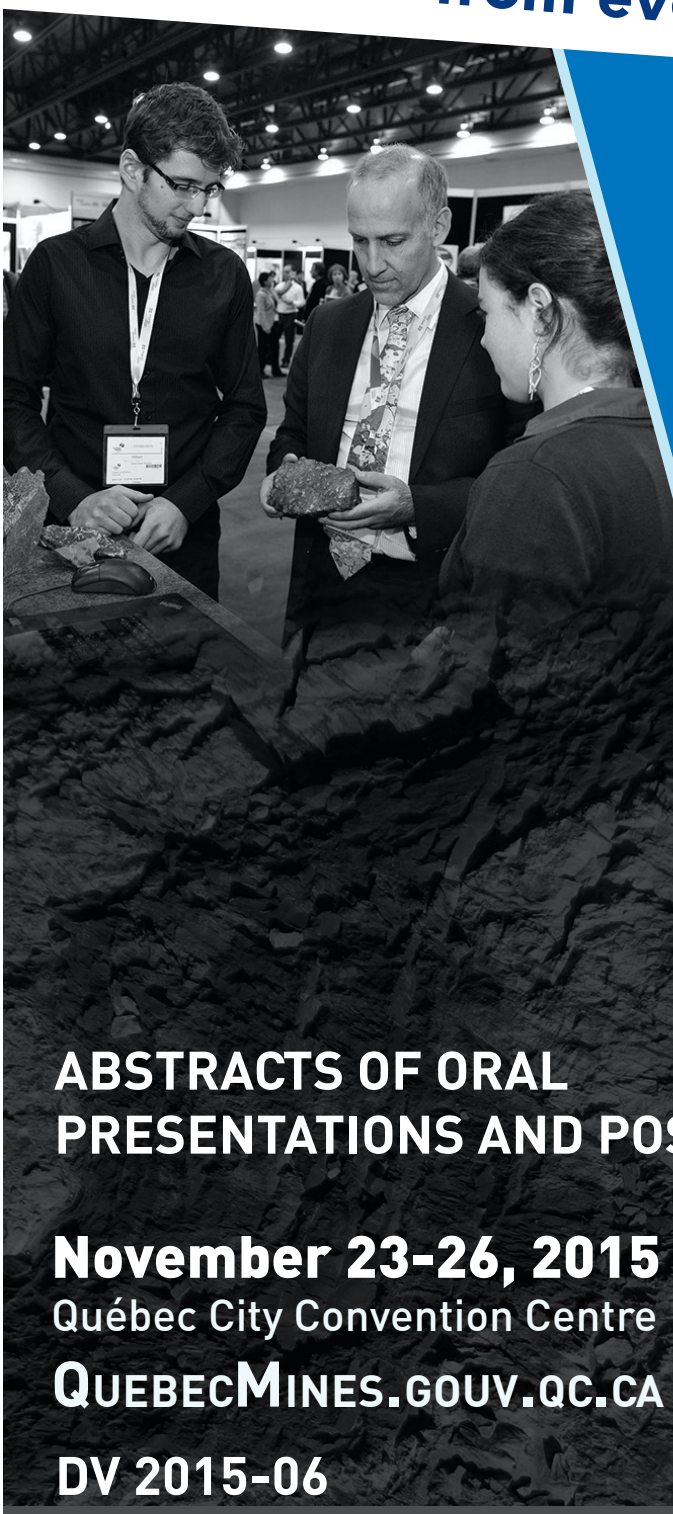
Mines from every angle

QUÉBEC MINES 2015
CROSSROADS OF GEOSCIENCE AND MINERAL RESOURCES



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ABSTRACTS OF ORAL PRESENTATIONS AND POSTERS

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A WORD FROM THE MINISTER FOR MINES, MR. LUC BLANCHETTE

It is with great enthusiasm that I invite you to attend Québec Mines 2015 under this year's theme Mines from Every Angle. This convention, organized for the past 35 years by the *Ministère de l'Énergie et des Ressources naturelles*, gathers everyone together with an interest in Québec's mining development, whether it be industry representatives, the general public, researchers and undergraduates.

"NO MATTER WHO YOU ARE, QUÉBEC MINES IS AN EXTRAORDINARY VENUE FOR LEARNING, DISCOVERING AND NETWORKING"

This year's program is of the highest quality. It offers a wide range of talks, workshops and networking activities given by people of high calibre, many with an international reputation. As for large-scale government projects — the Plan Nord, the *Chantier sur l'acceptabilité sociale*, the Maritime Strategy, and of course the Strategic vision for Québec mining development — the convention will cover vital subjects on these fronts, whether it be recent exploration work, the financing of exploration projects, mining development in northern settings, nickel exploration, research, the use of technology at all stages of the mining process, new geological discoveries or the social acceptability of mining projects.

"THE EXHIBITION HALL WILL SHOWCASE THE KNOWLEDGE, EXPERTISE AND KNOW-HOW OF ALL THOSE INVOLVED IN MINING DEVELOPMENT IN QUÉBEC"

The Ministry will also unveil the results of its annual geological work, which typically identifies new exploration targets. The international facet of the convention will build bridges between our province and elsewhere, especially in light of the *Stratégie économique pour la Francophonie*, which was adopted during the 15th Francophonie Summit held in Dakar in November 2014.

One thing is certain: Québec Mines will highlight the province's geoscientific knowledge and the development of its mining industry. It is the premier rendezvous for key actors in the mining sector, at home and abroad.

I hope to see you in great numbers from November 23 to 26, 2015.

Luc Blanchette
Minister for Mines

WORD FROM THE DEPUTY MINISTER FOR MINES

I'm proud to invite you to Québec Mines, the annual *ministère de l'Énergie et des Ressources naturelles en matière de développement minier* convention. This unifying and open to the world convention brings together stakeholders from here and elsewhere in the mining world. So for a few days, Québec Mines will raise the issue of mining development from all angles.

We are able to present a rich and exciting program each year which includes many networking activities. Québec Mines 2015 is certainly worth a visit! There will be 13 workshops and training sessions, as well as nearly 90 high-level conferences over 15 sessions that are structured around three major themes: the economy, environment and society; mining; and finally, geology and exploration. It includes several exclusive features and brings together internationally renowned specialists to a workshop and two nickel exploration conference sessions! This is a unique event in North America!

I wish to emphasize that this major convention is counting on the invaluable participation of several community partners again this year and I would like to thank them for their involvement. The exceptional quality of the Québec Mines program demonstrates its commitment to benefitting all convention participants.

I invite you to fully enjoy Québec Mines 2015.

Line Drouin

Associate Deputy Minister, Mines Sector

Ministère de l'Énergie et des Ressources naturelles

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Sadi Aid
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SESSION 2

Summary of the various stages and conclusions of the McLeod Deep feasibility study

François Pronovost (Glencore)

A summary of the various stages and conclusions of the feasibility study on the McLeod Deep deposit, including the mining method, comparative studies, manpower and equipment requirements, and the link to production from the current deposit. The presentation will also provide an overview of the deposit's evolution from the project phase to the current expansion of an active mine.

SESSION 2

Costs and benefits of replacing steel cables by equivalent high-performance synthetic cables for production hoisting in deep and ultra-deep underground mines

Raymond J. Gaëtan (Natural Resources Canada, CanmetMINES)

The main factor limiting the hoisting capacity in deep and ultra-deep mines is the weight of the steel cables generally used to hoist ore.

For underground hoisting systems, steel cables are appropriate given their breaking strength and durability. However, steel cables are relatively heavy for the breaking strength they provide to meet regulatory safety criteria. As hoisting depths increase, particularly in mature mining camps, the cable life decreases due to higher stresses and their physical effects on the cables. The dead-weight of steel cables, at hoisting distances considered deep and ultra-deep, has a dramatic impact on the working load that may be hoisted, not to mention the higher energy consumption required to support this additional dead-weight. This translates into significant losses in productivity and higher direct operating costs.

The difference in energy consumption between hoisting systems using steel cables and facilities equipped with equivalent synthetic cables (same breaking strength and diameter) is at least 20%. The use of synthetic cables can thus yield significant economic and ecological benefits.

This presentation will focus on the economic and ecological impacts, as well as risk factors related to the use of high-performance synthetic cables instead of conventional steel cables. The results of three case studies in ultra-deep mines will also be presented as a function of specific key criteria.

The development of high-performance synthetic cables in aramid fibre will also be discussed, as well as potential non-destructive testing methods.

SESSION 2

The challenges of Alimak mining at the Langlois mine

Jean-François Dorion (Nyrstar Langlois)

Situated roughly 40 km from Lebel-sur-Quévillon, the Langlois mine (owned by Nyrstar) has been producing zinc and copper concentrates since the middle 1990s. Given the high level of dilution related to unstable wall rocks, combined with low metal prices and rising production costs, it was necessary to find alternative mining methods that would make the operation profitable. The shape of the massive sulphide deposit — subvertical dip and narrow — made it possible to use the Alimak method. Two mineralized zones were mined by this method, and adjustments were made as needed while the work was being carried out using the experience gained during the process. Production drilling took place once the Alimak raise was driven and fully supported. The stopes were used as shrinkage stopes during the drilling and blasting steps; only enough ore was removed to allow for swell volume in order to stabilize the walls. After the final blasting, intensive extraction could begin. The poor quality of the walls made the waste rock fall into the stopes during ore breakage. Currently, half of each stope or more is filled with waste rock following ore extraction. The upper part of the stope is filled with paste backfill. Ground control and extraction management are some of the challenges posed by Alimak mining at the Langlois mine.

SESSION 2

Logistics and challenges for dike construction in northern Québec

Steve Quessy (Canadian Royalties)

This presentation has two parts. The first will address the logistical aspect of constructing dikes at mining operations, as well as the issues and difficulties associated with remoteness and access. Since mining companies are responsible for a large part of the construction work, very careful planning several months in advance allows the mine and mill to operate while using some of the resources to carry out important work. The slightest oversight in logistics or construction material can be enough to delay the project until the following year. The goal of the construction work is to protect the environment, thus there is very little margin for error.

The second part will concentrate on the challenges faces by several projects in the design, construction and operation of these structures. During the design stage, the availability and physical characteristics of on-site materials must be taken into account if they cannot be obtained elsewhere. The construction period is also crucial because the window of opportunity in the summer months is limited and must be utilized as fully as possible. The operation of the structures must also be optimal given that their improper use or poor performance would have direct and long-lasting consequences on mining operations.

The construction of large-scale structures like retention dikes requires major engineering effort, ingenuity and interdepartmental cooperation when the site is located near a town. For projects in northern settings, the difficulties multiply.

SESSION 2

Automation as a solution to challenges faced in mining

Mikko Koivunen (Sandvik)

This presentation will provide an overview of underground mining automation and discuss prerequisites for its implementation from technical and mining application point of view. Practical reference cases will provide insights to typical applications, describe the drivers for implementing automation and the benefits automation has brought to the operations. The presentation will also describe best practices and factors to consider for succesful implementation of automation systems.

SESSION 3

Synthesis of geological work on the Opinaca and La Grande subprovinces: Implications for gold exploration

Jean Goutier (MERN), MERN geologists, and the geological research team at Université Laval

The contributions from the mining heritage component of the Natural Resource Fund are very important for understanding gold mineralization in the Eeyou Istchee James Bay Territory.

One of the first contributions consisted of high-resolution aeromagnetic and spectrometric surveys covering a vast area (245,000 km^2), which produced a regular grid that connected to the Abitibi grid. These surveys improved field work planning, led to better geological programs and improved the delineation of geological units. Since 2008, *Géologie Québec*'s mapping work in this region produced 32 new maps (1:50,000) and 2,758 rock analyses, led to the examination of 19,100 new outcrops and yielded U-Pb age determinations on roughly 40 rock samples. Without this work, to which can be added the re-analysis, in 2014, of 3,100 existing rock samples and more than 10,000 lake bottom samples, it would not have been possible to generate new zones of high favourability for orogenic gold deposits. Except for a few differences, the parameters used for the mineral potential assessment were the same as those used by Lamothe (EP 2008-02). However, with 29 extra deposits, a larger database and a better understanding of the geology of the area, the high-favourability zones are much better defined, particularly in newly mapped areas. The gold occurrences in the Eeyou Istchee James Bay Territory are distinguished from those in the Abitibi by their mineralogical assemblages that reflect a higher level of metamorphism, a frequent association with iron formations and a higher number of mineralizing episodes, some of which could be Mesoarchean and others as young as 2.6 Ga.

Since 2014, the geological research team at Université Laval has been working in collaboration with *Géologie Québec* on a major project for the characterization of gold mineralization and tectono-metamorphic events in the La Grande and Opinaca subprovinces.

Without the contribution from the mining heritage component, it would have been difficult to carry out systematic geological mapping, and to undertake a detailed study of one of the most important gold metallotects in the Eeyou Istchee James Bay Territory.

Reference

LAMOTHE, D., 2008 – Assessment of the potential for orogenic gold deposits in the Baie-James region. Ministère des Ressources naturelles et de la Faune, Québec; EP 2008-02, 54 pages.

SESSION 3

The UQAT-UQAM Chair in Mining Entrepreneurship: From the mine to the community

Michel Jébrak (UQAM) and Suzanne Durand (UQAT)

The UQAT-UQAM Chair in Mining Entrepreneurship was created in 2011 to foster the emergence and development of new mining companies and the success of existing mining companies in Québec, from exploration to production. It is a unique construct that brings together two universities acting in two complementary fields (Earth sciences and management). It is managed by a committee composed of representatives from the industry and investment sectors, government and universities.

The challenge for Québec not only resides in having more mining entrepreneurs, but in having the best! To this end, the Chair has focused its efforts on gaining a better understanding of mining entrepreneurship in Québec and best practices for investors and entrepreneurs, particularly in terms of innovation. It also ensures knowledge transfers through various scientific publications and by holding, each year, a series of thematic meetings in Montréal or in the Abitibi region. Since 2012, UQAT now offers an MBA program and a micro-program in management applied to the mining industry, which have attracted more than forty students.

Launched in the midst of a mining boom, the Chair has witnessed the increasing importance of social issues for the mining industry and the increasing struggles of entrepreneurs. It has developed a social responsibility approach for companies, specifically in the exploration phase. The development of a social risk index and a sustainable development certification standard constitute the first end-products of this approach. In light of the changes occurring in our society, particularly with regard to resources, it is important to develop robust methodologies that are respectful of all stakeholders. Entrepreneurial success was measured from an educational, historical and structural standpoint, particularly in northern regions. Surveys were conducted to acquire better data on corporate governance and to build a portrait of exploration companies and service providers. The Chair has grown in partnership with the INMQ, AMF, AEMQ and MERN, and relies on an international network of research experts in a wide variety of disciplines, from Earth sciences to human and social sciences.

Mining entrepreneurs in Québec are facing new challenges. Subjected to severe cycles, mining projects must be more resilient and need to gain wider acceptability from affected communities and for the environment. Québec has many assets it can count on to rise to the challenges associated with the establishment of a sustainable mining ecosystem.

SESSION 3

CONSOREM: An exploration R&D business model

Réal Daigneault (CONSOREM-CERM-UQAC)

Exploration is the spearhead of all mining development. It is a key component of resource renewal and the springboard of future economic development. The exploration process is a broad field that includes the appropriation of expert knowledge on how ore deposits form and on the mineral potential of prospected regions. The discipline integrates the constantly evolving techniques and methods of many fields (geophysics, geochemistry, geostatistics, structural geology, etc.).

Bearish mining cycles caused by an unfavourable economic climate have a direct impact on exploration activities and investment, which ultimately results in a shedding of experts equipped with knowledge and techniques specific to the field. Recovery periods are marked by a break in intergenerational transfer, and the new generation is left to re-appropriate the lost expertise.

R&D in mineral exploration involves a set of players with specific goals and interests. Companies adopt strategies suited to their size, expertise and exploration philosophy. Governments promote the mineral potential of territories that was gained through knowledge acquisition, and they implement appropriate legislation to create an environment of sustainable development that will benefit communities. Universities favour the development of specialized knowledge and actively participate in the training of qualified mineral exploration personnel.

Several business models for exploration R&D include all three components to various degrees. While the R&D level of companies may be obviously competitive – demanding a certain degree of confidentiality – that of governments and universities is one of pre-competition, favouring the public disclosure of findings. In appearances alone, the needs and goals of the three components may seem incompatible.

CONSOREM is a research partnership between companies, governments and universities. It was founded in 2000 to support the boom in mineral exploration across Québec. It is an entity that focuses on the needs of the industry, and conducts projects that provide tools, methods and exploration models that are adapted to the province's exploration environments. The combination of all three components – companies, governments and universities – facing common issues together is likely CONSOREM's greatest contribution. It also contributes to the collective memory of the exploration sector by taking the responsibility of transferring knowledge to users. This way of functioning has provided Québec with a strategic advantage in the future development of its territory.

SESSION 3

Cree Mineral Exploration Board, Cree Nation and the mining industry

Youcef Larbi (CMEB)

The Cree Mineral Exploration Board is one of the results of "La Paix des Braves", the agreement between the government of Québec and the Crees of Québec.

Mining is not in the culture of the Cree nation as the environment, and the nature respect are. The mineral resources of Eeyou Istchee were all property of the mining industry. The Creation of the CMEB permits the participation of the Crees to the mining activity and regulation of environment impact in the territories.

The main purposes of the Mineral Exploration Board consist of (a) assist the Crees in accessing mineral exploration opportunities and evaluating the environment impact, (b) facilitate the development of mineral exploration activities by Cree Enterprises, (c) facilitate and encourage the access by the Crees and Cree Enterprises to regular Quebec program funding and other encouragements for mineral exploration activities, (d) act as an entry mechanism for offers of services by Crees and Cree Enterprises in the field mining.

Furthermore, the CMEB acts as an intermediate between the mining industry and the Crees to resolve matters concerning mineral resources and the land. The board has the mandate to develop the mining activity and answer to environmental needs of the Cree trapelines. It supports and funds also consistent projects for the all communities and specifically the Cree prospectors.

Concerned by the regional development, the CMEB collaborates with several entities, Cree and none Cree. These collaborations are a great success.

CMEB program and projects are managed by his board. This latest evaluates the administrative structure and also compares with what is known elsewhere in Canada and in the rest of the world in the trend to ameliorate and reach the excellence.

SESSION 5

Restoring the Solbec Cupra mine site

Annie Blier (IAMGOLD)

The Solbec mine (Québec, Canada) has been in operation from 1962 to 1977. The site is located in the Eastern Townships, about 200 km east of Montreal, between Aylmer and Lake St-Francois.

More than 2.5 million cubic meters of sulphide tailings were placed into the tailings pond and sporadic samples taken between 1972 and 1980 confirmed the presence of acid mine drainage (AMD) on the site. A tailings pond characterization report was filed in 1987 and proposed flooding as the most viable solution to address the problem. A series of experimentations and studies followed from 1989 to 1993 to test the effectiveness and viability of the solution. The work required for the flooding was carried out from 1994 to 1996. Thereafter, a monitoring project was implemented under the MEND program to monitor the water quality and groundwater of the tailings pond. After twelve sampling campaigns with more than fifty samples each and involving more than ten parameters by recording, the solution is effective. The pH is now close to neutral and the results have shown that the water covering the old tailings met all requirements outlined in the Directive 019 Director (Ministry of Sustainable Development, Environment and the Fight against Climate) and also the regulation of drinking water in Québec.

The old tailings pond became the Domaine des Hauts-Cantons with Lake of Héronnière. In 1997, a developer who discovered that environment back to life and offered an exceptional setting with fish and wildlife abundant life. Le Domaine des Hauts-Cantons covers an area of over 450 acres around Lake of the Héronnière and consists of 66 waterfront lots.

Planned with a constant effort to harmonize human activities with nature, the project development is done in the utmost respect for the environment. This is in complete tranquility you can experience the splendor of the lake.

The presentation would have the historical site data, experimentations, reclamation work, results and what happened to the site.

SESSION 5

Waste management – From concept to rehabilitation: Case of the Éléonore Mine, Goldcorp

Martin Duclos (Goldcorp, Éléonore)

Goldcorp's Éléonore mine is an underground gold operation in the Eeyou Istchee Baie-James Territory of Québec. It has been in production since 2014 and attained commercial production in April 2015.

During the advanced exploration stage, a mine waste geochemical characterization program was undertaken using representative drill core samples. The program also included the geochemical characterization of tailings issued from metallurgical testing (future concentrator tailings), as well as process water (water issued from mining operations).

The characterization program established the design basis for the tailings management and wastewater treatment facilities, which were then constructed.

The innovative dry tailings management program at the Éléonore mine will reduce its environmental footprint in terms of disturbed surface area and volume of water involved. The selected design will emphasize an effective and durable progressive rehabilitation approach.

SESSION 6

The lithium-ion battery revolution and the raw materials that will drive it

Andrew Miller (Benchmark Mineral Intelligence)

- Focus on the market potential for graphite, lithium and cobalt in batteries
- Downstream market analysis: where will the batteries be made, at what scale
- North America's battery stance
- Beyond the Tesla Gigafactory
- Analysis of the emerging EV
- Utility storage market for batteries.

SESSION 6

From exploration to processing: Example of the Lac Knife graphite mine and industrial transformation projects of Focus Graphite

Benoit Lafrance (Focus Graphite)

This presentation will provide an overview of the most important physical characteristics when assessing the potential value of a graphite occurrence, the different applications for graphite, and both the traditional and high-technology graphite markets. Focus Graphite's projects will be used as examples to explain exploration techniques, and to describe different types of graphite-related mining and industrial projects. When it comes to graphite mineralization, flake size and purity are key parameters that must be assessed by metallurgical tests at the very beginning of exploration work.

Focus Graphite is currently working on the financing of its Lac Knife mine project, located 27 km south of Fermont, from which it expects to produce a high-grade flake graphite concentrate. The Lac Knife deposit, wholly owned by Focus Graphite, ranks among the best in the world for the graphitic carbon content of its flakes (15%), as well as for their size and purity. Metallurgical studies demonstrated that it would be possible to produce high-grade flake graphite containing 98% carbon (average for flake size above 200 mesh) using only flotation circuits (no purification process). The high grade of the initial concentrate (98% C) will greatly reduce the already-high costs of thermal or hydrometallurgical purification needed to produce graphite with more than 99.95% C, the minimum grade for manufacturing lithium-ion batteries and accumulators, as well as electronic products. This is the considerable advantage of Lac Knife compared to other deposits.

The company intends to capitalize on the high grade of its Lac Knife concentrate. At the beginning of the year, it announced the launch of a feasibility study for a graphite concentrate transformation plant in Sept-Îles. The objective is to purify the concentrate and produce value-added products using graphite concentrate originating from Lac Knife or other sources. Focus Graphite aims to produce coated spherical graphite, used in the emerging lithium-ion battery markets for electric vehicles and accumulators, as well as expanded graphite, used in portable electronic devices (smartphones, tablets, laptops).

Focus Graphite expects to become a graphite concentrate producer with one of the lowest production costs thanks to its Lac Knife project, and the company is well positioned for the future as a clean technology mining company.

SESSION 6

Apatite and ilmenite in Québec: World-class potential

Stéphanie Lavaure (Arianne Phosphate)

In the field of industrial minerals, the economic viability of a deposit depends not only on the quantity or quality of its resources, but also on the specific characteristics of the market. The need to secure a client to guarantee the product's value adds an important parameter to the economic equation leading to the successful development and mining of this type of deposit.

