and boudinaged along the steeply-dipping WSW-ENE-striking regional cleavage (S_1). The fibrous quartz-tourmaline veins were emplaced syn- to late-D_1 and are deformed within D_2 shear zones. Flanking structures and asymmetric Z-shaped drag folds are indicative of dextral shear along the shear zones. A later flat-lying differentiated crenulation cleavage (S_3) and associated shallow crenulation lineation (L_3) overprints earlier structures and is overgrown by metamorphic chloritoid porphyroblasts within the older surrounding felsic metavolcanic rocks, suggesting that alteration of these rocks occurred prior to peak metamorphism. Mineralization is offset by Matachewan(?) diabase dykes with an apparent sinistral, E-side up sense of motion. Further work is being undertaken to provide absolute timing constraints on mineralization through Re-Os and U-Pb geochronology of post-Au_1 molybdenite and syn- to post-Au_2 xenotime, respectively.

Mohamed Farhat

The Stratigraphy of the Steep Rock Lake Greenstone Belt, Atikokan, Northwestern Ontario

Understanding the stratigraphic relationships between units in Archean greenstone belts can help decipher the tectonic settings for their emplacement. The Steep Rock Lake greenstone belt of the central Wabigoon subprovince predominantly consists of Mesoarchean volcanic and sedimentary rocks and Neoarchean volcanic and sedimentary rocks. The eastern margin of the Steep Rock Lake greenstone belt is bounded by the Mesoarchean Marmion batholith basement. The southern margin of the greenstone belt is bounded by the Quetico fault, a major dextral strike-slip fault that separates the greenstone belt from the Quetico subprovince. Volcanic rocks of the Mesoarchean Perch assemblage are the oldest rocks in the Steep Rock Lake greenstone belt. This assemblage consists of felsic flows, tuffs and fragmental volcanic rocks. The younger Neoarchean Steep Rock Group is a rift-platformal sequence consisting of sandstone and conglomerate of the Wagita Formation, limestone of the Mosher Formation, iron formation of the Jolliffe Formation, and ultramafic volcanic rocks of the Dismal Ashrock. The Witch Bay assemblage structurally overlies the Dismal Ashrock Formation. It consists of mafic to felsic volcanic rocks and siliciclastic sedimentary rocks. Mafic and intermediate intrusive rocks intrude the extrusive rocks. The Witch Bay assemblage was previously interpreted as 1) a structural allochthon that was thrusted above the Steep Rock platformal sequence or as 2) a conformable unit that was deposited above the Steep Rock platformal sequence during rifting of the Superior craton. New Thermal Ionization Mass Spectrometry (TIMS) results from a rhyolite sample from the Witch Bay assemblage shows that the Steep Rock group could be roughly the same age as the Witch Bay assemblage now dated to be 2779.1 ± 0.8 Ma. This new age suggest that the Witch Bay assemblage was emplaced on top of the platformal sequence during rifting. This interpretation can be used to define the age of a rifting event that could be extensive throughout the Superior Province.

Théo Lombard

Val-d'Or: A typical Archean orogenic gold mining district (Literature review)

Orogenic gold deposits are the most explored type of gold deposit in the world and represent 45% of gold deposits containing more than 1 Moz of gold. They are generally hosted in Precambrian greenstone belts along major deformation zones. With over 900 metric tons of gold, the mining district of Val-d'Or is commonly considered a representative example of a world-class orogenic gold camp. A literature review of the general geology of the Val-d'Or area and key characteristics of its gold deposits is the first step to later compare mineralized and low-mineralized sections of major deformation zones (respectively the Val-d'or area, Abitibi, and the Dryden area, Wabigoon) and subsequently document crustal-scale processes leading to gold mineralization. The overall idea will be to investigate both sides of the fault zone by quantifying the intensity of the deformation and documenting the petrography, geochemistry, mineral chemistry and texture of the country rocks and veins in the aim to : I) understand hydrothermal fluid-rock interactions along deformation zones, II) define large scale processes that control the distribution of gold deposits, and III) identify new exploration vectors. The Val-d'Or mining district is located in the eastern part of the Abitibi subprovince, north of the Cadillac-Larder Lake Fault Zone (CLLFZ), between the Malartic and Louvicourt bimodal metavolcanic groups (2714-2702 Ma) of the Abitibi subprovince, and the metasedimentary group (2785-2782 Ma) of the Pontiac subprovince. Series of intermediate to felsic intrusions (2694-2640 Ma) crosscut rocks from both subprovinces and locally act as structural traps for mineralization. However, most of the gold deposits are hosted within metavolcanic rocks, primarily along E-W subvertical shear zones active during greenschist facies regional metamorphism. The gold mineralization is typically expressed as veins of two compositional types that formed during two successive hydrothermal events: I) early quartz-carbonate (QC) veins, which were emplaced before regional peak metamorphism; II) late quartz-tourmaline-carbonate (QTC) veins, which were emplaced after regional peak metamorphism. The source of the mineralized fluid is not yet well defined but the stable isotope compositions (C, O, S) in QC and QTC veins suggest similar fluid sources. The current model proposes a mixture of metamorphic and upper crustal fluids. This model is still debated and may need to be reconsidered. This overview of the Val-d'Or area and the origin of the auriferous fluids will facilitate interpretations for the upcoming study on the footprints of crustal-scale deformation zones in the Archean greenstone belts of the southern Superior Province.