For apatite, the market is primarily dependent on global demand for fertilizers, which in turn is controlled by population growth and changes in the diet of emerging countries. Demand for phosphate rock is consistently growing (2-3% annually) and increasing environmental awareness is also leading to greater demand for high-purity phosphate, such as that derived from igneous apatite. This makes it an important mineral for North America and particularly for Canada, which is now strongly dependent on imports since the closure in 2013 of its last phosphate mine in Kapuskasing.

Québec, with its share of Grenvillian geology, can become well positioned in the mining of high-quality phosphate with very little contaminants. The Mine Arnaud deposit and Arianne Phosphate's deposit are in fact about to become leading mining operations in this industry. There is every reason to believe that many other apatite deposits may also be discovered in the next few decades.

As for ilmenite, the market all but collapsed during the 2008 economic crisis and is still reeling from its impact. Nevertheless, titanium is used in the aeronautic, aerospace and military industries as well as for chemical and petrochemical applications and as a result, many governments still consider ilmenite a strategic mineral.

The largest ilmenite deposit in the world is located in Havre-Saint-Pierre (Lac Tio mine, Rio Tinto). Another important deposit, the BlackRock project (BlackRock Metals), is currently in the advanced development phase. Additionally, ilmenite commonly occurs as a potential by-product in apatite deposits in Québec. Similarly to apatite, given the geological setting in Québec, it is quite likely that future ilmenite deposits may be discovered in the next few decades.

For these reasons, development of apatite and ilmenite deposits is considered a priority within the scope of the Plan Nord over the next five years. With its unique geology, Québec could indeed become a player to be reckoned with on these markets.

SESSION 6

Rare earths: From ore to applications

Alain Rollat (Global Business Unit Special Chem – Solvay Group)

In 2011, the European and American media discovered that rare earth elements, largely unknown to the general public, were indispensable to our economies, specifically to high-tech industries. The reason for this unprecedented attention is obvious: China, which produces 95% of the world's rare earth elements, had just imposed a major reduction in its export quotas, effectively creating a supply crisis.

But what is hiding behind the unusual name of these elements, and why are they indispensable to so many key technologies in developed countries? To answer these questions, it is important to understand the following:

- the fundamental physico-chemical characteristics of the lanthanides;
- the specifics of the rare earth market and their applications;
- the manufacturing processes for rare earth-based materials.

Solvay Group, which has been one of the world leaders in rare earth purification and the formulation of rare earth compounds for over 50 years, owns the only global separator unit outside of China. After investing in its Saint-Fons and La Rochelle sites where rare earth elements are recycled from energy-saving lights, Solvay can now process the concentrate from new rare earth mining companies at its La Rochelle site.

SESSION 9

Gold in Rhyacian terrigenous detrital metasediments (2300-2050 Ma)

Marc Bardoux (Barrick Gold Corporation)

The Rhyacian is a unique geological and metalliferous period. Following the first period of global glaciation (the Huronian "Snowball Earth"), our planet's atmosphere and hydrosphere oxidized (sulphide erosion and oxidation) as Archean fragments of the first supercontinent (Atlantica) converged, and a biosphere established along cratonic margins (Gabon). In part of Atlantica, large igneous provinces (LIPs) developed while gigantic clastic sedimentary basins (several times the size of the Amazon basin) formed around them along the margins of Archean masses. The convergence of these masses and the stratification of Rhyacian sediments led to the formation of the first multi-kilometric orogenic mountain chains. More than one-third of Rhyacian gold is found in faulted folds of considerable size that overprinted the sediments. Metamorphism of the sediments generated a large volume of fluids that mobilized the S, Au, As and other diagenetic metals they contained into their surroundings. Rare intrusions (alkaline) were emplaced in these sediments. We will examine the deposits of Rhyacian trans-Atlantic basins (Birimian, Guianese), and pose the question of whether this gold is strictly of mantle origin. This metallotect is systematically present in the world's most fertile Precambrian greenstone belts.

SESSION 9

Gold exploration in Archean metasedimentary rocks: Constraints and tools derived from applied metamorphic petrology

Peter H. Thompson (Thompson Geological Consulting) and Marc Bardoux (Barrick Gold Corporation)

Even though many economic geologists accept that metamorphism is an ore-forming process, application of metamorphic data and concepts as exploration tools is not widely practiced. The methodology should be a key component of the search for gold deposits in Archean metasedimentary rocks.

Mapping of metamorphic features across tens of kilometres in orogenic terranes and across tens of millimetres in thin sections is the basis for applied metamorphic petrology. Together with concepts developed to explain the origin of metamorphic rocks, metamorphic data assist gold exploration by imposing key constraints on the geological setting and timing of gold mineralization, and by outlining potential fluid conduits.

Deposition of gold in metasedimentary rocks occurs during chemical and clastic sedimentation and diagenesis (*sedimentary gold*) and during orogenesis (metamorphic gold). Applied metamorphic petrology is a way of seeing through the effects of metamorphism and deformation in order to reconstruct the pre-metamorphic lithologies and depositional environment of *sedimentary gold* and identifying prospective rock packages. Metamorphic data constrain pressures(depths), temperatures, and fluid compositions that prevailed during metamorphism as well as the duration and timing of the process relative to deformation, plutonism and formation of *metamorphic gold* deposits. Mapping district-scale metamorphic zone boundaries and kilometre-scale (or smaller) metamorphic anomalies has the potential to outline zones of anomalous metamorphic fluid flow, thereby assisting in the prioritization of exploration targets.

Remobilized and concentrated by Archean regional metamorphism and deformation, *sedimentary gold* is a likely source of *metamorphic gold* in metasedimentary rocks of the Slave Province. The perspective provided by applied metamorphic petrology is necessary to explain the origin of the Meadowbank gold deposit in Nunavut where Proterozoic *metamorphic gold* occurs in Archean metasedimentary rocks.

SESSION 9

The Eleonore mine: A metamorphosed world-class gold deposit, hosted in wackes (<2675 Ma), Eeyou Istchee Baie-James, Québec, Canada

Arnaud Fontaine (INRS-ETE), Benoît Dubé (GSC-Q), Michel Malo (INRS-ETE), Vicki McNicoll (GSC-O), Tony Brisson, Eric Fournier (Goldcorp, Éléonore) and Jean Goutier (MERN)

The Eleonore mine is the first world-class gold mine in Eeyou Istchee James Bay region with reserves of 4.10 Moz at 9.63 g/t Au and resources of 4.03 Moz at 6.49 g/t Au. Located a few kilometers south of the contact between the Opinaca (paragneiss, migmatites and intrusions) and the La Grande (tonalitic basement, volcano-sedimentary rocks and intrusions) subprovinces, the deposit is mainly hosted by wackes (<2675 Ma). The bulk of the gold mineralization occurs within several plurimetric ore zones, oriented NNW-SSE that formed a subvertical envelope of 70-80m thick with a vertical extension of at least 1.4 km. Those share a common metallic signature of Au-As-Sb-W-Bi-Sn-Mo, including various mineralization styles from i) quartz-dravite-arsenopyrite-pyrrhotite veinlets and veins network in association with quartz-microcline-phlogopite-arsenopyrite replacement zones (*Roberto zone*), ii) quartz-diopside-schorl-lollingite-arsenopyrite vein and/or silica-flooding zones and/or hydrothermal breccia with microcline and quartz-actinolite veins (*East-Roberto zone and Hanging-wall zones*), iii) biotite-amphibole schists (*Lake zone*) and iv) phlogopite-actinolite-diopside replacement zones (*North zone*). Proximal hydrothermal footprint of the deposit is characterized by high K_2O/Na_2O, Rb/Cr, SiO_2/Na_2O ratios and with positive anomalies in B and negative anomalies in Ba.

At regional scale, the host sedimentary sequence defines four stratigraphic units. A polymictic conglomerate (<2702 Ma) is at the base and unconformably overlain the Kasak Formation (pillow lavas and lapilli tuffs, 2704 Ma). Within the deposit, a massive wacke (<2714 Ma) and aluminosilicate-bearing metapelitic unit (<2697 Ma) are structurally above a finely bedded wacke (<2675 Ma), host of the major part of ore zones. The latter is located in the footwall of a thrust oriented NNW-SSE. Underground mapping suggest i) an important structural control of this structure, interpreted D_1, on the emplacement of the main ore zones (*Roberto and East-Roberto zones*) and ii) their deformation by D_2 and D_3 structural events. Originally oriented NNW-SSE, such as the contact of the two subprovinces in the mine area, this thrust probably influenced the formation and preservation of the deposit during exhumation of the migmatitic centre of the Opinaca.

Textural attributes of the Roberto zones, including i) recrystallization, ii) presence of phlogopite porphyroblasts, quartz ± feldspar subparallel veins, locally saccharoidal and lollingite, confirms that the deposit is affected by prograde metamorphism (amphibolite facies), illustrating by high-grade gold-bearing paragneiss. Metamorphism (650-750°C, 5-6 kbars), syn- to late-D_2, is discordant to the hydrothermal auriferous system and spatially associated with emplacement of granitic dykes and intrusions (ages between 2617 and 2600 Ma). At regional scale, magmatic rocks host gold mineralization (Cheechoo tonalite and pegmatites) suggesting polyphase mineralization and/or remobilization. Those are younger than migmatization (i.e. 2672 to 2637 Ma) in the Opinaca subprovince. Pre-D_2 intrusions are also present (Ell Lake diorite, monzonite, feldspar-phyric dykes)

Although deformed and metamorphosed, ore bodies of the Eleonore mine share analogies with those from Archean gold deposits hosted by sedimentary rocks (proximity with a contact between two subprovinces, host rock (<2675 Ma) localized in the upper part of the stratigraphic sequence; potassic alteration; fold hinge location; metallic signature; metamorphic gradient; presence of conglomerate).

SESSION 9

Geology of gold mineralization associated with Canadian Shield banded iron formations: Example of the world-class Musselwhite (Ontario) and Meadowbank (Nunavut) deposits

Sébastien Castonguay (GSC-Q), William Oswald, Vivien Janvier (INRS-ETE), Benoît Dubé, Patrick Mercier-Langevin (GSC-Q), Vicki McNicoll (GSC-O) and Michel Malo (INRS-ETE)

The gold deposits associated with banded iron formations (BIF) represent a major exploration target in the southern Canadian Shield. The Musselwhite (Ontario) and Meadowbank (Nunavut) deposits were studied as part of the Targeted Geoscience Initiative (TGI) in order to better define the geologic controls, hydrothermal footprint and exploration vectors for this style of mineralization.

The Musselwhite deposit is enclosed in polydeformed metamorphosed (amphibolite-facies) BIF of the Mesoarchean North Caribou greenstone belt (Superior Province). Three phases of Archean deformation created complex interference fold patterns. The ore is most commonly in the form of pyrrhotite-rich replacement zones and silica flooding within the garnet-grunerite-rich silicate facies. The gold zones, which are associated with D2 high-strain zones, are preferentially concentrated along hinges and strongly attenuated fold limbs of F2 folds. Stratigraphic and structural relationships, as well as new U-Pb dating, indicate that the mine sequence is inverted in an overturned kilometre-scale F1 fold, strongly overprinted by D2. This structural context influenced BIF distribution and geometry, and constitutes a regional exploration vector.

The Meadowbank deposit is enclosed in polydeformed metamorphosed (greenschist- to amphibolite-facies) rocks belonging to the Neoarchean Woodburn Lake Group (Churchill Province). Notwithstanding cryptic Archean deformation, four phases of Proterozoic Trans-Hudsonian deformation have been documented, including two series of isoclinal folds and faults (D1 and D2), and late folds. The BIF-hosted gold is associated with zones of pyrrhotite ±pyrite with traces of chalcopyrite and arsenopyrite, as well as grunerite. Gold-rich quartz-pyrrhotite±pyrite veins are locally present in volcaniclastic rocks altered to sericite±chlorite. The bulk of the mineralization is found along D1 faults and was remobilized and deformed by D2. Geochronological data indicate that the Meadowbank fault zone separates two lithological assemblages with distinct ages (2717 and 2711 Ma). This boundary may constitute a regional metallotect.

These deposits occur in complex geological settings where mineralized zones are associated with competency contrasts and anisotropies in host rocks that were highly reactive to hydrothermal fluids. The influence of the different folding phases and fault zones should also be taken into account in the emplacement or remobilization of the gold.

SESSION 9

Orogenic gold mineralization in sedimentary rocks: Example of deposits in the Otago district of New Zealand and their genetic implications

Damien Gaboury (UQAC-LAMEQ)

With the exception of Archean belts, major gold districts are commonly associated with sedimentary rocks. In Québec, the Appalachians offer an immense area to explore for gold mineralization. But success has been limited, perhaps due to the lack of precise exploration guides. The Otago Schist belt in New Zealand consists of three Mesozoic sedimentary nappes that formed in accretionary wedges. The Otago gold district has been the subject of a great deal of scientific research due to 1) the young age of the deposits (100 to 140 Ma), 2) the different metamorphic facies (prehnite-pumpellyite to upper greenschist facies) overprinting similar sedimentary assemblages, and 3) the absence of magmatism. More than 200 gold-bearing quartz veins, scattered over a district of roughly 65,000 km^2, have yielded a historical production of 240 tonnes of gold, primarily from placer mining operations. In addition to the veins, the Macraes mine exploited a gold-bearing shear zone, gently dipping (15°), thick (<50 m) and traced for more than 30 km. This world-class deposit hosts >300 tonnes of gold, more than the production of the entire district. The spatial distribution, in which this giant deposit is masked by the background noise of showings and deposits, is not unique and demonstrates the need to better understand the mineralizing process in order to improve exploration guidelines. To this end, we studied 45 samples covering the entire district in order to characterize the mineralizing fluids. The fluid inclusions were primarily aqueous (82-100%) throughout the district, with little CO_2 (<13%) and lesser amounts of H_2 (<7.9%), N_2 (<1.4%), CH_4 (<1.12%), C_2H_6 (<0.44%) and H_2S (<0.03%). Genetically, it has been demonstrated that primary pyrite in shales (organic-rich rocks) was the source of gold in the Otago district. The pyrite released Au and HS^- during its metamorphic conversion to pyrrhotite. Ethane (C_2H_6) has proven to be the best tracer for assessing the contribution of deeply buried shales in the generation of metamorphic fluids and gold enrichment. C_2H_6 is mainly present in fluid inclusions in veins found in the northern part of the district, corresponding to the Torlesse terrane, the host to the Macraes deposit. These results demonstrate the importance of a fertile gold source at depth, particularly pyritic shales, in forming world-class orogenic deposits.

SESSION 9

New developments in Appalachian metallogeny

Georges Beaudoin (UL) and Michel Malo (INRS-ETE)

From a metallogenic perspective, the Appalachians of Eastern Québec and New Brunswick are mainly known for their felsic-siliciclastic volcanogenic massive sulphide deposits of Ordovician age and their porphyry and skarn deposits (Cu-Au) of Devonian age. A wider range of deposit types has now been documented for this region. These are discussed below.

In the Early to Middle Devonian, in the Fournier Group of New Brunswick, mafic-type cupriferous volcanogenic massive sulphides (Turgeon deposit) were deposited in a juvenile back-arc basin setting. Sedimentation in the deep and suboxic environment of the back-arc basin was accompanied by the formation of Pb-Zn-Ag massive sulphides in massive pyrrhotite lenses (Nicolas-Denys deposit). These deposits were subsequently deformed during the Taconic Orogeny. In the Silurian, the copper mineralization of the Transfiguration deposit formed in association with the continental red beds of the Robitaille Formation. This mineralization was related to a period of emergence during arid conditions, when oxidizing fluids from overlying red beds mixed with reducing fluids issued from the reaction of organic-rich rocks in the Cambro-Ordovician basement. In the mafic volcanics of Mont-Alexandre, argentiferous native copper mineralization formed as a result of infiltrating warm oxidizing seawater in a setting of oceanic crust spilitization. In the Devonian, basaltic and dacitic rocks emplaced in a volcanic arc of calc-alkaline affinity host the sericite-adularia to neutral epithermal gold mineralization of the Lemieux Dome. The epithermal veins of the Lemieux Dome are cut by younger Cu-Fe(±Au) mineralization that is similar to the Mont-de-l'Aigle copper-gold-iron oxide (IOCG) deposits. During Acadian deformation, major strike-slip faults were spatially associated with epizonal orogenic gold mineralization, such as that of Sainte-Marguerite, along the Sainte-Florence Fault. At Saint-André-de-Restigouche, disseminated Carlin-type Au-As-Sb-Hg mineralization is found near the Grand Pabos Fault.

SESSION 10

Innovation in mining finance: The Osisko Gold Royalties approach

Bryan A. Coates (Osisko Gold Royalties)

Financing is currently a major challenge for all development stages of a mining company.

This presentation will discuss the financing of mining companies in today's context, and the Osisko Gold Royalties approach, which fosters mining development in Québec.

SESSION10

Developing the next great canadian base metal mine

Mark Selby (Royal Nickel Corporation)

Maintaining momentum and exploring non-traditional financing structures are key components of advancing a large-scale base metal project in the current state of the metals market. Royal Nickel Corporation's Dumont Nickel Project is continuing to make progress on a financing package that will involve several components, including traditional and non-traditional sources of funding. Dumont's continued progress is largely based on three main factors: 1) the mid to long term fundamentals for the nickel market are very positive 2) Dumont is a long life, low cost project with critical permits in place, and 3) Dumont is located in the Abitibi region of Québec, one of the top mining jurisdictions in the world.

Potential financial participants in the Dumont project understand the nickel market is facing a long term structural shortage. The looming shortage is largely driven by declining primary nickel output in China coupled with a drop in investment in new nickel projects following the market peak in 2007. As a result, Dumont is now one of a very few large-scale nickel projects with the potential to start production within the next few years. This fact, coupled with the project's location in a politically stable jurisdiction with low cost power and key infrastructure in place, makes Dumont a high priority development opportunity.

SESSION 10

How to support our present and future mining flagships

Dany Pelletier (Caisse de dépôt et placement du Québec)

After a decade of strong growth, Québec's mining sector has experienced difficult times since 2010. In this context, several questions need to be addressed:

- How can we ensure the emergence and growth of Québec's mining flagships today and in 2030?
- What can we rely on to guarantee the success of companies at the exploration stage?
- What conditions are essential for projects to succeed?

This presentation will cover the key elements that will guarantee the long-lasting success of the sector, with a focus on young mining companies that will be at the helm of flagship projects in 2030.

The presentation will provide an overview of the current situation, particularly related to financing, and concrete examples will offer a better understanding of the Caisse's vision when it comes to supporting companies.

As a long-term investor, *Caisse de dépôt et placement du Québec* covers all financing phases in the mining sector, from exploration through development and construction to production.

SESSION 10

A case study of the 2014 financing of the Renard project: C$1B for Québec's first diamond mine

Matt Manson (Stornoway Diamonds)

A review is presented on the structuring and execution of Stornoway Diamond Corporation's C$946 million[1] project financing transaction for the Renard Diamond Project, en-route to becoming Québec's fist diamond mine. The financing was unique in that it entailed the simultaneous negotiation and closing of multiple interrelated elements, namely C$347m of public and private equity offerings, a C$120m senior loan, US$81m in convertible debentures, US$35m in an equipment financing facility, US$250m for the world's first diamond streaming arrangement, and C$48m in cost overrun facilities. The financing was designed to cover all project costs, contingencies, escalation allowances, capitalized operating costs and working capital requirements, and was carefully constructed to provide balanced rates of return across the differing components of the capital structure. The Renard project financing represents a model for the circumstance where the funding required to develop a mining project represents a multiple of the market capitalization of the project developer. However, the execution of such a transaction also requires the close alignment of the interests and objectives on the individual financing parties involved and, to the greatest extent possible, the de-risking of the project: the financing was greatly aided by the efforts made prior to its launch by the Stornoway operating team to secure all necessary regulatory authorizations, complete critical access infrastructure, fully optimize all mining and construction studies, and develop a strong social license and working partnership with the Crees of Eyou Istchee. This in turn was made possible by the consistent support of Stornoway's principal stakeholders, including its largest shareholder Investissement Québec, and the timely launch of the Plan Nord. The successful completion of the financing in July 2014 and the quality of the project's preparatory work has allowed the Renard Project to advance efficiently into construction, proceeding within its forecast cost to complete of C$811m and its schedule to achieve commercial production by the second quarter of 2017.

(1): assumes a C$:US$ conversion rate of $1.10.

SESSION 11

Post-placement mechanical behaviour of mine backfill: A study of backfill-rock interactions

Tikou Belem, Nabassé Jean-Frédéric Koupouli, Khadija El Mahboub (UQAT) and Patrice Rivard (Université de Sherbrooke)

The Québec mining industry generates significant benefits but it can also cause potential environmental pollution, particularly due to the waste material accumulated on surface (acid mine drainage or contaminated neutral drainage). Using part of the concentrator tailings (up to 50%) underground, in the form of cemented paste backfill (CPB), can reduce this potential environmental impact, while contributing to secondary ground stability measures. When designing an underground backfilling system, certain criteria must be met in order to avoid any risk of failure of the CPB, which could lead to material damage or bodily harm. The greatest challenge lies in ensuring the stability of backfilled stopes exposed vertically or longitudinally, while reducing the cost of backfilling operations. Based on research studies already carried out in this field, we can formulate the right CPB recipe that will provide the mechanical strength required to ensure stability. However, for the concentrator tailings of any given mine, this formulation is exclusively derived from theoretical values of the confined and unconfined compressive strength required for the CPB, values based on limit-equilibrium stability analysis (Mitchell *et al.*, 1982).

CPB is a highly complex material that is in constant evolution, from its preparation at the backfill plant, during its transport and after its placement in open underground stopes. Repeated observations indicate that for the same CPB recipe poured in an underground stope and in laboratory casts, the *in situ* resistance of CPB is systematically three to six times greater than in lab casts. Despite some uncertainty, we can say that this difference in performance is due to the contribution of the following factors: underground curing temperature, gravitational consolidation of CPB, interactions at the backfill/rock interface, and stress fields in backfilled stopes, which depend on the geometry and fracturing of the enclosing rock mass. This presentation will review all of the above-mentioned mechanical aspects, focussing on the current state of knowledge and recent advances resulting from comprehensive laboratory testing performed at UQAT in recent years.

Reference

MITCHELL, R.J. – OLSEN, R.S. – SMITH, J.D., 1982 – Model studies on cemented tailings used in mine backfill. Canadian Geotechnical Journal, 1982, Volume 19, No. 1, pages 14-28.

SESSION 11

Studies of the interaction between backfill and host structures for more reliable barricade design

Li Li (École Polytechnique de Montréal)

The mining industry is important for the economic development of Québec. Today, the mining sector is increasingly safer for workers in Québec. However, accident frequency rates remain higher than in other industries.

Underground backfilling is common practice in the mining industry, as it provides a safer platform or workspace for workers. Backfilling of openings after ore-bearing rocks have been mined helps reduce dilution and mining losses and improve overall ground stability. Using mining waste as the base material for the production of backfill makes it possible to decrease the amount of mining waste accumulating on surface, thus reducing the environmental impact of mining activities. Consequently, underground backfilling is recognized as a practice promoting the sustainable development of the mining industry.

Application of this technique requires the construction of barricades in access drifts to maintain the backfill in place. Recent cases where barricades have ruptured suggest their design remains problematic. This represents an imminent danger for the health and safety of all mine workers where underground backfilling operations are performed.

Gaining a better understanding of the interaction between backfill and host structures (rock walls and barricades) is critical to provide the mining industry with a tool to design safer and more reliable barricades.

In this presentation, the present state of knowledge on barricade design will be briefly reviewed, followed by an update on our studies focussing on estimating pressures in backfilled stopes and access drifts, as this is a key component for barricade design.

SESSION 11

In situ stress measurements – 35 years of research at Polytechnique Montréal

Robert Corthésy and Maria Helena Leite (École Polytechnique de Montréal)

The safe and optimal design of underground excavations for mining applications requires a good knowledge of the in situ stress state distribution in the rock mass. Numerical modeling has become the main tool for designing underground excavations and estimating their safety factor. The main inputs in these models are the rock mass mechanical properties and the in situ stress state at their boundaries. Still today, the only means of knowing with an acceptable degree of confidence stress magnitudes and orientations requires their measurement, which allows an estimation of their distribution and scatter within a given rock mass volume.

This presentation gives an overview of the main developments made at the rock mechanics laboratory of Polytechnique Montréal during the last 35 years in the area of in situ stress measurements with equipment and field procedures and also with data interpretation models.

Concerning the equipment and field procedures, the research at Polytechnique Montréal has concentrated around the modified *Doorstopper* cell which is an evolved version of the cell initially developed in 1967 by Leeman. The modified cell is used in conjunction with a second generation programmable in the hole data logger which uses wireless communications and numerous other enhancements.

In parallel with advances in field procedures and equipment, important developments were made relative to data processing. Along the years, interpretation models allowing to consider rock anisotropy, non-linear behaviour, creep and heterogeneity were developed. Recently, an approach based of the inverse problem which allows the use of all the field data in order to increase the confidence level in the measurement results was proposed and is in the process of being validated.

The guideline for the research in stress measurements at Polytechnique Montréal has always been to provide solutions which are applicable in the field. This has allowed us to perform measurements in diverse geomechanical settings in various Québec mines. To name a few, we were the first to perform stress measurements in permafrost in America, measurements in rock masses showing nearly null RQD values and measurements at great depth where core disking could be observed.

SESSION 11

Optimization of intact rock property characterization in mining projects using statistical analysis

Catherine Boudreau, Martin Grenon and Geneviève Bruneau (UL)

The design of underground mine workings relies on the geotechnical characterization of the rock mass. Intact rock properties are evaluated in the laboratory according to the recommendations prescribed by the International Society of Rock Mechanics. During laboratory testing, they suggest a minimum number of specimens to test per rock type. However, the variability, heterogeneity and anisotropy of a rock mass can make it difficult to establish representative values for the requested parameters. Moreover, a geomechanical testing program should also take into consideration practical and financial limitations. Using the case study of a mine site in Québec, this presentation will examine a methodology that directly relates the statistical analysis results of laboratory data to the target knowledge levels for geotechnical data, and it does so through all stages of the mining project.

SESSION 11

Estimating fault-slip potential in seismically active mines

Hani Mitri and Atsushi Sainoki (McGill University)

Fault-slip related seismic events that occur in underground mines could inflict severe damage to underground openings. Thus a proper estimation of fault-slip potential in active mining areas is of paramount importance for mine safety and production without delays. Large seismic events often originate far from the stopes being extracted yet they cause severe damage. This presentation explains fault-slip related seismic events taking place in the footwall of Garson Mine, Sudbury, Canada. It is postulated that variations in shear stiffness within the shear zone contribute to the generation of high slip potential resulting in the occurrence of seismic events. The methodology can be used with back analysis of microseismic records to determine the mechanical properties of the weak shear zone, which leads to better estimation of future fault-slip potential.

SESSION 11

Ground control strategies for seismically active underground mines

Denis Thibodeau (Stantec)

The demand for ore combined with the depletion of surface deposits has led to ever-deeper mining operations, which induces high stress tensors. This presentation will review the phenomena and hazards caused by stress variations related to ore extraction. We will also discuss a strategic and tactical approach to mitigating the risks associated with stress variations.

SESSION 12

The formation of magmatic sulphide deposits: Have we really learnt nothing new in the past 25 years?

Nicholas T. Arndt (Université Joseph Fourier, Grenoble)

The formation of magmatic Ni-Cu sulfide deposits is directly linked to interaction between mafic-ultramafic magma and rocks of the continental crust. This interaction decreases the solubility of sulfide in the magma and/or adds sulfur to generate an immiscible sulfide liquid. Strongly chalcophile Ni, Cu and PGE become concentrated in the sulfide and if this phase accumulates in sufficient quantity and with sufficient tenor, an ore deposit is formed. Most models propose that sulfide droplets segregate and accumulate from magma that flows rapidly through conduits. These 'high-flux' models are at odds, however, with the following observations. Many ores appear to have been emplaced as magmatic breccias (Norilsk-Talnakh, Russia; Aguablanca, Spain) or crystal mushes (Jinchuan, China) that contain a high proportion of sulfide. Such mixtures are very dense and could not have migrated upwards through the crust from a deeper staging chamber. In the Uitkomst and Platreef deposits (South Africa), screens of sedimentary rock maintaining the same orientation as adjacent sedimentary strata separate layers of ultramafic cumulates, some containing abundant sulfide ore. This geometry suggests that ultramafic mush and ore sulfides oozed into the sedimentary sequence, replacing less resistant strata. These features can be explained if sulfide-rich masses of magma accumulated higher in the magmatic plumbing system then slumped downwards. Most mafic-ultramafic intrusions do not differentiate in place but grow through the injection of magmas of differing compositions and crystallinities. Highly mafic magmas, particularly those charged with ferromagnesian crystals and sulfide, have high densities and they are injected into the lower parts of growing intrusions while less-dense, more evolved and/or plagioclase-rich magmas are injected at higher levels. Many ore-bearing intrusions are hosted in conduits with sloping margins. As magma flows up along these margins, the denser sulfide/inclusion/crystal-rich mush accumulates near the lower border while a sulfide-crystal-poor silicate liquid ascends along the upper part. This process differentiates the magma, producing evolved decanted liquids that flow upwards and erupt, and a sulfide-rich slurry that periodically becomes unstable and slumps down the conduit. The magma interacts with the slumping sulfide in the lower part of the conduit, enriching the sulfide in chalcophile metals. This interpretation, if correct, requires re-evaluation of the geological criteria used to locate ore deposits in magmatic systems. High fluxes are associated with decanted magma flowing upwards through the system but ore formation results from intermittent downward flow of sulfide mushes. To understand these processes requires detailed 3D mapping of magma conduits.

SESSION 12

The mafic-ultramafic Yacouba layered complex (2.09 Ga) – Host of the next world-class base metals district in West Africa (Ivory Coast)?

Marc-Antoine Audet (Sama Nickel), Christian Picard (Université de Franche-Comté, Besançon-Université Joseph Fourier, Grenoble) and Gnamba Gouedji (Sama Nickel)

The newly discovered mafic-ultramafic Yacouba Layered Complex has been identified through exploration work performed by Sama Resources since 2009 in the Bounta-Yorodougou district in western Ivory Coast. The Yacouba Complex is composed of layered dunites, websterites, gabbros, gabbro-norites, diorites, anorthosites and magnetite-rich gabbro/anorthosite units. These rocks are intrusive through the gneissic and granulitic assemblage of the Man Archaean Rise (3.5–2.7 Ga). The complex can be traced discontinuously along a NE-SW corridor of at least 30 km long and by at least 10 km and appears open in all directions.

The Yacouba Complex is characterized by its ultramafic to mafic feeder system (peridotites, pyroxenites, chromitites and minor gabbros or gabbro-norites) which vertically crosscut the Archaean rock assemblage. The complex also display a sub-horizontal succession of noritic to anorthositic assemblages in the Yepleu and Guezonpleu areas near Bounta village, extending over a surface area of at least 25 km^2.

All layered successions, regardless of been sub-vertical or sub-horizontal, also contains massive chromite layers, identified at surface in more than six locations within the project area.

Ultramafic and mafic rocks of the complex appear to be the host of Ni-Cu sulphides (mainly pyrrhotite-pentlandite and chalcopyrite) and disseminated Pt and Pd minerals (Bismutho-tellurides, sulpharsenides...).

Gouedji *et al.*, 2014, gave a paleo-Proterozoic age to the Yacouba Complex based on U-Pb ages on zircons and rutile (2.09 Ga), an age that is supported by recent work on recrystallized monazite collected in interlayered residual charnockites in the Bounta area which returned ages from 2.8 to 2.1 Ga, with the later age related to the intrusion of the Yacouba Complex's sequence (Picard, in prep). Isotopic determinations on sulphur suggest a mantellic origin for the mineralized pyroxenite. Studies on metamorphic minerals (mainly sapphirine) observed at the Samapleu Extension 1 deposit's contact zone with the gneiss, suggest that the complex intruded deep into the lower Archaean crust whereby granulitic to amphibolitic conditions (P=7.5Kbar and T=850°C). Hence, it is proposed that partial melting of Archaean continental crust members, including sulphide rich jotunites, during the intrusion process can be responsible for the essential sulphide liquid immiscibility processes that would have produce the discovered Ni-Cu-PGE orebodies.

Comparisons with well-known world class Ni-Cu orebodies, including Voisey's bay and Jinchuan, show significant similarities with the Samapleu Ni-Cu-PGE mineralization. It is the authors believes that the Bounta-Yorodougou area could become the next World Class Base Metals District located in West Africa.

Reference

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SESSION 12

The Nkomati Ni-Cu-Cr-PGE deposit of the Uitkomst Complex, South Africa: downward collapse of magmatic silicate-sulfide-chromite slurries into a devolatising dolomitic footwall

Wolfgang D. Maier (Cardiff University, UK), Steve Prevec (Rhodes University, South Africa), Sarah-Jane Barnes (UQAC) and Tafadzwa Gomwe (Val-d'Or)

The Uitkomst Complex of South Africa is a mafic-ultramafic layered intrusion of tubular shape, i.e., with a width and height of approximately 1 km, and a length of > 12 km. It hosts one of South Africa's largest Ni-Cu deposits, Nkomati. The magma was emplaced into the basal portion of the Transvaal Supergroup, and thus the host rocks to the intrusion are dolomite, shale, and quartzite. Massive sulfides occur in several lenses in the immediate quartzitic footwall, and economically important amounts of disseminated sulfides occur in gabbros and peridotites of the lower portion of the intrusion. Based largely on its shape and compositional data, the intrusion has previously been interpreted as a magma conduit. Our new trace element data and Nd isotope ratios show strong similarities with the Lower and Critical Zone of the Bushveld Complex, consistent with a common magma lineage for the intrusions. Based largely on the compositional similarities with the Bushveld Complex, it is proposed that the Uitkomst parent magma was derived from the SCLM. In addition, the Uitkomst magma was contaminated *in situ* with dolomitic and, possibly, pelitic host rocks, as suggested by strongly negative $\delta^{34}S$ and locally elevated $\delta^{18}O$ values in the xenolith-rich lower portion of the intrusion. Contamination also added Pd (and Cu) to the magma, resulting in lower Pt/Pd and higher Cu/Ni of sulfides than in the Bushveld reefs. Ore formation was critically aided by substantial devolatisation and thus removal of dolomitic floor rocks, causing hydrodynamic concentration of sulfide and chromite rich crystal slurries.

SESSION 12

The Mesoarchean Venus Greenstone Belt in Nunavik: A komatiite succession fertile in Ni-Cu-PGE in the Northeastern Superior Province

François Huot (UL), Michel Houlé (GSC-Q), Vital Pearson and Paul Archer (Osisko Gold Royalties)

The Venus Greenstone Belt (VGB), situated in the northern part of the La Grande Subprovince (Superior Province), consists of a sequence of volcano-sedimentary rocks metamorphosed to lower amphibolite facies. Its strike length has been traced for more than 15 km, and its maximum apparent width is about 5 km. The belt, which is thought to belong to the Gayot Complex, comprises two main lithological assemblages. The lower assemblage, with an age of approximately 2880 Ma and structurally juxtaposed against the Favard Tonalite Suite, is composed of intermediate to felsic volcanic and sedimentary rocks of calc-alkaline affinity injected by differentiated komatiitic sills and dykes (Lower Komatiite Unit: LKU). The upper assemblage consists of a thick sequence of tholeiitic basalts interdigitated with thick komatiitic basalt flows with spinifex texture (Upper Komatiite Unit: UKU). The boundary between the two lithological assemblages is marked by sulphide- and quartz-rich exhalative layers.

The LKU is composed of peridotites (<43% MgO), which locally display cumulate textures consisting of serpentinized olivine and harrisite, as well as pyroxenites and gabbros, all considered to be intrusions. This interpretation is based on the absence of volcanic textures, the presence of chilled margins, and the sometimes discordant nature of the contacts with country rocks that underwent contact metasomatism. On the other hand, the presence of magnesian basalts, locally pillowed komatiitic basalts and volcanic breccias collectively support an extrusive origin for the very fine-grained ultramafic rocks of the UKU. The VGB is an excellent example of komatiitic magmas that were emplaced as both intrusions and lavas in a felsic-mafic bimodal volcano-sedimentary sequence, similar to other Archean greenstone belts (e.g., Abitibi, Agnew-Wiluna).

At least thirteen Ni-Cu-PGE prospects are associated with the Nancy dyke and the subconcordant sills of the LKU. The mineralization, observed in ultramafic rocks and adjacent lithologies, is present as disseminated and semi-massive sulphides, and more rarely, as discontinuous massive lenses. The elevated metal contents (>20% Ni and 20 g/t PGE, recalculated to 100% sulphides), combined with MgO-rich komatiitic intrusions displaying evidence of interaction and contamination with sulphur-bearing country rocks, provide evidence of the VGB's potential for Ni-Cu-PGE mineralization.

SESSION 12

Diversity of Ni-Cu-PGE mineralization of the Ring of Fire Intrusive Suite, Ontario: Evolution of a komatiitic feeder system

Michel Houlé (GSC-Q), C. Michael Leshe, Naghmeh Farhangi , Heather Carson (MERC-LU), Riku Metsaranta (OGS), Vicki McNicoll (GSC-O) and Anne-Aurélie Sappin (GSC-Q/UL)

The ca. 2734 Ma mafic-ultramafic Ring of Fire Intrusive suite (RoFIS) in the McFaulds Lake greenstone belt in northern Ontario is well-known for its exceptional chromite resources, which exceed 285.8 Mt @ 31.5% Cr_2O_3, however, it also contains other commodities such as Ni-Cu-PGE and Fe-Ti-V mineralization. The RoFIS have been subdivided into two subsuites: an ultramafic-dominated subsuite (including the Black Thor intrusive complexes - BTIC and the Double Eagle - DEIC) containing Cr-(PGE) and Ni-Cu-(PGE) mineralization and a mafic-dominated subsuite (including the Butler and Thunderbird intrusions) containing Fe-Ti-V mineralization.

The BTIC and the DEIC and are relatively large elongate intrusions exposed over a strike length of about 15 km and a maximum width of about 3 km. The intrusions have a komatiitic affinitiy with thick lower ultramafic parts and thinner upper mafic parts and host several types of Ni-Cu-PGE mineralization mainly within the ultramafic component. Ni-Cu-PGE mineralization types include: (1) sulfide-rich conduit-style mineralization within the feeder systems (e.g., Eagle's Nest, AT-12); (2) sulfide-rich contact-style mineralization along the basal contact of the intrusion (e.g., BTIC Basal Contact, AT-12 Extension); (3) sulfide-poor disseminated reef-style mineralization in the chromitite horizons (e.g., Black Label, Black Thor); (4) sulfide-rich disseminated PGE-poor reef-style mineralization in fractionated gabbroic rocks in the mafic part (e.g., BTIC); (5) sulfide-rich breccia mineralization associated with intrusion of the BTIC by a coeval but younger websterite intrusion (e.g., BTIC SW/Central/NE Breccia Zones); and (6) tectonically/hydrothermally mobilized sulfide-rich mineralization within shear zones (e.g., transition zone between ultramafic and mafic parts of BTIC).

The BTIC and the DEIC represent flow-through ultramafic-dominated feeder sills where the lower ultramafic parts have been produced by repeated influxes of komatiitic magmas accompanied by crystallization of Ol±Opx±Chr-rich cumulates and fractionation of the residual liquid, resulting in a layered stratigraphy comprising interlayered (from base to top) dunites/harzburgites, harzburgites/websterites/chromitites, and websterites/gabbros. After initial emplacement but before complete crystallization, a cogenetic websterite intrusion reactivated the feeder conduit and transected the basal part of the BTIC. The BTIC was subsequently cross-cut by late biotite-bearing gabbroic and tonalitic dikes. The wide diversity of Ni-Cu-PGE sulfide mineralization styles within these complexes supports the dynamic nature and the generation of sulfide mineralization over the complete lifespan of this magmatic system with early-magmatic, sulfide-rich mineralization within the conduit and along the basal contact; intermediate-magmatic mineralization within the chromitite horizons and upper gabbro, late-magmatic sulfide-rich mineralization associated with magmatic breccias and finally post-magmatic tectonically/hydrothermally

SESSION 13

Agnico Eagle in the Canadian Arctic

Guy Gosselin (Agnico Eagle Mines)

Agnico Eagle Mines is an international gold company based in Canada with mining operations in Canada, Mexico and Finland. It also conducts exploration in Canada, Europe, Latin America and the United States. Since it was founded in 1957 in the mining town of Cobalt, Ontario, the company has experienced significant growth. Today, it employs 6,600 people and produced 1.4 million ounces of gold in 2014.

The company's strategy consists in focussing on high-quality assets in low-risk regions. Over the past decade, through its development program, Agnico Eagle has grown from a single-mine producer to an international gold producer operating several mines. Today, Agnico Eagle operates eight mines in Canada, Finland and Mexico, and holds an extensive portfolio of exploration projects.

Since its inauguration in 1988, the LaRonde mine in Abitibi, Québec, Canada, has been a driving force for the company, producing about 4.9 million ounces of gold and significant amounts of by-products including silver, copper, zinc, and lead. The success of the LaRonde mine has enabled the company to seek out new opportunities, to develop the Goldex and Lapa mines and acquire a 50% interest in the Canadian Malartic mine.

In parallel with its expansion in the Abitibi mining region, Agnico Eagle began to develop internationally with the start-up of production at the Kittila mine in northern Finland and the Pinos Altos mine in Mexico in 2009. The Creston Mascota mine (in operation since March 2011) and the La India mine (in commercial production since 2014) were subsequently added.

In its quest for a fourth operational platform, Agnico Eagle took a decisive step in Nunavut Territory in the Canadian Arctic by acquiring the Meadowbank project in 2007 followed by the Meliadine project in 2010. The acquisition in 2013 of new mining rights in unknown territory about 50 kilometres northwest of the Meadowbank mine led to the discovery of the Amaruq deposits. Less than two years after staking, the latter now contain an estimated 2.0 million ounces of gold in inferred resources.

These three properties – Meadowbank, Meliadine and Amaruq – represent Agnico Eagle's commitment in the sparsely populated Kivalliq area in Nunavut in the Canadian Arctic, where it is not simply producing gold but also developing unique skills in exploration, permitting, development, construction and mining, as well as in training and community relations.

SESSION 13

Renard project challenges

Patrick Godin (Stornoway Diamonds)

Developing a mining project today entails numerous challenges, whether in terms of infrastructure, engineering or construction. Technical, social, environmental or financial issues arise at every phase the project must go through. This is even more true when the project is located in a remote area, and the task simply becomes colossal when the company developing the project is not already a mining producer. Financing then becomes a critical issue, particularly given the current situation in the mining industry.

This presentation will focus on the numerous challenges faced by Stornoway Diamonds during the development of its Renard diamond project. We will also discuss efforts currently underway and upcoming milestones that will lead us to become the first diamond producer in Québec and a major diamond producer on the world scene.

SESSION 13

James Bay exploration: Some ingredients for success

Mathieu Savard (Osisko Gold Royalties)

Exploration projects in northern environments often incur additional cost and logistic challenges compared to established mining camps, thereby increasing the inherent exploration risk. On the other hand, the geological understanding of these regions is incomplete and the mineral potential enormous.

For an exploration company working in the James Bay region of Northern Québec, the discovery of a gold deposit such as Éléonore or Coulon constitute a success from an exploration standpoint. In addition to the geological characteristics of the deposits, other elements, such as favourable conditions, timely financings, the objective, perseverance, innovation and partnerships all played a role, sometimes in unexpected ways, in the discovery of Éléonore and Coulon. This presentation will provide a detailed history of the exploration success at the Coulon deposit. Particular attention will be paid to the various contexts—economic, corporative, strategic and, of course, geoscientific—that were in place before, during and after the discovery of the base metal lenses constituting this deposit.

SESSION 13

Éléonore - Past and present

Martin Duclos (Goldcorp, Éléonore)

For Goldcorp, Québec ranks among the best mining jurisdictions in the world, with its stable political and fiscal regime, its rich pool of professional talent, and a complete range of technical and mining services.

The Éléonore mine is the product of a solid business partnership with the Cree Nation of Wemindji and the James Bay community. The Opinagow Agreement sets an important precedent in terms of entrenching respect for the territory, culture, traditions and environmental concerns of the Cree Nation and ensuring the latter derives maximum benefit from mining operations at Éléonore. Goldcorp has now signed collaborative agreements with the First Nations of Canada in all the territories where it has mining operations.

From 2011 to 2014, Goldcorp invested about $2 billion to build the Éléonore mine, making this project a cornerstone of its developing gold sector. Éléonore is an integral part of the company's growth strategy. Based on current reserve estimations, the exceptional potential of this ore deposit provides a mine life of at least 15 years. It is expected to produce between 500,000 and 600,000 ounces of gold per year at full production capacity, and to employ between 900 and 1,000 workers.

Éléonore is a modern and highly secure mine site at the leading edge of technology, where the highest standards are implemented to preserve the health and safety of workers and ensure strict compliance with environmental regulations. Goldcorp not only intends to maintain its status as an environmental leader in Québec's mining industry, but also to protect its most precious resource: its people.

SESSION 14

Magmatic Ni-Cu-PGE mineralization in Canada: A spectrum of ages and magmatic, volcanic, and tectonic settings

C. Michael Lesher (MERC-LU) and Michel Houlé (GSC-Q)

Canadian Ni-Cu-PGE mineralization is associated with a wide range of ages (NeoArchean to Cretaceous), parental magma compositions (high Mg-komatiite to Qtz dioritic), volcanic-subvolcanic-plutonic settings, and host unit geometries (lava channels, channelized sheet flows, sills, dikes, and plutons), including volcanic (e.g., Alexo, Langmuir) and subvolcanic (e.g., Dumont, Sothman) high-Mg komatiite-associated deposits in the Archean; subvolcanic low-Mg komatiite (e.g., Thompson, McFauld's Lake), volcanic (e.g., Raglan) and subvolcanic (e.g., Expo Ungava) komatiitic basalt, plutonic picritic (e.g., Voisey's Bay), and impact-concentrated quartz diorite (e.g., Sudbury) associated deposits in the Proterozoic; flood basalt-related subvolcanic intrusions in the Triassic (e.g., Wellgreen), and plutonic zoned/composite complexes in the Jurassic and Cretaceous (e.g., Turnagain, Giant Mascot). The deposits are localized in a variety of dynamic systems: lava channels (e.g., Raglan), channelized sheet flows (e.g., Alexo), channelized sills (e.g., Sothman, Thompson), and feeder dikes (e.g., Eagle's Nest; Mequillon; Voisey's Bay). Tectonic settings include continental rifts, continental margins, and convergent margins. The degree of preservation ranges from essentially unmetamorphosed and undeformed (e.g., Voisey's Bay, Sudbury N Range) through low-grade metamorphosed with very localized deformation (e.g., Alexo, Raglan) and medium-grade metamorphosed with locally pervasive deformation (e.g., Sudbury S Range, Redstone) to high-grade metamorphosed with rare undeformed domains (e.g., Thompson).

Archean deposits have high Ni/Cu/PGE ratios and are often high grade, but typically small tonnages. In comparison, Proterozoic deposits have intermediate Ni/Cu/PPGE ratios and grades, but very large tonnages. Phanerozoic deposits are quite variable, but commonly have intermediate Ni/Cu/PPGE ratios and low grades, but may be relatively large tonnage. These differences are attributable to variations in the mode of emplacement and geological setting. Archean high-Mg komatiitic magmas had much lower viscosities and were emplaced under more dynamic conditions that allowed crustal sulfide xenomelts to equilibrate with larger amounts of magmas, but had access to smaller amounts of crustal S, resulting in higher tenors but lower tonnages. Proterozoic komatiitic basaltic and picritic magmas typically had access to larger amounts of crustal S, but had higher viscosities and were emplaced under less dynamic conditions that allowed crustal sulfide xenomelts to equilibrate with smaller amounts of magma, resulting in higher tonnages but lower ore tenors. Phanerozoic deposits were less dynamic and/or had access to smaller amounts of crustal S, often resulting in lower abundances of sulfide and lower ore tenors. Most sulfides have variable and non-magmatic S isotope compositions and/or S/Se ratios, and appear to have been derived by incorporation of crustal sulfides via melting rather than assimilation. The mode of emplacement of the sulfide xenomelts is still being debated in some localities, but in most cases they appear to have been generated at the same stratigraphic level and less commonly transported upwards (less likely) or downwards (more likely).

The bulk of Canadian Ni-Cu-PGE production is from deposits in Proterozoic extensional settings within highly dynamic systems where magmas were able to interact with S-bearing country rocks, regardless of magma composition or tectonic/volcanic setting.

SESSION 14

Using geochemistry as a vector to Ni-Cu-PGE mineralization in the Labrador Trough, Nuvavik, Québec: Case study from the Idefix property

Christine Vaillancourt and Ian Bliss (Northern Shield Resources)

The Montagnais Sills of the Labrador Trough in the Nunavik region of the province of Quebec are highly prospective for Ni-Cu-PGE mineralization. The areal extent of the mafic-ultramafic magmatic systems (500 x 50 km) poses exploration challenges and the region has seen little systematic exploration despite the numerous Ni-Cu-PGE occurrences.

Northern Shield's developed geochemical exploration methodology successfully separates the Montagnais Sills into distinct phases, and only one of them appears to be systematically fertile in Ni-Cu-PGE and also exhibits other criteria known to be present in large deposits. This discrimination allowed the Company to focus exploration efforts on smaller areas including its Idefix Property located in the northern portion of the Labrador Trough.

Based on geochemical analysis of over 3,000 rock samples collected from the Montagnais Sills, the Company has identified at least two importantly distinct phases of gabbroic intrusions. The better Ni-Cu PGE results are consistently found in the "Idefix-type" gabbro, which exhibits cumulate textures and strong fractionation trends within the sill. The vast majority of the Montagnais Sills, as currently mapped, consists of "Regional Gabbro", which is not fractionated and exhibits a sub-ophitic texture. These sills are likely high-level intrusions and portions may actually be extrusive. This gabbro is not significantly mineralized in Ni-Cu-PGE. Additionally, Cu/PGE ratios consistently show the high-level gabbros and mafic flows to be depleted in PGE relative to mantle values while the "Idefix-type" is dominantly enriched.

Reef-type PGE mineralization was the focus at Idefix after the discovery of extensive mineralization with grades up to 16 g/t Pt+Pd. Drilling and surface sampling defined true reef-type mineralization averaging 0.2-0.4 g/t PGE over 16-34 meters widths that can be traced for 7 km. However, the presence of large Ni-Cu-PGE bearing sulphide globules observed in every drill hole along the Idefix escarpment points to the possible existence of nearby massive magmatic sulphides following a Noril'sk-type model. The globules are up to 3 cm in diameter and their morphology is remarkably similar to those found adjacent to the massive sulphides at Noril'sk. Preliminary analysis of these globules show grades on the order of 2% Ni, 4% Cu and 20 g/t PGE.

This exploration methodology is an example of how simple geochemical ratios can be used: 1) to discriminate between various gabbroic phases; 2) to identify gabbroic bodies fertile in PGEs (and Ni-Cu); 3) as a vector for reef-type PGE mineralization and; 4) to discriminate between the different types of Ni-Cu-PGE mineralization in magmatic mafic rocks.

SESSION 14

Trace element contents of sulfides and oxide minerals from magmatic ore deposits: Implications for petrogenesis and exploration

Sarah-Jane Barnes (CRCMM-UQAC)

Over the past 15 years the development of laser ablation ICP-MS analysis has made it possible to determine the concentrations of trace elements in minerals down to the ppb level. This information has been used by the academic community to address petrogenetic problems. However, trace element contents can also be used in exploration for and exploitation of ore deposits. At LabMaTer, Université du Québec à Chicoutimi we specialize in determining trace element contents of magmatic sulfide and oxide minerals. Our approach consists of studying well characterized type examples of each ore type by: considering the texture of the minerals; determining the whole rock composition, and determining the trace element content of the minerals. Combining all of the data makes it possible to carry out a mass balance and deduce which mineral is controlling which element and try to deduce which process was important in the controlling each element.

The results of our studies could be applied to less well known samples, to heavy mineral separates from till or stream samples and to the evaluation of extraction efficiencies. Trace element contents of sulfide minerals are particularly important in exploitation of Ni and PGE deposits because the PGE may be present either in the sulfide minerals or as platinum-group minerals (PGM). Efficient extraction requires an understanding of which minerals contain each of the PGE. We have found that in most deposits 20-40 % of the Pd is present in pentlandite with the balance in PGM. Almost all of the Pt is present as PGM, although some can be present in pyrite. Rhodium is mainly present in pyrrhotite, pentlandite and pyrite. Osmium, Ir and Ru are present in pentlandite and pyrrhotite. Chalcopyrite contains very little of the PGE budget. Sulfide minerals can be preserved in till samples. If pyrite is present in a heavy mineral separate and the pyrite contains Rh and or Pt this would be a good indicator of the presence of a nearby Ni or PGE deposit. Furthermore pyrite from magmatic deposits can be distinguished from other sources using plots of Co/Sb vs Se/As. If pentlandite is present plots of Rh vs Pd can be used to distinguish pentlandite from PGE reef deposits and Ni-Cu sulfide deposits.

Trace element contents of oxides are also useful. For Fe-oxides it is possible to distinguish magnetites from layered intrusions, anorthosites, granites, magmatic sulfides deposits and hydrothermal deposits. In each case the exploration strategy could be adapted to the target for instance layered intrusion magnetites are a source of V whereas anorthosite oxides are a source of Ti and P. Trace element contents of chromites from the mantle, boninites, komatiites, MORB, layered intrusions and OIB are different; with incompatible element concentrations increasing from mantle chromites to OIB chromites. Interestingly chromites from volcanic rocks contain the platinum-group elements (PGE) Ru and Rh, whereas the layered intrusion chromites do not. This could be used in exploration.

SESSION 14

Nickel on the move: Generation of high-Ni sulphide and alloy phases during serpentinization at the Dumont Sill, Québec

Michelle Sciortino (Royal Nickel Corporation), Jim Mungall (University of Toronto) and Johnna Muinonen (Royal Nickel Corporation)

The Dumont deposit, located in the Abitibi region 25 km west of Amos in Quebec, is a large (1179 Mt reserve), low-grade (0.27 per cent nickel) nickel sulfide project hosted within a zoned komatiitic sill which is differentiated into a lower ultramafic zone, composed of peridotite and dunite, overlain by a mafic zone, with clinopyroxenite, gabbro, and quartz gabbro subzones. Royal Nickel Corporation (RNC) acquired the project in 2007 and has since taken the deposit through to feasibility. The disseminated nickel sulfide and alloy mineralisation is hosted within the pervasively serpentinized dunite subzone of the Dumont Sill. Although the dunite contains several layers enriched in primary Ni sulfide minerals, which add considerable value to the deposit, 47% of the resource consists of awaruite- and heazlewoodite-bearing serpentinized dunites which formerly contained Ni only in silicate minerals. In layers containing primary accumulations of magmatic sulfide, serpentinization has resulted in the remobilization of nickel from olivine to enrich cumulus sulfides. In layers lacking primary sulfide accumulations, serpentinization was accompanied by the formation of awaruite by reduction of Ni originally hosted by olivine. Pentlandite ($(Ni, Fe)_9S_8$), heazlewoodite (Ni_3S_2) and awaruite ($Ni_{2.5}Fe$) are the dominant nickel-bearing metallic phases and can be recovered by conventional methods (flotation, magnetic separation). Non-recoverable nickel is also present within serpentine and olivine of the silicate matrix.

A detailed mineralogical program including 1420 QEMSCAN® samples and 4400 electron microprobe points was undertaken to increase the understanding of the nickel deportment in the various recoverable and non-recoverable phases in a spatial context across the deposit. Assemblages that are completely serpentinized contain lower nickel in silicates, higher nickel tenor sulfides, and more modal awaruite which results in higher recoveries compared to those that are weakly and partially serpentinized, which are characterized by higher nickel in silicates and lower Ni tenor sulfides. Understanding the spatial variability of Ni deportment in recoverable and non-recoverable phases through mineralogy is the key to understanding metallurgical performance, thus unlocking the value of the Dumont deposit. Exploration for similar large tonnage low-grade ultramafic nickel deposits should be focused on dunite adcumulates formed from unfractionated komatiites, which have undergone complete serpentinization under conditions of diffusion-controlled low water-rock ratio.

SESSION 14

Ni-Cu ± PGE showings in the Portneuf-Mauricie Domain of the Grenville Province (Québec): An example of atypical magmatic mineralization in a Proterozoic island arc

Anne-Aurélie Sappin, Marc Constantin (UL) and Thomas Clark (URSTM-UQAT)

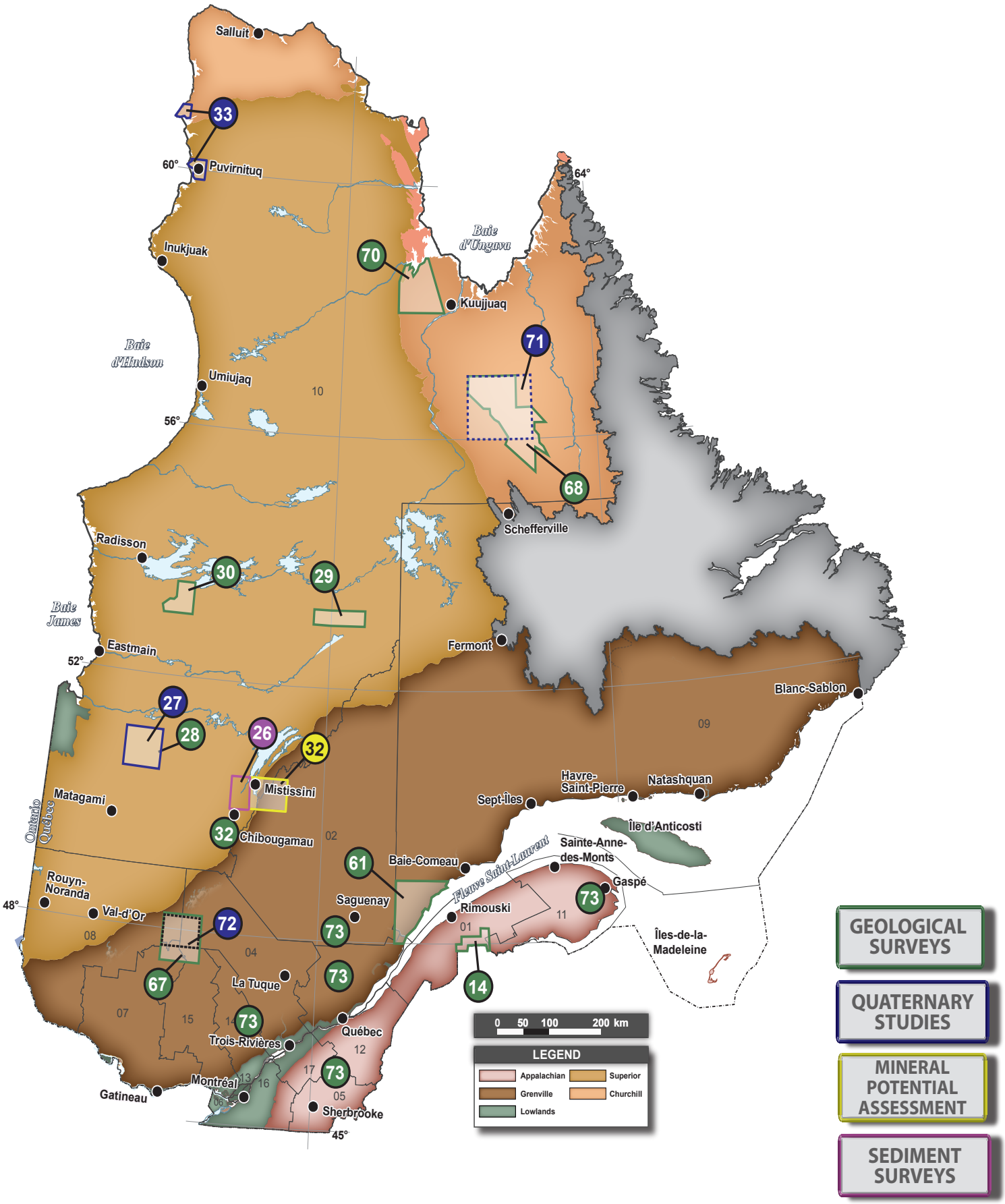
The Portneuf-Mauricie Domain, situated in the south-central part of the Grenville Province, is composed mainly of metasedimentary and metavolcanic rocks belonging to the Montauban Group (1.45 Ga), which are cut by plutons of the La Bostonnais Complex (1.40–1.37 Ga). This assemblage formed in a magmatic arc setting. The sequence was injected by mafic and ultramafic intrusions containing Ni-Cu ± platinum group element (PGE) prospects as well as a former Ni-Cu mine. The mineralized intrusions were emplaced in a mature island arc setting between 1.40 and 1.39 Ga, along the volcanic front of the arc. However, the Lac à la Vase intrusion was an exception as it formed in a back-arc basin. Geochronological work and a study of the geodynamic setting associated with their formation indicate these intrusions belong to the La Bostonnais Complex.

The intrusions hosting the Ni-Cu±PGE prospects formed as a result of the injection of primitive, hydrous and sulphur-undersaturated mantle-derived melts into a lower magma reservoir. The trace element signature indicates these magmas were mainly produced by partial melting of a metasomatized mantel source composed of spinel lherzolite. During their ascent, the magmas underwent fractional crystallization and sulphide saturation as they interacted with country rocks locally containing sulphur. Two main episodes of sulphide saturation and segregation took place. The first occurred in deep conduits. This early loss of a small amount of sulphides (<0.1 wt%) caused the magmas to become depleted in base metals and, to a greater extent, precious metals. The second episode of sulphide segregation probably took place in the lower magma reservoir. The formation of sulphidized melt in this chamber was followed by interactions between magma and sulphides that led to the enrichment in Ni, Cu and PGE sulphides. Finally, the injection of primitive magma into the lower chamber partially remobilized and transported the sulphide melt into shallow magmatic chambers, forming the mineralized intrusions of the Portneuf-Mauricie Domain.

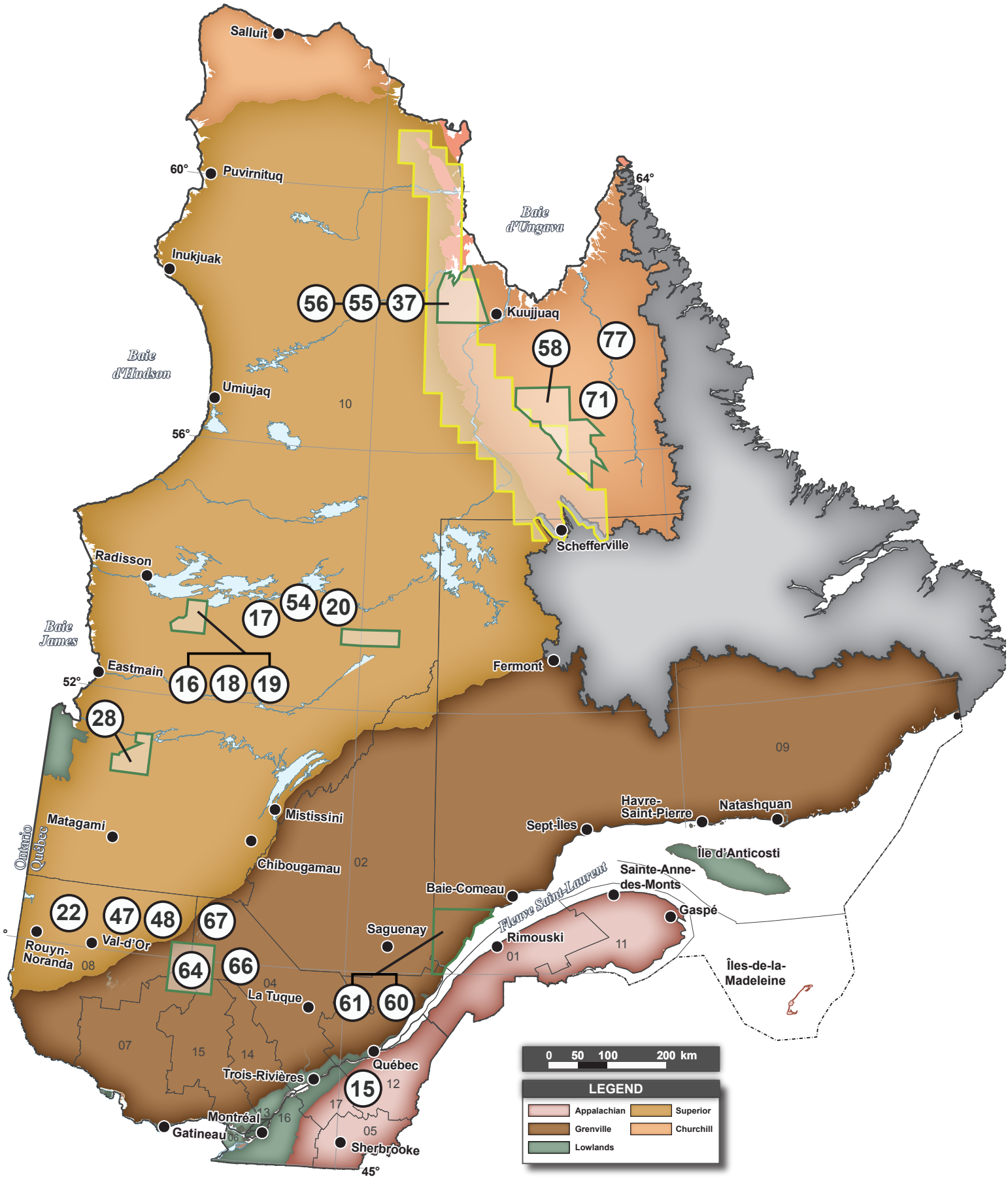
The presence of other Ni-Cu±PGE prospects (such as the Renzy deposit) that were also emplaced in magmatic arc settings demonstrates the exploration potential of these uncommon environments for Ni-Cu±PGE in the Grenville Province.

ABSTRACTS OF POSTERS

LOCATION OF PROJECTS AT GÉOLOGIE QUÉBEC



LOCATION OF UNIVERSITY PROJECTS



G13

The Québec stratigraphic lexicon – An essential tool for the geoscience community

Ghyslain Roy and Mona Baker (MERN)

The stratigraphic lexicon project is the first step in the future development of electronic geological reporting at Géologie Québec. The objective is to provide users with a synthesis of all stratigraphic units in use in Québec. Easily accessible via the Internet in the form of factsheets, the lexicon will be continuously updated with the addition of new units following geological surveys and the compilation of historical data. One of the major advantages of this lexicon will be its direct link with the interactive map in Québec's geomining information system (SIGÉOM). SIGÉOM users will therefore be able to locate a stratigraphic unit easily within the province and consult all available information.

G14

Geological compilation of the Rivière Patapédia region, Bas-Saint-Laurent

Robert Thériault, Claude Dion and Charles St-Hilaire (MERN)

Geological mapping covering the equivalent of five NTS map sheets at a scale of 1:20,000 (21N16-NW and NE, 22B04-SW, SE and NE, and 22C01-SE) was carried out in June 2015 in the Rivière Patapédia region, roughly 60 km southeast of Rimouski in the Bas-Saint-Laurent administrative region. Better road access has opened up this territory, where there was previously very little geological data.

The mapped region is part of the Connecticut Valley–Gaspé Synclinorium and consists primarily of Siluro-Devonian sedimentary rocks deposited in an intracratonic basin that formed following the Taconic orogeny. The mapped sedimentary units belong to the Cabano, Chaleurs and Fortin groups, the Temiscouata Formation, the Upper Gaspé Limestones and the Gaspé Sandstones. The sequences are characterized by a series of open folds oriented NE-SW and several normal or strike-slip faults of the same orientation.

The Cabano Group occurs in the northwestern part of the region. It consists of dark grey mudstones interbedded with grey lithic wackes. The Chaleurs Group overlies the Cabano Group along an erosional unconformity. In the study area, it is represented by the Awantjish, Val-Brillant and Saint-Léon formations. The Awantjish Formation is composed of red and green mudstones, sometimes very dark grey in the summital part of the formation. It is overlain by the Val-Brillant Formation, which is composed of thick beds of whitish to yellowish-grey quartz sandstone, sometimes dark grey in the basal part of the formation, with local occurrences of conglomerate beds belonging to the Lac Castor Member. The Saint-Léon Formation consists of a sequence of siltstones and laminated fine-grained sandstones locally associated with layers of calc-siltstone. The Fortin Group is composed of alternating siltstone and fine-grained sandstone beds, whereas the Temiscouata Formation, its lateral equivalent, is primarily composed of siltstones and clayshales. Layers of calc-siltstone of the Forillon Formation (Upper Gaspé Limestones) crop out sporadically. Finally, the York River Formation (Gaspé Sandstones) consists of green sandstone beds in the eastern part of the region, and dark grey siltstones in the west.

Although no occurrences of mineralization were observed during the mapping work, there is nonetheless some potential for silica (quartz sandstone of the Val-Brillant Formation) and architectural stone (conglomerate of the Lac Castor Member).

G15

Geology of the Québec Appalachians: Southwest map sheet – Montérégie, Cantons-de-l'Est, Centre-du-Québec and Chaudière-Appalaches regions

Alain Tremblay, Stéphane de Souza, Morgann Perrot (UQAM) and Robert Thériault (MERN)

In the Canadian Appalachians, the Humber and Dunnage zones, amalgamated during the Taconic orogeny, represent the vestiges of Laurentia and its adjacent oceanic terrains, which are covered in Québec by the Siluro-Devonian sedimentary sequence of the Gaspé Belt. Over the past twenty years, the detailed structural analysis and determination of U-Pb and $^{40}Ar/^{39}Ar$ ages were crucial factors to better understand the tectonic evolution of the Québec Appalachians. These data constrained the structural and metamorphic episodes to the Ordovician (D1), Late Silurian to Devonian (D2) and Middle Devonian (D3). The Ordovician ages are associated with NW-directed thrusting in the Humber Zone, the result of ophiolite obduction and the subsequent collision with Laurentia. The Siluro-Devonian ages are related to a series of folds and SE-verging faults, and provide constraints that are compatible with the exhumation of Laurentia and the formation of the Gaspé Belt. The metamorphism and structures of the Devonian Acadian orogeny exhibit varying intensities, but are often associated with superimposed folds.

Since 2010, UQAM has collaborated with the MERN to carry out a compilation program at 1:50,000 scale of the Québec Appalachians. The geological map, produced at a scale of 1:300,000 and covering an area of 36,000 km^2, synthesizes the compilation work for southern Québec. The Dunnage Zone crops out in the hanging wall of the Baie Verte–Brompton Line, which has been reinterpreted as a normal fault at its contact with the Humber Zone. The Dunnage Zone consists of ophiolites, the Saint-Daniel Mélange, the Magog Group and the Ascot Complex. The available U-Pb and $^{40}Ar/^{39}Ar$ isotopic ages suggest that ophiolite obduction onto Laurentia took place over a period of 15 Ma, and the Humber nappes are contemporaneous with the "early" exhumation of the Taconic accretionary prism. The Saint-Daniel Mélange and the Magog Group form a basin that unconformably overlies a "basement" of continental, ophiolitic and volcanic rocks. The "exotic" lithologies in the Saint-Daniel Mélange are tectonic windows that expose either its base or its basement, or they represent stratiform volcanic sequences and/or lateral facies variations. The Magog Group is a 300-km sedimentary basin overlying the Saint-Daniel Mélange to the NW and the Ascot Complex to the SE. The Gaspé Belt unconformably overlies the Dunnage Zone or is in tectonic contact with it along the La Guadeloupe Fault.

G16

Tectonometamorphic evolution of the Opinaca and La Grande subprovinces, Superior Province, Québec: Advances in thermobarometry and geochronology

Antoine Rhéaume Ouellet, Carl Guilmette (UL), Jean Goutier (MERN), François Huot (UL) and Matthijs Smit (UBC)

The La Grande Subprovince is an Archean volcanoplutonic assemblage in mostly tectonic contact with the Opinaca Subprovince to the south, a Neoarchean metasedimentary subprovince at higher metamorphic grade. Numerous gold occurrences are associated with the contact zone between the two subprovinces. The very existence of a metamorphic gradient and its genetic relationship with these gold occurrences are based on the hypothesis that metamorphism in the two subprovinces took place contemporaneously. But the ages of protoliths in the two subprovinces suggest the La Grande Subprovince represents the basement of the Opinaca basin; thus, more intense metamorphism in a stratigraphically younger unit is hardly consistent with current tectonic models proposed for the region.

Modern advances in geochronology and thermobarometry may shed new light on the geodynamic setting in which the two subprovinces were juxtaposed and on the nature of this contact zone. Two study areas straddling the contact were selected: the Poste Le Moyne area (NTS 33G06) and the Lac Dalmas and Lac Joubert area (NTS 33H08 and 33H01). Based on a petrographic study in the Poste Le Moyne area, a prograde syntectonic event at the amphibolite facies is recognized in the La Grande Subprovince and to the south, a sharp transition to anatectic metasedimentary rocks in the Opinaca, which underwent two episodes of partial melting, at least one of which reached granulite-grade conditions. In the Lac Dalmas and Lac Joubert area, the La Grande Subprovince to the north locally reached the granulite facies and the metamorphic gradient toward the Opinaca is not as clearly defined. We currently have partial thermobarometry results from both forward-pseudosection modelling and multi-equilibrium inverse modelling. These results will be used to characterize the pressure-temperature path and quantify the intensity of the apparent metamorphic gradient. Our ongoing study also includes a geochronology component based on the Lu-Hf radiogenic system on garnets (four ages in the Opinaca Subprovince and three in the La Grande Subprovince) and U-Pb on zircons and monazites. Distributed in both areas and in both subprovinces, these direct age dating analyses of prograde and retrograde metamorphic events will help determine the timing of the latter relative to the juxtaposition of the two subprovinces. These new data on the metamorphic history of the two subprovinces in two distinct regions will be used to confront existing geodynamic models for this part of the Superior Province (accretionary complex versus metamorphic core complex).

G17

Gold mineralization of the Orfée orogenic gold deposit, Eeyou Istchee James Bay Territory

Adina Bogatu, François Huot (UL), Jean Goutier (MERN), Carl Guilmette, Antoine Rhéaume Ouellet, Georges Beaudoin (UL) and Don Davis (University of Toronto)

The Orfée deposit (~0.2 Mt at 14.5 g/t Au), discovered by Virginia Gold Mines in 1998, is situated in the La Grande Subprovince (NTS 33G06) at a distance of 300 m from the contact with the Opinaca Subprovince. Numerous gold occurrences have been discovered along this contact, but the abundant and detailed data available for the Orfée deposit along with its accessibility make it a prime example with which to study the tectonic and metallogenic processes that were responsible for these occurrences.

Two gold zones, Orfée and Orfée East, are associated with an iron formation comprising oxide and silicate facies, and with graphitic mudrocks containing up to 20% pyrrhotite and pyrite as disseminations or masses. These zones are bordered to the north by basaltic amphibolites and to the south by wackes. An early foliation oriented NNW-SSE (S1) developed in the basalt amphibolites, whereas the main foliation (S2) is E-W. Irregular zones of pyrrhotite-bearing garnetiferous amphibolite represent the recrystallization of pervasive alteration that predates regional metamorphism. Weakly plagioclase-phyric diorite dykes were injected into the amphibolites and cut the early foliation. One of these dykes, dated at 2703 Ma, is boudinaged within a pyrrhotite-rich gold-bearing shear zone oriented E-W. The graphitic mudrock unit is also crossed by one of these E-W shear corridors. The geometry of the mineralized zone follows the graphitic mudrock unit, dipping steeply to the north, and continues into the iron formation and the semi-massive to massive pyrrhotite breccias containing fragments of magnetite, grunerite, hedenbergite and hornblende. The wackes are divided into two populations, one with intermediate composition (<5% hornblende) and the other mafic (>30% hornblende, with high MgO, Cr and Ni contents). These two populations are interstratified, and are more mafic than the wackes and paragneisses found in the Opinaca. The amphibolites, iron formation and wackes are injected by a wide variety of deformed quartz veins yielding a maximum gold grade of 2 g/t. A pegmatite granite dyke, dated at 2614 Ma, cuts the wackes and amphibolites, and is boudinaged and sheared, suggesting a post- to syn-intrusive deformation event. This type of pegmatite intrusion is similar in age and composition to the intrusions found in the Éléonore mine area.

The Orfée showing is a good example of an orogenic gold deposit metamorphosed to amphibolite facies and controlled by the remobilization of mineralization contained in shear zones hosted by graphitic mudrocks and iron formations.

G18

Classification of gold occurrences near the contact between the La Grande and Opinaca subprovinces, south of La Grande 3 Reservoir, Eeyou Istchee Baie-James

Roman Hanes, François Huot (UL), Jean Goutier (MERN), Philippe Drouin, Georges Beaudoin and Carl Guilmette (UL)

The contact zone between the La Grande and Opinaca (LGO) subprovinces in the Eeyou Istchee Baie-James region exhibits certain characteristics similar to the Cadillac Fault in the Abitibi Subprovince. The north part of the LGO regional unconformity, which may be traced over a distance of about 600 km, appears highly prospective and hosts a number of gold occurrences (Zone 32, Orfée, Marco). However, a better understanding of this regional lineament is necessary. We have summarized the current state of knowledge in terms of geology, structural parameters and types of mineralization for an area that extends over 80 km along the northwest segment of the LGO contact, more specifically to the south of La Grande 3 Reservoir.

Within the study area, the La Grande Subprovince comprises Mesoarchean and Neoarchean intrusive rocks and volcano-sedimentary sequences (2.8-2.7 Ga) underlain by an older tonalitic basement (3.45-2.79 Ga). In contrast, the Opinaca Subprovince is younger (2.7-2.6 Ga) and is largely dominated by sedimentary rocks, with a greater proportion of felsic intrusions. The metamorphic grade in this area ranges from the greenschist to the amphibolite facies in both subprovinces. Preliminary results indicate two major deformation events along the northwest portion of the LGO contact. An early D1 deformation, characterized by an intense NNE-trending schistosity, is only locally preserved as it is strongly overprinted by deformation D2. This second event is mainly represented by a NE-SW to E-W-trending foliation and locally intense deformation zones. Three major types of gold mineralization are observed in the area, namely: (1) disseminated sulphides and sulphide veins along shear zones in various lithologies, including early mineralization in the La Grande Sud tonalite; (2) sulphides or silicate-rich banded iron formations; and (3) quartz-tourmaline and quartz-carbonate extension gashes and infill veins. In addition to the Zone 32 Au-Cu deposit and other minor prospects where part of the mineralization has been interpreted as pre- to syn-D1, most gold occurrences appear to be spatially and genetically related to the major D2 event along the LGO contact. The main objectives of this project are to characterize the various types of gold mineralization along the north segment of the LGO contact, and integrate their genesis in the tectonometamorphic history of this regional unconformity. Complete metallogenic models will be proposed to guide future gold exploration programs in the region.

G19

Study on the tectonometamorphic setting of the Laguiche Complex, Opinaca Subprovince, Eeyou Istchee Baie-James

Myriam Côté-Roberge, Carl Guilmette (UL), Jean Goutier (MERN) and Nathan Cleven (UL)

The Laguiche Complex is a metasedimentary assemblage included in the Opinaca Subprovince. This Neoarchean subprovince of the Superior Province is characterized by abundant granitic intrusions that, along with a few small discrete ultramafic injections, cross-cut a thick sedimentary sequence. It is mainly bordered by the Paleo- to Mesoarchean La Grande volcano-sedimentary Subprovince.

Despite the keen interest this remote region has attracted since the discovery of gold deposits such as Roberto (Éléonore mine), certain areas have never been the focus of detailed geological mapping, and certain segments of the contact zone between the Opinaca and La Grande subprovinces remain poorly documented. Several hypotheses are currently considered to explain the geodynamic setting: presence of a metamorphic core complex, a dome-and-basin system, or extensive basement detachments onto Laguiche metasedimentary rocks.

The objective of this study is to clarify the geodynamic setting of emplacement of the Laguiche sedimentary sequence and of subsequent episodes of regional deformation and metamorphism.

Field mapping was carried out in the summer of 2015 (NTS sheets 33F01, 33F08 and 33F09) in a poorly known but important part of the Laguiche Complex. More than 80 representative samples (or bearing interesting metamorphic minerals) were collected for petrographic, geochemical and geochronological studies. The results will enable us to define metamorphic isograds in this region and identify new shear zones. Structural data analysis, combined with high-quality aeromagnetic surveys and age dating of sedimentary sequences and metamorphic events, will help constrain metamorphism and deformation events in the Laguiche metasedimentary rocks, from the time of deposition onward.

Preliminary observations reveal a complex pattern of metamorphic indicators (such as garnet, staurolite, cordierite, sillimanite and diopside) that do not define a simple N-S or E-W gradient. Certain E-W-trending bands exhibit stronger migmatization and deformation relative to adjacent areas, suggesting the presence of deformation zones within the Laguiche Complex. Some of these zones appear to join up with the main shear between the La Grande and Opinaca subprovinces, thereby suggesting the possibility that gold-bearing trends may extend into the Opinaca.

G20

Progressive polyphase deformation between the northeastern La Grande and Opinaca subprovinces of the Superior craton: Preliminary field results from the Lac Joubert region

Nathan Cleven (UL), Pénélope Burniaux, Hanafi Hammouche (MERN), Antoine Rhéaume-Ouellet (UL), Lyal Harris (INRS-ETE), Jean Goutier (MERN) and Carl Guilmette (UL)

The Lac Joubert region (NTS 33H01, 23E04 and 23E05) covers the contact between the volcano-plutonic La Grande Subprovince (LGSP) and the anatectic metasedimentary Opinaca Subprovince (OSP), in the northeastern part of the Archean Superior craton. The nature and evolution of the contact between these two subprovinces, which has been associated with numerous gold occurrences, are still enigmatic. The problem at the local scale is that the dominant metasedimentary lithologies in the two subprovinces have similar characteristics, such as their metamorphic facies (subgranulite) and the syntectonic overprinting of the migmatization. This study aims to better constrain the nature of the contact through a preliminary analysis of the structural evolution.

The structural analysis of the OPS near the contact suggests that a single event created cylindrical folds that are upright, open to isoclinal, asymmetrical and oriented east-west. The folds are particularly evident in leucocratic injections. The fold axes plunge gently to the west. The main body of the LGSP reveals a second phase of folding that was superimposed on a first phase, similar to the one observed in the OPS; fold hinges are concentrated along an east-west axis, distributed in a subvertical plane. This association suggests a secondary compressional event that created an elongate dome-and-basin interference pattern. The correlation between the mylonitization of metapelite layers and the dip-parallel lineations indicate that deformation was accomplished through ductile interlayer-slip. The two subprovinces are separated by a region of south-verging ductile thrusting and intense folding. This region, roughly 12–15 kilometres wide, is lithologically similar to the LGSP. The structures bordering the region are characterized by ductile thrust zones with widespread submylonitic deformation and high concentrations of stromatic leucosomes. The southern zone registered a dextral strike-slip event. Folding in this region is different from the surrounding areas in that all the folds are overturned to the south. The hinge zones plunge gently to the east and there is no evidence of a second phase of folding. We conclude that this transition zone between the Opinaca and La Grande subprovinces preserved the deformation associated with the convergence, remaining tectonically detached from the main body of the La Grande Subprovince.

G21

Structural and metamorphic study of the Attic Complex (Phase 2): Lac Parent region – Josselin Pluton, Québec

Nicolas Revelli, Sacha Lafrance and Alain Tremblay (UQAM)

The Superior Province encompasses several subprovinces, mainly composed of TTG-type felsic intrusive rocks and greenstone belts, that were amalgamated at *ca.* 2.72 Ga and 2.68 Ga. Although the geology of these terrains is relatively well understood, the nature of their contacts remains open for debate. For example, based on seismic data, the contact between the Abitibi and Opatica subprovinces has been interpreted as the trace of a subduction zone. Ongoing studies show however that this contact is not marked by particularly intense deformation or sharp metamorphic contrast, thereby suggesting the two subprovinces in fact represent the same segment of Archean crust, simply exposing different crustal domains. Similarly, in various parts of the Abitibi, TTG-type intrusive rocks are exposed in the core of vast antiforms rimmed by greenstone belts. This is the case for the Attic Complex, bounded by the Grenville Front to the east and by a submeridian line that runs from Lebel-sur-Quévillon to Senneterre to the west. The Attic Complex, which exhibits geological characteristics comparable to the Opatica, may constitute a structural window exposing a crustal series that represents the "basement" for Abitibi sequences. The objective of this doctorate study, launched in the summer of 2014, is to investigate this hypothesis.

During the summer of 2015, the south part of the Attic Complex – the Josselin Batholith and its supracrustal sequence – was studied. In this region, the granodiorite-tonalite assemblage of the Josselin Batholith intrudes mafic volcanic and plutonic country rocks. The Josselin Batholith and its country rocks are affected by a regional foliation (S_n) that wraps around the contours of the intrusion. In areas where deformation is more intense, S_n is overprinted by S_{n+1} and S_{n+2} fabrics. In the core of the batholith, a migmatitic facies with centimetre-scale garnets and amphiboles occurring in metre-scale bands appears to constitute the relics of a deep metamorphic facies that was uplifted during emplacement of the intrusion. The acquisition of geochronology data (U-Pb age dating underway) and a detailed analysis of regional metamorphic conditions will help constrain the tectonic and metamorphic evolution of the Attic Complex and improve our understanding of the crustal architecture, not only of the area between Lebel-sur-Quévillon and Senneterre, but also of the Archean Abitibi crust in general.

G22

Gold mineralization and deformation at the Malartic Lakeshore showing, Abitibi Subprovince, Québec

Francis Guay (UQAC), Pierre Pilote (MERN) and Réal Daigneault (CERM-UQAC)

The objective of this Master's project, undertaken at UQAC in collaboration with the MERN, is to establish the relationship between intrusions, deformation, and lode gold mineralization on the Malartic Lakeshore gold property, wholly owned by Golden Share Mining Corporation. The study area, located about 5 km east of the village of Rivière-Héva, encompasses two vast stripped outcrops (West and East), where several quartz-calcite veins with gold, pyrite, chalcopyrite and galena mineralization are exposed.

Stratigraphically located in the Southern Volcanic Zone of the Archean Abitibi Subprovince, rock units on the property are assigned to the Louvicourt Group in the north (Heva Formation) and the Malartic Group (Dubuisson Formation) in the south. They form an assemblage of tholeiitic intermediate to mafic (basalts and andesitic basalts) and ultramafic (komatiitic basalts) volcanic rocks, in contact with a calc-alkaline felsic volcaniclastic unit (lapilli tuff) to the north. Mafic volcanic rocks are commonly pillowed. Regional metamorphism reached the upper greenschist facies.

The West outcrop contains an exceptional density of centimetre-scale to multidecimetre-scale dykes. A petrographic study outlined four types of dykes: biotite tonalites, lamprophyres with actinolite-tremolite and chlorite, quartz-feldspar porphyries (QFP), and gabbroic dykes interpreted as synvolcanic. The first three types of dykes have a calc-alkaline affinity but the gabbros have a transitional affinity.

Rock units on the property show a high degree of ductile deformation, with a highly penetrative flow cleavage oriented 132°/79° on average. All deformation in this area is related to the deformation zone that characterizes the Rivière Héva Fault, reaching its maximum at the contact between mafic volcanic rocks and felsic volcaniclastic rocks. Stretching lineations show variable attitudes, ranging from a dip-parallel to a strike-parallel component in more strongly deformed zones. As evidenced by this variability in lineations and the presence of abundant crenulation cleavages, the area has undergone polyphase deformation, shifting from early shortening to late dextral strike-slip. Dykes systematically exhibit oblique lineations with a strike-parallel component, suggesting emplacement during dextral strike-slip movement.

Mineralized veins, less than one metre thick, are stacked over a few tens of metres. Locally, grades reach up to 188 g/t Au (with a few visible gold grains) and 1,400 g/t Ag. The veins are strongly deformed (folded, boudinaged, dismembered) and subparallel to the main schistosity. They are systematically cross-cut by tonalite, QFP and lamprophyre dykes. Vein wall rocks have undergone intense hydrothermal alteration to biotite over a few centimetres. This biotite is affected by the main schistosity and is partially destabilized to chlorite as a result of retrograde metamorphism interpreted as late relative to deformation. A hydrothermal biotite stockwork zone with similar characteristics is also recognized within the ultramafic unit, near the contact with the felsic volcaniclastic unit. All observations point to an early lode gold mineralization that predates regional deformation.

G23

Structural, geochemical and petrographic characterization of the contact between the Caste and La Motte-Vassan formations: Lac Malartic-Manneville South Fault, Abitibi, Québec

Florence Bédard (UQAM), Pierre Pilote and Pierre Lacoste (MERN)

This study is part of a larger mapping project at a scale of 1:20,000 in the Val-d'Or–Malartic area undertaken by the *Ministère de l'Énergie et des Ressources naturelles* (MERN). It presents the detailed geology of a key outcrop mapped in the summer of 2014 and located about 15 km northwest of Val-d'Or (NTS sheet 32C04).

Our interest in the study area lies in its stratigraphic and structural setting, namely the presence of the Lac Malartic Fault (which corresponds to the eastward extension of the Manneville South Fault) that marks the contact between the Caste and La Motte-Vassan formations. Sedimentary units of the Caste Formation are wedged with volcanic rocks of the La Motte-Vassan Formation by the La Corne Batholith to the north, which constitutes a major regional unconformity.

The Lac Malartic-Manneville South Fault runs directly across the outcrop under study. This fault zone takes the form of an important shear zone with a directional component that may be traced over several tens of kilometres. The outcrop exhibits evidence of folding, which affects the entire study area. The main schistosity is undulating and partly follows WNW-ESE-trending lithologies. Stratigraphically, the south part of the outcrop lies at the base of the Malartic Group in the La Motte-Vassan Formation, and is characterized by mafic and ultramafic volcanic rocks intruded by several sets of dykes. The north part of the outcrop corresponds to the Caste Formation. These rocks of sedimentary origin are strongly deformed, such that no primary textures have been preserved, and contain several veins and pods of disseminated pyrite. These sedimentary units are intruded by late tonalitic dykes that appear weakly folded or not at all. Mineral assemblages in these rocks suggest the metamorphic grade ranges from the greenschist to the lower amphibolite facies.

Fieldwork carried out during the summer of 2014 on this outcrop consisted in detailed mapping along a grid, structural measurements, and sampling of the various lithologies. As a first step, all structural data were plotted on a map for interpretation. Upcoming work will include petrographic descriptions of the various units (in thin section) and interpretation of geochemical data.

G24

Lithological characteristics of the Piché Group and implications on its origin, Abitibi, Québec

Pierre Bedeaux (UQAC), Pierre Pilote (MERN), Silvain Rafini (CONSOREM) and Réal Daigneault (UQAC)

The Piché Group is an assemblage of volcanic rocks that were historically associated with the Cadillac Fault, a major metallotect for the emplacement of orogenic gold deposits in the Abitibi. Even though the role of the Piché Group as a structural trap for this type of mineralization has been well documented and there are several models that explain its specific relationship with the Cadillac Fault, it nonetheless remains a poorly understood entity. Its lithologic and geometric characteristics are not well defined, its stratigraphic relations with adjacent rocks are not well known, and there is still no consensus on its place in the geological history of the Abitibi.

With the support of the *Ministère de l'Énergie et des Ressources naturelles*, a compilation of drill hole data was used to generate sections perpendicular to the Cadillac Fault in order to document the thickness of the Piché Group, its constituent lithologies, their relative abundance, and the lateral variations and heterogeneity of the group's characteristics. Field surveys conducted in the summers of 2013 and 2014, including detailed mapping of several areas, provided information on the stratigraphic relationships between these rocks. In addition, the geochemical analyses of 135 samples collected at surface and from drill core were used to define the geochemical signature of the Piché Group rocks.

The thickness of the Piché Group is highly variable at the regional scale, ranging from less than 10 metres to several hundred metres. Volcanic rocks, the dominant lithologies, are essentially mafic-ultramafic with minor andesitic components. However, the relative abundance of the different lithologies shows tremendous local variations; a single lithology may constitute the entire Piché Group in one place, yet be completely absent in others. The lithologies are cut by numerous intermediate to mafic synvolcanic dykes, as well as by felsic synvolcanic intrusions. The analyzed volcanic units define tholeiitic and calc-alkaline suites. The geochemical signatures commonly show negative Nb and Ta anomalies, suggesting crustal contamination of the original melts.

Younging directions observed in drill core and at surface always face north. Although no unfaulted contacts have been observed, field relationships suggest the Piché Group is generally in direct contact with the Pontiac Group, and appears to be overthrust by the Cadillac Group. The different lithologies, their distribution, abundance and ages are similar to those of certain formations in the Malartic Group, suggesting a link between these two groups.

G25

Geology of the Malartic Group and adjacent volcano-sedimentary groups: Overview and outlook

Pierre Pilote, Pierre Lacoste, Jean David (MERN), Réal Daigneault (CERM-UQAC) and Vicki McNicoll (GSC-O)

The Val-d'Or–Malartic region is underlain by volcanic rocks (the Malartic and Louvicourt groups) and sedimentary rocks (the Mont-Brun, Cadillac, Caste and Pontiac groups, all roughly around 2685 Ma; and the Timiskaming Group, <2678 Ma and <2676 Ma). These groups are renowned for their fertility in terms of volcanogenic massive sulphide deposits and gold deposits. The Malartic Group (2714 to 2706 Ma) contains the La Motte-Vassan, Dubuisson and Jacola formations, whereas the Louvicourt Formation (2706 to 2700 Ma) contains the Val-d'Or and Heva formations. The continuation and thickness of these units is highly variable. The general orientation of stratigraphic surfaces is also variable, changing from WNW-ESE in the Preissac and Malartic areas, to E-W in the Val-d'Or area.

The regional schistosity S1, moderately to intensely developed, is commonly subparallel to stratification S0. An S2 cleavage trending E-W cuts the S1 fabric, particularly in places where S0 and S1 are trending WNW-ESE. Stretching lineations are commonly contained in the S1 fabric and plunge moderately or steeply to the east. The La Motte-Vassan Anticline, an F1 fold oriented NW-SE, crosses the entire region.

The Val-d'Or–Malartic region is marked by the following kilometre-scale shear zones and longitudinal faults trending WNW to E-W, with steep dips to the north: La Pause, Parfouru, Rivière Héva, Manneville South, Norbenite and Marbenite. These faults, subparallel to the S0 surface, truncate or repeat the stratification. They merge with the Cadillac Tectonic Zone at a shallow angle. In several cases, the faults consist of envelopes containing a high density of dykes and/or stocks of monzonitic or tonalitic composition, with ages ranging from pre- to late- to post-tectonic.

Several gold mines and showings — Norlartic, Kiena, Snow Shoe, Sullivan, Goldex (diorite: U-Pb age of 2687.0 ±1.2 Ma), Siscoe, Joubi, Sigma and Lamaque — are spatially associated with these faults. The diversity of ages and styles of gold mineralization clearly establishes multiple distinct episodes of mineralization and telescoping over time. This particular feature is one of the characteristics of world-class mining camps.

The Cadillac Tectonic Zone is historically associated with talc-chlorite-serpentine schists (ultramafic and mafic volcanics, deformed to varying degrees) known as the Piché Group. This group extends somewhat continuously from Louvicourt to Rouyn-Noranda (>150 km), but it varies in thickness from less than 100 m to more than 1,500 m. Its origin remains uncertain. It could be a single stratigraphic unit or a composite assemblage. Recently, two U-Pb ages were obtained from zircons: 1) at the Buckshot pit to the NE of the Canadian Malartic deposit (felsic dyke, 2710 Ma), and 2) at the Pan Canadian deposit (lapilli tuff, 2705.9 ±0.9 Ma). These ages make the Piché Group a correlative unit to certain parts or elements of the Malartic Group.

G26

Geology of surficial deposits south of Lac Mistassini, Québec: Preliminary results

Mohamed El Amrani (MERN) and Antoine Archambault (UL)

A field program in the summer of 2015 focused on the mapping and morphology of Quaternary formations to the south and southeast of the village of Mistissini. The study area covers 3,965 km^2 on map sheets 32I03, 32I04, 32I05 and 32I06 (1:50,000).

The study of landforms and erosional marks revealed a complex series of four ice flows: one to the SE (125–145°), an old and poorly recorded movement; one to the south, major and well defined; one to the SSE (160–175°) in the eastern part of the study area; and one to the SSW (185–215°) in the western part. The relative timing of the last three is unknown, but all three may be related to the last Wisconsinan ice sheet. The sequence of flows reflects either a displacement of ice-dispersion centres, or east-trending ice divides with a topographic control on ice flow.

The retreat of the last Wisconsinan glacier from this region left behind a variety of deposits that shape the current landscape. Basal till is the most widespread and forms a single sheet overlain by a thin layer of ablation till. The deposits form vast fields of tapered landforms (NNE-SSW) to the south of Mistissini. Melt-out till is found in terrain characterized by buttes and depressions where it occupies some of the valley floors. Glaciofluvial deposits generally form eskers oriented N-S or SSW to SW, as well as outwash plains on the floors of major valleys. A glaciolacustrine facies, probably associated with Lake Ojibway, was identified in the southwestern part of the region. Post-glacial sediments are represented by slope deposits and present-day alluvium, locally surrounded by rare terraces of ancient alluvium. Eolian parabolic dunes were observed near some of the glaciofluvial deposits, indicating the dominant winds were from the WNW to NW. Deposits of organic material occupy large areas with poor drainage.

Erratic blocks originating from the Proterozoic sedimentary sequences of the Chibougamau-Mistassini area show a regional distribution pattern towards the S and SSW. These boulders appear to be excellent lithological indicators for tracing the transport of materials during the last glaciation.

G27

Drift prospecting in the Lac Evans area, James Bay region: Till sampling and Quaternary deposit mapping (NTS 32K10, 32K11, 32K14, 32K15, 32N02, 32N03) – Preliminary results

Olivier Lamarche (MERN) and Eric Leduc (UQAM)

The bedrock of the James Bay Lowlands is covered by a thick layer of sediments deposited during the Late Wisconsin glaciation of the Quaternary Period, making it difficult to apply classic drift prospecting techniques when conducting mineral exploration. Nevertheless, drift prospecting is an effective way to use glacial sediment cover (e.g., till) to obtain information about a region's mineral potential.

The *Bureau de la connaissance géoscientifique du Québec* (BCGQ) carried out Quaternary mapping and till sampling in the Lac Evans region (NTS 32K10, 32K11, 32K14, 32K15, 32N02 south and 32N03 south).

Approximately 150 till samples were collected during field work in 2015. The objective was to characterize the geochemistry of the matrix in terms of major and trace elements, and platinum group elements (PGE). Heavy mineral concentrates were also analyzed to assess the potential for certain deposits (gold, diamonds, sulphides, etc.) by studying indicator minerals. An inventory of glacial erosion marks (striae, grooves, chatter marks) and glacial deposit features (streamlined forms, moraine trains) complements the new geochemical data and provides context with respect to the regional geology. The results of these analyses will be available at Québec Mines 2016.

The different types of sediments associated with the last glaciation were identified by mapping the unconsolidated deposits. The region is dominated by a plain of glaciolacustrine sediments deposited by Lake Ojibway which gave rise, beginning in the Holocene, to the many peat bogs and wetlands that characterize the James Bay Lowlands. The topographic features that pierce this plain are usually outcrops of bedrock accompanied by moraine trains aligned in the direction of ice flow, which formed during the deglaciation of the New Québec dome. These hills were chosen as sampling targets for the project. The region is also marked by a series of small end moraines that were used to identify the positions of the ice margin at various stages during the deglaciation. These moraines are sometimes accompanied by glaciofluvial subaqueous outwash sediments, mainly sands and gravels.
A relatively brief period of sporadic littoral reworking was observed on the flanks of most hills in the region.

G28

Geology and economic potential of the southwestern Lac Nemiscau region, Lac Rodayer area (NTS 32K13, 32K14, 32N03 and 32N04-SE)

Daniel Bandyayera (MERN), Yannick Daoudene (UQAT) and Simon Bourassa (MERN)

A geological survey at 1:50,000 scale was conducted in the summer of 2015 in the Lac Rodayer area, 110 km north of Matagami. The mapped area covers the contact zone between the sedimentary Nemiscau Subprovince to the north, and the Opatica Subprovince to the south. In the transition zone between the two lies the Colomb-Chaboullié Group, a band of volcano-sedimentary rocks injected by kilometre-scale mafic-ultramafic intrusions that delimits the Rupert Group paragneiss to the north and the Opatica plutonic rocks to the south. The volcano-sedimentary units of the Colomb-Chaboullié Group form a continuous NE-SW to E-W belt extending for more than 70 km long and up to 5 km wide. They comprise massive to pillowed basalt, massive to porphyritic andesite, felsic tuff, wacke and, locally, conglomerate. The Opatica is formed of an assemblage of diorite, quartz diorite and, in some places, tonalite or tonalite gneiss; the assemblage is cut by late tectonic intrusions of granodiorite or granite. A new multi-kilometric syenite intrusion (18 km by 3 km) was discovered in the southwestern corner of the region. Associated with a strong magnetic anomaly, clearly circular at Lac Rodayer, it follows the northern edge of the Rivière Nottaway Shear Zone (RNSZ).

Within the Colomb-Chaboullié Group, the structural grain is NE-SW and the tectonic fabrics are very steep. In the Opatica, the foliation shows greater variation, suggestive of a dome-and-basin geometry. In the southwest, the plutonic Opatica rocks and the adjacent volcanic and sedimentary rocks were overprinted by the RNSZ (NW-SE), characterized by mylonites and L-S tectonites.

Sites of economic interest are found in six main geological settings: 1) gold-bearing volcanogenic massive sulphides in the volcanic units of the Colomb-Chaboullié Group (Lac Marcaut showing: several intervals of brecciated massive sulphides grading 1.5 to 8 g/t Au); 2) Ni-Cu-PGE mineralization associated with mafic-ultramafic intrusions (Horden deposit: estimated probable reserves of 1,238,333 tonnes at 1.9% Cu and 0.4% Ni); Au-Cu mineralization associated with quartz veins containing disseminated sulphides, which cut volcanic rocks (Lac Colomb–SW showing: 2.5 g/t Au and 0.95% Cu in a grab sample); banded iron formations (Lepallier, Gruet, Audru and Tremolite showings); 5) pegmatites containing 1% Be (Lac des Pointes and Lac Marcaut showings); and 6) the REE potential of a syenite intrusion.

G29

Geological and structural context of the Lac Joubert region, Eeyou Istchee James Bay Territory

Pénélope Burniaux, Hanafi Hammouche (MERN) and Nathan Cleven (UL)

The Lac Joubert region (NTS map sheets 33H01, 23E04 and 23E03) was the subject of a 1:50,000 geological survey in the summer of 2015. This region lies in the northeastern part of the Superior Province, specifically in the La Grande and Opinaca subprovinces. The area is underlain by rocks cut by mafic dyke swarms of Neoarchean (N-S to NNW) and Paleoproterozoic age (NE-SW and NW-SE).

In the northern part of the study area, the Archean sedimentary basin of the Rivière Salomon Formation surrounds large felsic intrusions. Some relicts of dismembered volcanic belts of the Triest Formation are still present, composed of mafic to felsic metavolcanics. To the east, a large post-tectonic granite intrusion of the Lataignant Suite cuts through the La Grande Subprovince. In the southwestern part of the study area, the Opinaca Subprovince is composed of an assemblage of migmatized paragneiss (biotite±garnet±orthopyroxene) belonging to the Laguiche Complex.

The structural arrangement is dome-and-basin style. The preliminary interpretation indicates a regional fabric of tight to isoclinal folds, overturned to the south. These structures were the result of an initial N-S deformation event, followed by an E-W deformation episode that generated large open to undulating folds with N-S axes. A major E-W shear, marked by a string of metre- to decametre-scale ultramafic sills, separates the La Grande Subprovince from the central domain, which is characterized by syn-tectonic intrusives exhibiting strongly stretched quartz grains. The central domain is limited to the south by another shear zone at the contact with the Opinaca Subprovince. These two major shears are evidence that the La Grande Subprovince was thrust over the Opinaca.

Metamorphism in the region varies from greenschist facies to granulite. The metasedimentary rocks in the north are characterized by the presence of garnet, cordierite, sillimanite and staurolite, and in the north by the presence of garnet and orthopyroxene. We also identified new alteration and metasomatic zones, characterized by assemblages of quartz-amphibole-diopside-garnet and biotite/phlogopite-calcite-amphibole-pyrrhotite. Metamorphic studies are underway to improve this characterization.

The known showings and new regional targets discovered during our work demonstrate the region's potential for orogenic gold mineralization.

G30

Geology of the Lac Villaret region, Eeyou Istchee James Bay Territory: Shedding new light on the Opinaca

Jean Goutier (MERN), Joséphine Gigon (URSTM) and Myriam Côté-Roberge (UL)

The Lac Villaret region is situated about 50 km south of the La Grande 3 Reservoir. The 1:50,000 geological survey covered NTS map sheets 33F01 and 33F08. Previous geological work was limited to reconnaissance geological mapping (1:506,880) by the Geological Survey of Canada in 1957; uranium prospecting and partial mapping of map sheet 33F08 in the 1970s; and some gold prospecting in the 2000s.

The study area is located entirely within the Opinaca Subprovince, in the northeastern Superior Province. The Opinaca is dominated by paragneisses derived from wackes migmatized to various degrees and injected by generally felsic Neoarchean intrusions. Small ultramafic intrusions were emplaced along major structures, the dimensions of which are currently unknown. These intrusions are much less deformed than the country rocks, but are metamorphosed to the same facies. Rocks of the La Grande Subprovince only crop out in the northeastern part of the study area. A pluton of the Duncan Intrusions and another belonging to the Bezier Suite are the only La Grande representatives. Several Neoarchean (Mistassini) and Paleoproterozoic (Lac Esprit) mafic dykes cut the earlier units. Archean metamorphism generally changes from north (greenschist facies) to south (upper amphibolite), characterized by wackes showing little metamorphism in the north, to highly migmatized paragneisses in some of the southern areas. Only one outcrop of paragneiss containing orthopyroxene was observed over the course of the summer. Regional metamorphism will be the subject of another Master's project.

The Opinaca Subprovince was previously regarded as a metamorphic dome. However, new data reveal a complex structural pattern with major shear zones that imbricate the Laguiche rocks. Some of these shears connect to the La Grande–Opinaca deformation corridor to the west, raising the possibility that gold-bearing structures continue along the La Grande–Opinaca contact, within the Opinaca Subprovince. This is supported by the presence of metamorphosed alteration zones (PG-AM-DP-QZ-PO-PY-CP).

Prior to our work, the mineral potential of the region was limited to a few uranium and thorium showings, but our discovery of several rusty zones (e.g., sulphide-bearing graphitic schist; metasomatic PO-CP-PY zones) suggests new mineral potential and exploration contexts for this very underexplored part of the Opinaca.

G31

Presentation of geophysical data published in 2015

Rachid Intissar and Siham Benahmed (MERN)

Géologie Québec continued its large-scale airborne geophysical surveying in various geological provinces during the 2014–2015 year, particularly in the Grenville and Churchill. The number of linear kilometres flown over the past year is on the order of 312,010 kilometres. The ultimate goal of these high-resolution surveys is to provide a tool to support the geological mapping programs conducted by both Géologie Québec and private companies. The data also encourage mineral exploration and stimulate private investment by generating targets of interest.

The results of the recent surveys were published by Géologie Québec in the following reports:

- **DP 2015-03:** Airborne magnetic survey covering, in whole or in part, four NTS map sheets at 1:50,000 scale in the Rivière Matapédia area of the Bas-Saint-Laurent region, Appalachian Province; the survey was conducted by GPR Geophysics International;
- **DP 2015-04:** Airborne magnetic survey covering, in whole or in part, 31 NTS map sheets at 1:50,000 scale in the Escoumins, Grenville Province; survey conducted by EON Geosciences;
- **DP 2015-05:** Airborne magnetic survey covering, in whole or in part, 18 NTS map sheets at 1:50,000 scale to the east of Gouin Reservoir, Grenville Province; survey conducted by Geo Data Solutions;
- **DP 2015-06:** Airborne magnetic survey covering, in whole or in part, 18 NTS map sheets at 1:50,000 scale in the area to the west of Lac-Saint-Jean, Grenville Province; survey conducted by Goldak Airborne Surveys;
- **DP 2015-07:** Compilation of new geophysical surveys in the province of Québec; and
- **DP 2015-08:** Airborne magnetic and spectrometric survey covering, in whole or in part, 18 NTS map sheets at 1:50,000 scale in the Rivière Arnaud area, Churchill Province; survey conducted by Geo Data Solutions.

G32

Geology of the Lac à l'Eau Jaune area (NTS 32G10)

François Leclerc, Francis Talla Takam and Mehdi A. Guemache (MERN)

The mapping revision of the Lac à l'Eau Jaune area (NTS sheet 32G10) is part of a larger mapping survey covering the Chapais-Chibougamau area. The objectives of this project are to: a) map the extension of the Chrissie Formation to the south of the Presqu'Île Pluton, b) define the stratigraphic setting of the Lac Winchester and Lac des Trois Îles area, c) map the Eau Jaune Complex and determine the extent of molybdenum mineralization; d) define the extension of the Palmer-Tippecanoe gold-bearing zone to the west of the Fancamp deformation zone, e) characterize the structural evolution of gold occurrences along the Monster Lake shear zone, and f) upgrade the map using the recent aeromagnetic survey and new geochemical and geochronological data. The study area encompasses the oldest volcanic rocks in the Abitibi Subprovince, with basalts, andesites, volcaniclastic rocks and PY-PO ± SP ± CP-bearing exhalites of the Des Vents Formation (2799 Ma) and the Chrissie Formation (2791 Ma). Exhalites characterizing the top of the Chrissie Formation were traced from the south of the Presqu'Île Pluton to the east of the Eau Jaune Complex. The Lac Winchester and Lac des Trois Îles area encompasses a band of coarse lapilli tuffs, PY-PO ± SP ± CP exhalites and basalts with CL-MG-EP alteration, typical of VMS environments. A geochronology study on a lapilli tuff sample will confirm the age of this unit. The Eau Jaune Complex consists of diorite successively intruded by tonalite and trondhjemite units. In these intrusive units, a gneissic and migmatitic texture has developed at the contact with centimetre-scale to multikilometre-scale enclaves of amphibolitic volcanic and sedimentary rocks. To the west of the Fancamp deformation zone, the westward extension of the Palmer-Tippecanoe deformation zone is oriented N310 and hosts several lode gold occurrences. The Monster Lake shear zone, parallel to the Fancamp deformation zone (N040), cross-cuts gold-bearing veins associated with N-S to NNE-SSW-trending shear zones. All of these structures are overprinted by the schistosity and cut by E-W-trending shear zones. Further studies are required to determine the extent of gold remobilization during the various episodes of deformation. As a result of this project, 753 outcrop descriptions (géofiches) were added into the SIGÉOM database, 212 samples were submitted for whole-rock geochemistry analyses, and 92 samples for assays.

G32

VMS exploration in the Chibougamau region: Recent work and exploration targets

François Leclerc, Patrick Houle (MERN), Pierre-Simon Ross (INRS-ETE), Jean Laforest (Tectonic Resources) and Claude Larouche (Ovalbay Geological Services)

The VMS potential of the Chibougamau region has been known since the discovery of the sulphide orebodies of the Lemoine mine (758,070 t at 4.2% Cu, 83.38 g/t Ag, 4.20 g/t Au and 9.56 % Zn) and the Scott deposit (5.4 Mt at 1.2 % Cu, 34 g/t Ag, 0.2 g/t Au and 4.6 % Zn),

Recent exploration work for VMS mineralization (prospecting, stripping, mapping, multiparameter analyses, airborne and ground geophysical surveys) has been carried out by prospectors (supported by the prospecting fund of the *Table jamésienne de concertation minière*), mining companies, INRS-ETE, the Geological Survey of Canada and the MERN.

The work has demonstrated that VMS-type mineralization signifies a hiatus in mafic volcanism, a time during which the following developed:

- veins and veinlets of CL-EP-SI-PY in pillow basalts altered to black chlorite and epidote masses;
- SR-PY alteration in felsic volcanic rocks;
- exhalites and sulphide-facies iron formations (PY±PO±CP) and carbonate-facies iron formations (AK-SD-CR-CL);
- bedded chert and arenite, with graded bedding and cross bedding;
- alteration to manganiferous garnet (spessartite).

These characteristic features of a volcanic hiatus were recognized not only in rocks of the Waconichi Formation, but also at several other levels in the stratigraphy, thus providing additional VMS prospecting targets:

- PY-PO-exhalites and metasomatized basalts (alteration to carbonates and spessartite garnet) in the upper member of the Chrissie Formation (2791 Ma);
- PY-exhalites and iron formations at the summit of basalts of the David Member (ca. 2729 Ma), north of Lac aux Dorés (Orofino-Kill Bill, Lac Taché showings, Sulphur Converting, David showing);
- iron formations and gossan zones (MG-PY) of the Andy Member (the Km 6 sector and the Indian Lake showing)
- PY-PO-exhalites and massive sulphides overlying variolitic basalts and volcaniclastic rocks at the base of the Blondeau Formation (ca. 2718 Ma; UMA, Lac France-East, Lac France-West, PAMAC, Lac Lucie-Nord and UMEX-2 showings).

G33

Aggregate resource inventory in the Puvirnituq and Akulivik areas

André Brazeau (MERN)

In the summer of 2015, an inventory was taken of aggregate resources in the northern communities of Puvirnituq and Akulivik on the eastern shore of Hudson Bay.

The village of Puvirnituq, situated along the northern shore of Puvirnituq Bay (60° 2' 8" N and 77° 16' 30" W), is the largest Inuit community in Hudson Bay, with a population of 1,808 inhabitants (*Répertoire des municipalités*, MAMOT, 2015). It has a hospital and an airport, the latter of which serves as a hub airport for the eastern coast of Hudson Bay.

The village of Akulivik is situated about 100 kilometres north of Puvirnituq, on a peninsula in Hudson Bay (60° 48' 37" N and 78° 11' 14" W). The population of this village is 676 inhabitants (*Répertoire des municipalités*, MAMOT, 2015).

Because many northern villages are experiencing strong population growth, the lodging and municipal infrastructure demands are very high. The presence of permafrost coupled with global warming renders it increasingly difficult to build such infrastructure, hence the growing demand for aggregate material to construct road bases and building foundations.

The inventory provides the locations and characteristics of aggregate materials and their quantities. Field work consisted of visiting natural cuts and sand pits, in addition to digging numerous test pits by shovel. A total of 18 samples of sand or gravel were collected from the villages and sent to a laboratory to determine their physico-mechanical properties.

The main sources of available aggregate in the study area are glaciomarine deposits (littoral sediments) dating back to the last glacial retreat, around 7,900 years ago. The glaciomarine deposits were emplaced along the shores of the Tyrell Sea, generally in the form of terraces topped by abundant gravels and rounded pebbles.

G34

Status of new geoscience compilations in Québec

Pierre Lacoste, Ghyslain Roy, Simon Auclair, Mona Baker, Charles St-Hilaire, Julie Vallières, N'golo Togola, Nathalie Bouchard, Ricardo Escobar and Jean Marie Nzengue (MERN)

Processing and dissemination of geoscience knowledge are important components of Géologie Québec's mandate. Again this year, Géologie Québec presents new compilations that were integrated into the SIGÉOM database. For each specific geoscientific data set, areas where new data were integrated into SIGÉOM or where existing data were updated are shown. The status of compilations provides information on new data acquired for the following geoscientific data sets:

- Bedrock geology;
- Quaternary geology;
- Deposits and showings – metallic substances;
- Deposits and showings – non-metallic substances;
- Deposits and showings – architectural, industrial and crushed stone;
- Drilling.

G35

Geoscientific map symbols and abbreviations

Ghyslain Roy (MERN)

This document deals with the symbology used to illustrate the various geoscientific geometric elements in Québec's geomining information system (SIGÉOM). It provides SIGÉOM users with an overview of the rules in use at Géologie Québec concerning the cartographic representation of point symbols, lines and polygons and the numerous abbreviations used in the databases.

G36

Major geological subdivisions in Québec

Ghyslain Roy (MERN)

This map shows the boundaries of provinces, subprovinces, and other major geological assemblages in Québec. These boundaries were established on the basis of lithological, stratigraphic, metamorphic, structural, geophysical, and geochronological characteristics derived from the latest information compiled in Québec's geomining information system (SIGÉOM).

G37

Characterization of mafic and ultramafic sills in the Gerido Zone, Lacs Qamaniik region, Labrador Trough, Nunavik, Québec

Marie-Pier Bédard (UL), Michel Houlé (GSC-Q) and François Huot (UL)

The mafic to ultramafic Montagnais sills of the Labrador Trough cut through almost the entire supracrustal sequence over a period of more than 280 million years. In the summer of 2015, mapping and sampling work was carried out to characterize the different types of mafic and ultramafic intrusions found to the northwest of Kuujjuaq (NTS 24K05, 24K06 and 24K12), where they were injected mainly into the Baby sedimentary formations and the Hellancourt volcanics of the Koksoak Group, both of which are associated with the second volcano-sedimentary cycle.

Three types of intrusions can be defined based on field observations: mafic (MI), ultramafic (UMI) and mafic to ultramafic (MUMI). Stratigraphic tops in the study area generally face east, based primarily on features observed in the MUMI — sedimentary and volcanic structures, as well as magmatic differentiation. No evidence of major folding was reported; on the other hand, some structural repetition cannot be ruled out. The MI are continuous over ~20 km and range in thickness from 400 to 1,500 m. They are mainly composed of massive, fine- to medium-grained aphyric gabbro, sometimes layered. Facies with variable and pegmatitic textures, and the appearance of bluish quartz, are more common in the uppermost section of the MI. Small concentrations of disseminated PGE-enriched sulphides (≤5 %) are locally present. The UMI are composed of peridotites that locally exhibit poikilitic (pyroxene) texture or pyroxenitic borders. Discontinuous and relatively thin (≤100 m), they are mainly found in the cores of the MI. They contain gabbroic enclaves of variable sizes. The MUMI form a differentiated mafic-ultramafic sequence that is continuous for at least 20 km and is ~130 m thick. The ultramafic part of the MUMI is composed of, from base to top (west to east), a gabbro unit overlain by pyroxenite and a unit of locally poikilitic peridotite. The upper part of the latter is characterized by alternating layers (centimetre- to decimetre-scale) of peridotite and pyroxene-rich peridotite that gradually evolve into pyroxenite. The mafic component of the MUMI is composed primarily of gabbro with variable grain size; bluish quartz appears towards the top.

The petrographic and geochemical characterization of the Montagnais intrusions in this area has been successful in distinguishing different types of intrusions and assessing their respective potential for Ni-Cu-PGE mineralization.

G38

Petrologic and mineralogical observations from the Ovoid ore body - Voisey's Bay Ni-Cu sulfide deposit, Canada - Implications for the formation of the ore body

Luiz Felipe Salim Amaral, Sarah-Jane Barnes and Philippe Pagé (UQAC)

Magmatic Ni-Cu platinum-group elements (PGE) sulfide deposits are commonly hosted in mafic-ultramafic rocks, which formed from mantle derived silicate magmas.

To form Ni-Cu-PGE deposits it is necessary that the magma reach early sulfide saturation and became saturated in an immiscible sulfide liquid capable of collecting the PGE and other chalcophile elements. During the crystallization of the sulfide liquid, Fe-rich monosulfide solid-solution (*mss*) crystallizes first and collects Re, Os, Ir, Rh and Ru. As the system cools, Cu-rich intermediate solid-solution (*iss*) crystallizes and collects Ag, Cd and Zn. However Pt, Pd, Au, Bi, As, Te and Sb are incompatible with *mss* and *iss*, and concentrate into a residual liquid. The residual liquid, crystallizes platinum-group minerals (PGM), among the *mss* and *iss*. Finally when the temperature is <650°C, pyrrhotite and pentlandite exsolve from the *mss* and chalcopyrite ± pentlandite exsolve from the *iss*.

The Voisey's Bay deposit (1.33Ga) is related to a troctolite-anorthosite ± granite plutonic suite located close to tectonic province boundaries. This deposit was formed at depth (~14km), which results in slow cooling and enough time to exsolve coarse grains of base metal sulfides minerals, and also exsolve PGM. Thus far, Voisey's Bay is the only significant deposit in this geological context. The main objective of this project is to study the massive sulfides from the Ovoid ore body from the Voisey's Bay deposit, in order to document and describe the distribution of PGE and other chalcophile elements distribution among the base metal sulfide minerals. Petrography, whole rock analysis, SEM analysis were carried out. The next step of this project will be carry out LA-ICP-MS analysis and mass balance calculations in order to develop a model of trace elements distribution in the Ovoid.

Preliminary results show two different sulfide mineral assemblages: *Fe-rich* comprises pyrrhotite, troilite, pentlandite and ± chalcopyrite. *Cu-rich* comprises cubanite, ± chalcopyrite, ± pentlandite. Magnetite, minor galena and sphalerite occur in both assemblages. Troilite and cubanite exsolve in temperature <200°C which means that the magma is enriched in Fe. Also the whole rock analyzes indicate a magma poor in PGE. The Ovoid cooled slowly so there is enough time to form extensions exsolutions of PGM and Bi-As-Te phases that can be observed in massive sulfides during the SEM analysis.

G39

Re-Os isotopic signature of laurite inclusions in chromites from Stillwater (Montana, USA) and identification of interstitial PGE-enriched phases

Laurène-Marie Wavrant, Sarah-Jane Barnes, Philippe Pagé (UQAC), Norman Pearson and William L. Griffin (ARC National Key Centre for Geochemical Evolution and Metallogeny of Continents – GEMOC)

The origin of chromitites in layered intrusions and their role in concentrating platinum group elements (PGE: Os, Ir, Ru, Rh, Pt and Pd) remains poorly understood. Various studies based on whole rock major and trace element geochemistry and isotopic signatures have concluded that contamination of a primitive magma by a crustal component plays an important role in the formation of chromitites.

The Re-Os isotopic system is particularly well suited to studying the origin of PGE enrichment because chromitites are enriched in Os. Osmium is generally present in laurite ($[Ru, Os]S_2$) inclusions in chromites. In a new approach to the problem, LA-MC-ICP-MS is used to determine the Re-Os isotopic compositions of laurite inclusions in chromites of chromitites from the Stillwater Complex (2.7 Ga layered intrusion, Montana, United States). The isotopic compositions obtained range from sub-chondritic to supra-chondritic and are extremely variable at the thin section scale (γOs = -2 to 7), raising doubts about the representativeness of whole rock isotopic compositions. The results call for a mixture of at least two components. The first is chondritic to sub-chondritic and requires a mantle source. The second is supra-chondritic and implies the contribution of a crustal component.

Three models can explain the results, In these models the laurites represent: i) remnants of mantle xenocrysts, ii) phenocrysts derived from magmas subjected to various degrees of crustal contamination, or iii) the diffusion of Ru and Os, initially present in the magma, into sulphides. Neither of the first two models alone can explain the observed variations in isotopic compositions. For the third model to work, (sub)chondritic compositions would have to be dominated by chromite signatures and the supra-chondritic compositions by sulphide signatures.

To validate this model, in which Os and Ru in chromite diffused into sulphide minerals, we conducted a project on the characterization of interstitial sulphides in chromitites of the Stillwater Complex and the localization of PGEs associated with these sulphides. Preliminary results reveal that PGEs are present as PGMs (platinum group minerals), and are generally associated with pentlandites ($[Fe, Ni]_8S_9$), altered or not.

G40

Trace elements in magmatic sulfides as petrogenetic indicator and exploration tool: What have we learned from massive sulfides of the Lac des Iles Pd-deposits (Ontario, Canada)?

Charley J. Duran, Sarah-Jane Barnes (UQAC) and John T. Corkery (NAP)

We have analyzed pyrrhotites, pentlandites and pyrites of sulfide-rich pods from the Lac des Iles Pd-deposits (Ontario, Canada) using laser ablation – ICP-MS. In comparing our data with those from the literature, we noticed that trace element signatures of pyrrhotites and pentlandites derived from primitive magmas (ultramafic intrusions and flows, layered intrusions, and flood basalts) are different to those derived from more evolved magmas (andesites). The Ni-Cu-Platinum group element (PGE) deposits associated with primitive magmas typically occur within stable cratons or at rifted intraplate margins whereas the deposits associated with more evolved magmas typically occur in convergent or transpressive settings (except Sudbury). Thus, in poorly documented or understood cases, the geochemical signature of pyrrhotite and pentlandite may be used to infer the nature of their parental magma. Furthermore, we identified that the trace element composition and distribution of pyrites from various Ni-Cu-PGE deposits are similar, suggesting a common ore-modifying process.

In addition, we noticed that pentlandites from PGE-dominated deposits are significantly enriched in Pd and Rh relative to pentlandites from Ni-Cu sulfide deposits. We also noticed that pyrites found in magmatic Ni-Cu-PGE deposits are enriched in Co and Se and depleted in Sb and As relative to pyrites found in low-temperature hydrothermal deposits (orogenic gold deposits and volcanogenic massive sulfides). A plot of Pd vs Rh in pentlandite appears to be effective at distinguishing pentlandites from PGE-dominated deposits to those from Ni-Cu sulfide deposits. Moreover, a plot of Co/Sb vs Se/As in pyrite allows to discriminate pyrites from Ni-Cu-PGE deposits to those from hydrothermal deposits. In glacial deposits (tills) present in large arctic and subarctic areas, pentlandite and pyrite can be recovered from the heavy mineral fraction. Therefore, the two plots that we developed can be used in exploration to fingerprint potential targets and adapt exploration strategies.

G41

The effect of chromite crystallization on Os, Ir, Ru and Rh fractionation in sulphide-undersaturated picritic magmas: An example from the Emeishan Large Igneous Province, Southwest China

Jean-Philippe Arguin, Philippe Pagé, Sarah-Jane Barnes (UQAC), Song-Yue Yu and Xie-Yan Song (SKLODG)

It is generally recognized that chromite plays a role in the fractionation of Os, Ir, Ru (collectively referred to as IPGE) and Rh during the fractional crystallization of sulphide-undersaturated mafic-ultramafic magmas. To investigate the effect chromite crystallization has on the fractionation of these elements, we analyzed, *in situ* by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), chromites derived from picrites of the Emeishan Large Igneous Province (ELIP), located in Southwest China. Although a few micro-inclusions of platinum group minerals (PGM) were detected, analytical signals for IPGE and Rh are generally constant, indicating these elements are homogeneously distributed in the structure of chromite grains.

Partition coefficients based on empirical calculations suggest the order of compatibility of IPGE and Rh in Emeishan chromites is as follows: Ru ($D_{Ru}^{Chr/Pic}$ $D_{Ru}^{Chr/Pic}$ = 127) > Rh ($D_{Rh}^{Chr/Pic}$ $D_{Rh}^{Chr/Pic}$ = 32) ≥ Ir ($D_{Ir}^{Chr/Pic}$ $D_{Ir}^{Chr/Pic}$ = 27) ≥ Os ($D_{Os}^{Chr/Pic}$ $D_{Os}^{Chr/Pic}$ = 23). Despite their strong compatibility, mass balance calculations reveal that chromite does not control the entire whole-rock budget for IPGE and Rh, collecting a maximum of ~85% Ru, ~50% Rh and less than 25% Os and Ir. The presence of micro-inclusions of PGM (laurite and Os-Ir±Ru alloys) may explain the missing portion of the whole-rock budget. However, supposing that IPGE and Rh may be compatible with olivine, the latter may also play a role in the control and fractionation of these elements as it is very abundant in Emeishan picrites.

Based on numerical modelling, we conclude that chromite, PGM and olivine all have a potential effect on the fractionation of IPGE and Rh during the early stages of fractional crystallization of sulphide-undersaturated picritic magmas. We have established that the preferential partitioning of Ru in the structure of chromite is responsible for Ru anomalies observed in standardized Ni-Cu-PGE patterns for ELIP basalts. However, although we strongly suspect that PGM play a major role in the differentiation of Os and Ir, the relative importance of PGM and olivine in the fractionation of IPGE and Rh remains uncertain.

G42

Mineralogical characterization of platiniferous showings in the Lac Lacasse and Lac Thévenet regions, northern Labrador Trough

Cynthia Brind'Amour-Côté (FEMN), Michel Houlé (GSC-Q) and François Huot (UL)

The Montagnais mafic and ultramafic intrusions of the Labrador Trough host several styles of Cu-Ni-PGE mineralization, including reef-style mineralization. As part of this study, the Ceres, Enish, Itokawa, Athena and Paladin showings, which are spread over more than 150 km, were the subject of a petrographic and geochemical characterization to better understand the distribution of their platiniferous mineralization.

Platiniferous mineralization at these showings occurs as small masses of disseminated sulphides (≤ 5% sulphides) associated with large gabbroic intrusions of tholeiitic affinity composed primarily of metagabbronorite exhibiting variable grain size (fine to coarse) and intergranular to subophitic textures. Metapyroxenites were also observed locally, for example at the Paladin showing. The dominant sulphide assemblages consist of chalcopyrite, pyrrhotite and pyrite. Pentlandite (altered to violarite), cubanite and sphalerite are common constituents, although generally secondary. Gersdorffite ([Fe,Ni,Co]AsS), another constituent in these assemblages, was not observed at the Athena and Paladin showings.

Grades from the different showings ranged from 1.6 to 4.8 g/t for platinoids (Pt+Pd), from 0.4 to 1.4% for copper, and from 0.05 to 0.1% for nickel. The Pd/Pt ratios have a broad range of values, from 0.6 to 6.0. Specifically, the ratios were as follows: ≤ 1 for the Ceres and Itokawa showings; ~ 1 for the Enish showing; ~ 2 for the Athena showing; and ≥ 5 for the Paladin showing. The documented platinum group minerals (PGM) are arsenides, tellurides and antimonides. The identified platiniferous PGM, sperrylite ($PtAs_2$), is present at all showings except Ceres. The identified palladiferous PGMs are merenskyite ($PdTe_2$) at the Ceres, Itokawa and Athena showings; temagamite (Pd_3HgTe_3) at the Enish showing; kotulskite (PdTe) at the Itokawa showing; and finally, borovskite (Pd_3SbTe_4) at the Athena showing.

In general, platinoid mineralization at the showings exhibits good correlation between S content and PGEs, which is further supported by petrographic and field observations. Despite the limited amount of available information, there are many apparent similarities between the showing in the northern part of Rivière Koksoak (Ceres, Enish and Athena) and the Paladin showing to the south, which is enriched in Pd.

G43

The Lac Soisson intrusive Suite: A potential extension of the Nain plutonic Suite in the western Core Zone

David Corrigan, Natasha Wodicka (GSC-O), Isabelle Lafrance, Carl Bilodeau and Daniel Bandyayera (MERN)

The Lac Soisson intrusive Suite consists of a swarm of small plutons and plugs of olivine-gabbro, gabbronorite and troctolite composition that were emplaced into Archean to Paleoproterozoic crust of the western Core Zone, west of the de Pas Batholith. These intrusions are non-metamorphosed, locally with unaltered, green olivine visible in hand specimen. They were mapped in detail by the *Ministère de l'Énergie et des Ressources naturelles* (MERN) in 2013 as part of the Lac Saffray mapping project in the Core Zone, and revisited this past summer where a B.Sc. Honours thesis was initiated, supported by the MERN. In 2000-2002, these intrusions had been targeted by the Western Mining Corporation (WMC) as part of their "Quebec-7" Ni-Cu-PGE exploration program along the western margin of the SE Churchill Province. Some of the values reported by WMC range up to 2% chalcopyrite, < 2% pentlandite and 108 ppb PGEs over meter-length sections in drill-core. During our targeted mapping in 2014 we sampled one of the main gabbroic phases of the intrusion for U-Pb dating. The sample yielded abundant, large baddeleyite and zircon crystals, which were analyzed at the Geological Survey of Canada laboratory in Ottawa. Preliminary TIMS results stemming from the baddeleyite ages suggest that the magma was emplaced at 1312 ±1 Ma, slightly younger than the ca. 1333 ±1 Ma Ni-bearing intrusions of the Voisey's Bay complex in Nain. Zircon from the same Lac Soisson sample, however, yields a younger SHRIMP concordia age of 1295 ±11 Ma. Interestingly, some of the Voisey's Bay zircons yield ages that are compatible with baddeleyite ages (1333 Ma), whereas others yield ages that are significantly younger, at ca. 1305 Ma. During the summer 2014, east-west oriented olivine gabbro dykes were also mapped and sampled as part of the regional mapping program. These E-W dykes are parallel to a set of crustal-scale faults and lineaments that appear to be associated to crustal extension related to emplacement of the Nain Plutonic Suite. Some may in turn be feeders to the Lac Soisson intrusions. However, preliminary TIMS results suggest an age of ca. 1270 Ma for one of these dykes. The age correlation shown herein suggests that Ni-Cu mineralized, olivine-bearing mafic intrusions of the Soisson Suite may very likely be related to the Voisey's Bay intrusions but were emplaced more than 300 km to the W-NW of the latter, in the western margin of the Core Zone.

G44

Samapleu and Yepleu dposits of the Yacouba mafic-ultramafic layered complex (Ivory Coast): A new type of NI-CU and PGM sulphide deposits?

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The ultramafic-mafic hosts of the Samapleu and Yepleu Ni-Cu-Pd deposits, recently discovered in Ivory Coast (Western Africa), belong to the Yacouba ultramafic to mafic layered complex that was emplaced during the Proterozoic (2.01 Ga) in the Archean Man craton.

The potentially economic mineralization is characterized by nickel and copper sulphides, principally pyrrhotite, pentlandite, chalcopyrite and pyrite. The mineralization most commonly occurs primarily as disseminations and, locally, semi-massive concordant masses in pyroxenite to dioritic-gabbro host rocks, and less commonly as semi-massive to massive lenses, several metres long, in sharp contact with mineralized host rocks. Platinum group minerals (PGM), principally bismuth-tellurides (Pd, Pt) and sulpharsenides (Rh, Pd), occur with sulphide phases or as individual mineral phases, or as inclusions in sulphide minerals.

The isotopic sulphur data, the Cu:Pd ratios and the R-factor values collectively suggest a mantle origin for these sulphides. Furthermore, the sulphides were likely the product of an immiscible sulphide melt that was contemporaneous with the injection of pyroxenite feeders into the Yacouba Complex (Yepleu), even into Archean granulites and charnockites (Samapleu). In addition, the presence of numerous residual intercalations of charnockitic material, often sheared and partially melted, suggests that the formation by immiscible sulphide melt in the ultramafic-mafic host rocks was influenced and even initiated by the assimilation of crustal rocks containing sulphide minerals (pyrite-chalcopyrite), as was the case for the jotunite-enderbite series intercalated within the Yacouba Complex. The formation of an immiscible sulphide melt appears to have been followed by gravity-driven accumulation and local-scale late-magmatic remobilization of sulphide material, as attested to by micro-veinlets of chalcopyrite and the presence of Pd-bismuthides, Pd-arsenio-antimonides and Pd-arsenides, all of which are indicators of the potential role played by hydrothermal fluids. Finally, P-T equilibria, determined from silicate phases and the composition of associated chromites and spinels, indicate that the ultramafic magmas, like the sulphide melts produced from them, crystallized under MP-HT granulite facies conditions, at depths on the order of 20 to 25 km within Archean continental crust.

Even if the nickeliferous PGM occurrences at Samapleu and Yepleu appear to be comparable to known deposits such as Jinchuan or Voisey's Bay, this latter particularity—slow sulphide crystallization at great depth in Archean continental crust under granulite facies conditions—sets Samapleu and Yepleu apart, perhaps even making them a new type of Ni-Cu-PGM deposit.

G45

Geological synthesis and mineral potential assessment of the Route 167 corridor

Ludovic Bigot, Stéphane Faure (CONSOREM) and Réal Daigneault (UQAC-CONSOREM)

The extension of Route 167, from the Lac Albanel area to the Renard mine held by Stornoway Diamonds, was completed in September 2013 and opens a new access route to the Baie-James region. The corridor along this new road hosts a wide variety of mineral occurrences with gold, silver, copper and zinc, not to mention uranium and diamond; however the area has seen very little exploration and geological data is fragmentary at best. The Eastmain volcano-sedimentary Belt has been the long-standing focus of exploration activities in the region. The bulk of geological knowledge is concentrated in the belt as it is a known metallotect for orogenic gold and Cu-Zn VMS. Areas outside the belt are very poorly known and warrant more attention. The objective of this project is to assess the mineral potential of the entire Route 167 corridor for various commodities.

Based on a methodical approach combining geological compilation and geophysical and geochemical data processing, we have developed a new geological and structural portrait of the Route 167 corridor, at a regional scale and for the Eastmain Belt.

At the regional scale, new geophysical data was used to interpret ductile deformation zones based on geophysical lineaments and magnetic domains, and to define the boundaries of the Opinaca and Opatica subprovinces as they now border the west and south branches of the Eastmain Belt. Recognition of sedimentary units and new greenstone belts is one of the highlights of the project. The surface area underlain by sedimentary rocks has increased 300% and now reaches more than 8,500 km^2. These sedimentary rocks may be part of the Laguiche Complex, a significant assemblage further west. Several greenstone belts, covering more than 120 km^2, were discovered, namely along the extensions of the Eastmain Belt, making these areas new targets of interest for metal occurrences.

For the Eastmain Belt, a new geological framework is proposed. The extent of the belt has been increased by 35% (now covering 879 km^2). The contacts of various geological units were defined in greater detail and many new units were also identified, namely rhyolite-rhyodacite units (covering 19.6 km^2) and felsic intrusions composed of granite, monzonite and syenite (covering 39.7 km^2). Evidence of ductile deformation is predominant throughout the Eastmain Belt; the west and east branches, including proposed extensions, may represent a major ductile deformation zone (unknown kinematics), inferred to be responsible for the current architecture of the belt. Previously, the metamorphic grade of the entire Eastmain Belt corresponded to the amphibolite facies, but rock units in the belt now range from the greenschist to the granulite facies. Greenschist and upper greenschist-facies areas coincide with shear zones, possibly indicating the occurrence of retrograde metamorphism associated with hydrothermal fluid circulation.

Several exploration vectors are proposed for various commodities and different types of ore deposits. Based on metamorphic transition criteria, structural style and lithological settings, eight segments along the corridor are deemed prospective for Éléonore-type gold mineralization, particularly along the south and west branches of the Eastmain Belt. For orogenic gold mineralization, areas of interest covering about 200 km^2 are identified based on the presence of sedimentary rocks (and iron formations) in greenstone belts (or along their margins), associated with deformation zones. Six areas of interest are defined for porphyry Cu-Au systems, based on geophysical criteria, namely demagnetization and circular structures, combined with Cu anomalies in lake sediments. Thirty-three targets are proposed for magmatic Ni-Cu mineralization, given the presence of Ni anomalies in lake sediments.

G46

Quantifying hydrothermal alteration: Methods and data

Lucie Mathieu (CONSOREM), Sylvain Trépanier (Osisko, CONSOREM), Stéphane Faure (CONSOREM) and Réal Daigneault (UQAC)

Methods dedicated to the quantification of hydrothermal alteration are geochemical tools abundantly used to comprehend mineralising processes. These tools are also used by the mining industry to prospect for mineralisation formed by hydrothermal processes. The chemical tools available are numerous and have specific advantages and limitations. Also, some tools are complex, require specific knowledge of the studied area, and are thus used by academic research while being less pertinent in an exploration context. In any contexts, selecting the appropriate method to quantify alteration can be challenging. Amongst the most frequently used chemical tools, we found: 1) mass balance methods that use sampled or modelled fresh precursors (i.e. fresh rocks); 2) alteration indexes calculated from elemental ratios or from normative minerals (and associated binary diagrams); and 3) Pearce Element Ratio (PER) diagrams. In this contribution, these chemical tools will be presented and their advantages and limitations will be discussed, as well as their ability to qualify and quantify alteration while being blind to the variable composition of precursors. Special attention will be paid to the amount of data needed to use these tools, unrevealing which methods are the most pertinent in an exploration context.

G47

Geochemical characterization of indicator minerals for orogenic gold deposits and of glacial sediments in the Val-d'Or region, Québec

Donald Grzela, Georges Beaudoin and François Huot (UL)

Indicator minerals are used in exploration to discover several types of deposits. In the orogenic gold deposits of the Val-d'Or and Cadillac mining camps, the minerals tourmaline, arsenopyrite, scheelite, rutile and magnetite demonstrate potential as indicator minerals. This project aims to define the chemical signature (major, minor and trace elements) of indicator minerals in known orogenic gold deposits in order to compare it with that of glacial sediments in the Val-d'Or region. Mineral chemistry will be determined using an electron microprobe and laser ablation combined with inductively coupled plasma mass spectrometry.

Mineralization in the Val-d'Or mining camp consists of a swarm of gold-bearing veins in which shear veins, tension veins and stockworks are composed of quartz, carbonates and tourmaline. The deposits of Sigma, Goldex, Lamaque, Beaufor and Lac Herbin are examples of orogenic gold mineralization that were sampled during the course of this project. The mineralization of the Lapa mine, situated in the Cadillac mining camp, was also sampled. This orogenic gold deposit is one of the rare deposits found in the Cadillac–Larder Lake Fault Zone. At depth, gold mineralization is associated with arsenopyrite, pyrrhotite and locally pyrite. At surface (≤1 km), native gold is associated with stibnite, aurostibnite and gudmundite contained with veinlets of quartz, dolomite and calcite.

During the Pleistocene, more than 95% of Canada's surface was covered by glaciers. In the Val-d'Or area, ice flow was to the southwest. Five till samples, as follows, were collected along a northeast-southwest transect aligned with ice flow in the Beaufor mine area: one sample in the north, one outside the Val-d'Or camp, three along the transect where it passed through the Val-d'Or camp and one to the south of the Val-d'Or camp in the Pontiac Subprovince.

Grains of tourmaline, scheelite, magnetite and gold were recovered from the till samples. Tourmaline was recovered from the 0.25 to 0.5 mm fraction of the heavy mineral concentrate. The tourmaline content increased from 18 grains in the northern sample to 41 grains in the second sample, before gradually decreasing to 14 grains in the southernmost sample.

G48

Preliminary results: Indicator minerals in orogenic gold deposits

Marjorie Sciuba, Georges Beaudoin and François Huot (UL)

Indicator minerals have specific chemical signatures depending on the type of deposit. As they have the ability to resist chemical and physical erosion, they are preserved in glacial sediments. Indicator mineral studies have become an increasingly important part of mineral exploration. For this project, seven indicator minerals were chosen to represent orogenic gold deposits: arsenopyrite, galena, rutile, scheelite, tourmaline, magnetite and hematite. The main goal is to define the discriminating factors in the major, minor and trace element compositions for a set of samples collected from world-class orogenic gold deposits, such as Dome, Lupin (Canada), Mt Charlotte, Paddington (Australia), Cuiaba (Brazil), Hutti (India) and Obuasi (Ghana). These deposits were selected to cover the full range of variables in orogenic gold deposits, specifically their diversity of geological features such as host rock type and age, intensity of metamorphism (lower greenschist to upper amphibolite) and age of mineralization (Archean to Eocene). The indicator minerals will be studied using polished sections and mineral concentrates produced by electric pulse disaggregation. This method liberates grains along zones of weakness, typically grain boundaries. Indicator mineral composition will be determined by electron microprobe and laser ablation inductively coupled plasma mass spectrometry.

G50

Rare earth characterization of apatites from the Lac à Paul P-Ti deposit, Lac-Saint-Jean Anorthosite Suite

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The study of rare earth elements (REE) in apatites taken from P-Ti-rich zones on the Lac à Paul property, in the Lac-Saint-Jean Anorthosite Suite (1.1–1.0 Ga), should prove useful in determining parent magma composition(s) and for studying fractional crystallization in this type of deposit. It is part of a research program on REE in Québec that was initiated by the DIVEX research network and the MERN.

The Lac à Paul property, currently held by Arianne Phosphate, is at the advanced exploration stage. Ore is nelsonitic peridotite, a rock generally composed of 30–50% iron oxides and 10–25% apatite, with 10–25% olivine. Two mineralized zones are present: the northern zone consists of massive, fine-grained nelsonite containing 7–12% P_2O_5, and the southern zone consists of coarse-grained to macrocrystalline nelsonitic gabbronorite with 4–6% P_2O_5. As part of this study, we will attempt to answer the following questions: Is apatite the main REE host in the ore deposit? Is REE distribution in the apatites homogenous, or, if not the case, what are the factors controlling REE distribution? We will also attempt to determine the petrogenetic relationships between the two mineralized zones and identify the parent magmas, thereby improving our understanding of how this type of ore deposit forms. Microprobe and laser ablation (LA-ICP-MS) analyses were conducted on samples from a stratigraphic section through the deposit, as well as samples from within the same stratigraphic level. Isotopic analyses using the Sm-Nd and Rb-Sr systems were conducted on apatite concentrates to try and determine whether the parent magmas for the two zones under study were cogenetic.

G51

Gold through time in the Val-d'Or district: From Meso-Archean to late Proterozoic!

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The Cadillac – Larder Lake Fault constitutes one of the largest gold provinces in the world. Despite U/Pb, $^{40}Ar/^{39}Ar$, and Sm/Nd isotopic time constraints along the fault, the timing and sources of gold mineralisation remain poorly understood. We report results form an innovative approach in analysing gold mineralisation from the Val-d'Or district, including Goldex, Lac Herbin, Lamaque, and Beaufor mines.

This approach combines detailed mineralogical, geochemical and Re/Os isotopic systematics of sample size-fractions. Breaking down samples into eight size-fractions allows systematic analysis of gold distribution and related alteration minerals. SEM coupled with EDX was used in defining mineralogy of each size-fractions. Isotopic analyses of rhenium and osmium were performed in the GEOTOP laboratories by the isotope dilution technique. The results allowed isochron, model ages and source determinations.

Five rhenium-osmium isochron ages where define for gold mineralisation. The oldest isochron yields an age of 2652 ±6 Ma with an intercept of 1.47 (ppt), indicating a crustal source. The dominant mineral assemblage of the isochron is dravite, pyrite, free gold and calaverite. Interestingly, several model ages from size-fractions defining this isochron yield Mesoarchean ages averaging 2899 Ma. These old source gold occurs only within mines proximal to the Cadillac fault. A second isochron yields an age of 2537 ±10 Ma with an intercept of 20 (ppt), resolutely a crustal source. Schorl-type tourmaline with chalcopyrite, pyrite, and molybdenite constitute the dominant mineral assemblage in relation to gold, which occurs within pyrite as inclusions.This third isochron yields an age of 2466 ±24 Ma with an intercept of 0.28 (ppt). Such a low intercept characterizes ultramafic sources (chromite). Distinctively, in this case gold occurs as intergrowth film with elbaite-type tourmaline of gem quality. A fourth isochron yields an age of 2123 ± 46 Ma with an intercept of 43 (ppt), calling for a highly crustal source. Finally, the last isochron yields an age of 1543 ±73 Ma with an intercept of 1.2 (ppt), calling for a mafic source from pyrite of 60-100µm size-fraction in Beaufor and Lac Herbin mines.

These results imply multiple sources through time for gold mineralisations within the Val-d'Or district. Thus, gold gets younger verging away from the Cadillac fault. Finally, this systematic approach illustrates the potential of the Re/Os system in investigating the significance of gold mineralization during the cratonisation of the Superior Province.

G52

Tourmaline-pyrite assemblages in gold mineralization at the Lamaque mine, Val-d'Or, Québec

Lucille Daver, Christian Sasseville and Michel Jébrak (UQAM)

Gold occurrences along the Cadillac Fault in the Abitibi region exhibit diverse mineral assemblages. The latter are the focus of a major age dating program using the Re-Os method on sulphides. In the Val-d'Or area, these gold occurrences form a metal district that includes nearly a dozen ore deposits. A detailed study of gold mineralization was carried out at the Lamaque mine, in the Triangle and Parallel zones. Mineralized rock samples were crushed, screened and divided into eight size fractions (>1000 µm; >500 µm <1000 µm, >250 µm <500 µm, >100 µm <250 µm; >60 µm <100 µm; >40 µm <60 µm; <40 µm; 2 µm). Heavy and light minerals were separated by density, then analyzed with a binocular microscope and a Hitachi TM3000 SEM coupled with a Bruker Quantax 70 EDX.

The same mineral assemblage was observed in the various locations. However, size fractions reveal distinct compositions for tourmaline and pyrite:

- Size fractions >250 µm contain massive pyrite with diffusion margins and inclusions of calaverite ($AuTe_2$), tellurobismuthite (Bi_2Te_3) and tetradymite (Bi_2Te_2S). It is associated with schorlite (Fe-rich tourmaline) which contains rare inclusions of automorphic molybdenite;
- Intermediate size fractions from 100 µm to 40 µm contain dodecahedral pyrite grains associated with elbaite (Li-rich tourmaline);
- Size fractions <40 µm contain cubic pyrite grains with traces of lead and gold, which are associated with dravite (Mg-rich tourmaline).

The order of crystallization of these tourmaline varieties is as follows: schorlite, elbaite, then dravite. The wide variety of tourmaline reflects the abundance of boron in the mineralization. In addition, observed associations reflect the circulation of iron-rich, then lithium-rich, followed by magnesium-rich fluids. Lithium and boron evoke the existence of a distinct intermediate episode of hypersaline hydrothermal solutions.

G53

A non-plate tectonic model for the Yilgarn Craton, Western Australia – Exploration implications and comparisons with the Superior Craton, Canada

Lyal B. Harris (INRS-ETE) and Jean H. Bédard (GSC-Q)

The Yilgarn Craton, Western Australia, comprises terranes traditionally interpreted as forming and being assembled through subduction-accretion processes, viz. the 3.2-2.6 Ga Narryer & Southwestern, 3.0-2.6 Ga Youanmi, 2.76-2.63 Kalgoorlie and 2.95-2.63 Ga E Yilgarn. The boundaries of Nd model age domains correlate with contacts between the Youanmi and Kalgoorlie terranes portrayed by P-wave seismic tomography. These two terranes host the majority of Au deposits. Komatiite sequences intruded the edges of these distinct continental blocks within mantle plume-related rifts (Mole et al. 2014, PNAS) depicted by enhanced long wavelength gravity images. Major Au deposits overlie rift-related transfer faults. Comparison between seismic profiles and centrifuge models suggests regional folds in the mid-upper crust formed during displacement on extensional shear zones. Rift margins localize subsequent regional sinistral transpressional shear zones which are reactivated and displaced by dextral transcurrent shears; orogenic Au mineralization occurred during both dextral and sinistral shearing. Similarly, Neoarchean granite-greenstone sequences of the Superior Province formed during rifting and fragmentation of terranes that previously constituted a composite Superior I craton. In the Abitibi, broad ductile shear zones however dextrally offset and rotate early N-S structures that may represent rifts or rift-related transfer faults. Conjugate brittle-ductile transcurrent shears formed during bulk N-S shortening displace earlier structures. Recognition of transfer faults is thus far more difficult than in the Yilgarn. Undoing shear displacements portrays a N-S to NNE-SSW elongate, denser/mafic dominated crustal block, interpreted as a > 300 km long oceanic plateau, in which all gold deposits in the Abitibi are situated. The contact between the Abitibi-Opatica 'terranes' of the Superior Province is not marked by a high strain shear zone nor by an abrupt change in metamorphic grade, and the Opatica simply represents basement to the Abitibi (Daoudene *et al.* 2014, MB 2014-04, MERN). Similarly, re-interpretation of seismic and MT data for the Yilgarn Craton shows that the Narryer Terrane is basement to the Youanmi Terrane, instead of being accreted to its NW margin. Field, geochronological, isotopic and geophysical studies in both the Yilgarn and Superior cratons do not support plate tectonic models for subduction and arc accretion for their formation and deformation.

G54

Hypercube®: A new mineral potential assessment tool

Éric Larouche (UQAC), Guillaume Allard (MERN), Réjean Girard, Clément Dombrowski (IOS Services Géoscientifiques) and Réal Daigneault (CERM-UQAC)

In recent years, the development of computerized data acquisition processes has brought about a significant increase in the amount of information accessible to geologists for mineral exploration purposes. It has therefore become quite difficult to analyze such great volumes of data and identify relevant links. Empirical (data-driven) methods consist in processing data to define new models using algorithms to establish links between different sets of variables. The most commonly known tools include support vector machines (SVM), J48 decision tree analysis, neural networks, weight of evidence, fuzzy logic, and the newcomer Hypercube®. Certain algorithms such as weight of evidence are commonly used for targeting purposes in mineral exploration, but each tool has its limits and difficulties. For example, depending on the selected algorithm, it may be difficult to recognize local phenomena, to obtain comprehensible results, or to follow and understand the entire process (black box).

The Hypercube® algorithm, marketed by BearingPoint GmbH, was developed about fifteen years ago to predict accidents and leaks in French nuclear power plants. It is currently recognized as the most efficient algorithm to predict rare events, according to MIT and the Pasteur Institute. Its application in the field of mineral exploration is just beginning and is hindered by the fact that it is not a system that uses spatial referencing. The objective of this project is to develop an interface between this algorithm and a spatial referencing system, in an effort to create predictive mineral deposit maps.

Within the scope of this Master's project undertaken at UQAC with the support of the *Ministère de l'Énergie et des Ressources naturelles* and *IOS Services géoscientifiques*, we will: 1) develop an interface to generate two-dimensional matrices compatible with Hypercube® from the SIGÉOM database; 2) develop an interface or a protocol to import the rules of Hypercube® into a spatially referenced database system; and 3) validate the performance of Hypercube® predictions in an area documented by the MERN.

The selected area for this project focussing on orogenic gold covers NTS sheets 33A, 33B, 33C, 33F, 33G and 33H in the Baie-James region. Preliminary results may be used first to assess Hypercube®'s ability to recognize exploration targets and secondly, to compare its predictions with the results of other existing methods such as those used for mineral potential assessments carried out by the MERN. A summary of the protocol currently being developed is provided.

G55

Characterization of a metamorphosed mafic-ultramafic layered intrusive unit, Core Zone, Southeastern Churchill Province, Nunavik

Pierre-Hugues Lamirande, François Huot, Carl Guilmette (UL), Carl Bilodeau (MERN), David Corrigan and Vicki McNicoll (GSC-O)

During regional surveys carried out by the MERN in the summer of 2015, a metamorphosed mafic-ultramafic layered intrusive unit was mapped. It is located about 80 km northwest of Kuujjuaq, in the Baie aux Feuilles Domain (Core Zone). This unit consists of two main intrusions (13 km × 5 km and 5 km × 3 km) enclosed in felsic to intermediate gneisses of the Kaslac Complex. The age of the intrusions and gneisses remains to be determined.

The dominant phase in this intrusive unit is a magnetite-rich gabbroic protolith where, as a result of metamorphism, centimetre-scale porphyroblasts of poikiloblastic garnet with pyroxene and hornblende rims may reach 50% modal proportion. They are accompanied by 10% to 30% tonalitic mobilizate, suggesting granulite-grade conditions of partial melting. The second most common lithology consists of granoblastic metagabbro exhibiting primary layering in the form decimetre-scale alternating leucocratic and melanocratic layers with a mottled texture, locally cut by boudinaged melanocratic veins. The rock contains up to 25% centimetre-scale porphyroblasts of poikiloblastic garnet, spatially associated with clinopyroxene and hornblende. Locally, small millimetre-scale garnets form rims around mafic minerals. These lithologies are accompanied by an assemblage of locally layered, garnet-free gabbros, gabbronorites and norites. Pyroxenite and peridotite are very minor components. The intrusive unit is largely injected with orthopyroxene-bearing felsic rocks and feldspar-phyric granitoids, forming parallel metre-scale bands and locally, magmatic breccias within the various mafic facies.

The objective of this project is to characterize the various facies that were mapped and determine the nature of the metamorphism, specifically if some of the observed assemblages are the result of early metasomatism. To do so, a detailed petrographic study (parageneses, mineral associations, reactions and compositional mapping) will be conducted. A lithogeochemistry study, thermobarometric calculations and age dating analyses (U-Pb on zircons and Lu-Hf on garnets) will complete our observations. Ultimately, we intend to propose a geodynamic setting of emplacement to establish if the intrusion constitutes the roots of a former magmatic arc or if it is associated with a Precambrian crustal extension event.

G56

Provenance analysis in the north of the Labrador Trough, Nunavik: Contributions from geochemistry of metasediments, U-Pb dating of detrital zircons and Sm-Nd systematics

Renato Henrique-Pinto, Carl Guilmette (UL), Carl Bilodeau (MERN), David Corrigan and Vicki McNicoll (GSC-O)

The Labrador Trough (LT), a Paleo-Proterozoic (2.17 -1.87 Ga) fold-and-thrust belt located in Nunavik, Canada, is famous for hosting numerous iron ore world-class deposits (e.g., Sokoman Formation) and several base metal deposits (e.g., Cu-Zn-Pb in metavolcano-sedimentary rocks; Cu-Ni in Montagnais Sills). The LT is part of the Paleoproterozoic New-Quebec Orogen, a supra-crustal belt separating the Archean Superior Craton from the Core-Zone, an Archean micro-continent (?) that underwent significant reworking during the Trans-Hudson Orogeny. The New-Quebec Orogen is subdivided as three NW-SE-trending domains: (1) western autochthonous low-grade volcano and sedimentary rocks (Kaniapiskau Supergroup, LT *per se*); (2) the central (allochtonous ?) Rachel-Laporte Zone (RLZ), consisting of medium to high-grade meta-volcano sedimentary rocks of poorly constrained origin; and (3) easternmost high-grade schists and gneisses possibly belonging to the Core-Zone.

Within the LT, two main meta-volcanoclastic cycles are recognized (2.17-2.14 Ga and 1.88-1.87 Ga). However their source area composition, sedimentary depositional environments and geodynamic significance are still unclear. Moreover, a third cycle interpreted as a "synorogenic molasses-type basin" uncomformably overlying the previous sequences remains poorly studied.

Previous studies have highlighted similarities between protoliths from the RLZ and the LT (e.g., thick platformal turbiditic units interlayered with metabasic rocks and subordinated metadolomites, metaquartzarenites and metamarls), suggesting that these two domains are correlated. However, the recent description by the MERN (2015) of metapsefitic units in both domains showing distinct sedimentary petrofabric and clast varieties might rather indicate different sources for the two domains. Polimyctic clast-supported metaconglomerates from the western autochthonous low-grade belt show a predominance of rounded blue quartz crystals, granites and intermediate igneous rock clast population, supporting a Superior Craton provenance, whereas polimyctic matrix-supported metaconglomerates from the RLZ (central belt) show a predominance granitic and gneissic clasts and boulders, which could be indicative of a Core Zone origin.

Following this discovery, we propose an investigation of LT and RLZ metasediments using whole-rock geochemistry, U-Pb detrital zircon dating and Sm-Nd isotopic systematic in order to determine the composition of potential source areas, as well as the nature of the basin(s) and their related paleo-environments. Whether the RLZ supra-crustals were deposited a) on the Superior margin like the LT units, b) on the Core Zone margin, or c) as an exotic terrane, would have implications for both the correlative economic potential of the RLZ and for the proposition of geodynamic models for the evolution of the Superior margin and of the Core-Zone during the Trans-Hudson Orogeny.

G57

An orbicular gabbro in the Labrador Trough

Simon Nadeau (UQAC) and Carl Bilodeau (MERN)

Mapping conducted by the *Ministère de l'Énergie et des Ressources naturelles* (MERN) in the Labrador Trough in the summer of 2015 has led to the discovery of two outcrops of orbicular-textured gabbro. The rock contains leucocratic spheroids consisting of concentric layers of contrasting mineralogy and texture around a generally coarse-grained central core. These outcrops are located within the Rachel-Laporte lithotectonic Zone, an important volcanosedimentary terrane that forms the eastern part of the Labrador Trough. Specifically, they are located near the western (Kaniapiskau Supergroup) and eastern (Core Zone) boundaries of the Rachel-Laporte Zone, both characterized by an abundance of mafic intrusions.

A preliminary examination of hand samples reveals the presence of centimetre-scale zoned quartzofeldspathic nodules with roughly 50/50 proportions for the two phases. Visually, the core appears to be compositionally different from the external rings, and a reaction rim was observed in many hand samples. The groundmass around the orbicules consists of melanogabbro, composed of black acicular amphibole, commonly encountered in most mafic rocks in the Rachel-Laporte Zone. Orbicules in the orbicular gabbro outcrop located near the western boundary of the Rachel-Laporte Zone show no evidence of significant deformation, whereas the gabbro exposed near the eastern boundary of the Rachel-Laporte Zone, near the frontal thrust of the Core Zone, shows orbicules that have undergone significant stretching, and concentric zoning is not as apparent in this location. However, the melanocratic groundmass is similar in both outcrops, and fine-grained amphibole is observed growing around the edges of orbicules.

The main objective of this project is to characterize, geochemically and petrographically, this atypical gabbroic unit to establish its genesis. Various hypotheses have been proposed to explain the peculiar texture of this rock unit, namely liquid immiscibility between two magmas, assimilation of felsic xenoliths into the gabbro, or a fractional crystallization process. Eighteen samples were collected for geochemical analyses and fifteen thin sections are in preparation, in an attempt to solve the mystery. Microprobe analyses are also planned to establish the distribution of elements in the orbicules and their groundmass. A comparison of results from the two outcrops will help determine the geological significance of this gabbro within the regional geodynamic setting, and provide insight on the history of this little-known part of the Labrador Trough.

G58

Southeastern Churchill transect: Tectonometamorphic evolution and geodynamic implications

Antoine Godet, Carl Guilmette (UL) and Loïc Labrousse (Université Pierre-et-Marie-Curie)

The Southeastern Churchill Province (SECP) in Nunavik is delimited to the west and east by the Archean cratons of the Superior and North Atlantic, respectively. It is defined as a tripartite structure, with an Archean block called the Core Zone (CZ) positioned between the Paleoproterozoic Torngat Orogen (TO) to the east and the New Québec Orogen (NQO) to the west. The current geodynamic model suggests that prior to 1.88 Ga, the CZ represented a microcontinent bordered by oceans to the west and east. An episode of oblique convergence resulted in the accretion of the CZ to the North Atlantic craton, creating the TO (1.87–1.82 Ga), followed by a collision with the Superior craton, creating the NQO (1.82–1.77 Ga). Based on age dating, episodes of deformation contemporaneous with the NQO took place in the TO. The interpretation is that the CZ acted as a rigid block between the two cratons, setting the scene for limited Proterozoic tectonometamorphic overprinting, and implying that the widespread migmatization of the CZ predates the collisions.

However, recent petrochronologic studies in the TO suggest that the predominant tectonometamorphic episodes recorded in the eastern margin of the CZ are Paleoproterozoic, thus implying burial contemporaneous with the TO. If this finding is valid for the entire CZ, then the migmatization, contemporaneous with the TO, would have considerably weakened the CZ crust, rendering the rigid block model unlikely. A competing model suggests that the SECP may represent a single orogenic phase (1.97–1.77 Ga, Trans-Hudsonian) extending over more than 400 km, and may be similar to a Large Hot Orogen (LHO) that led to the development of the CZ.

The project, integrated into an ongoing mapping project conducted by the *Ministère de l'Énergie et des Ressources naturelles*, aims to document a transect from the Superior craton to the North Atlantic craton in order to constrain the tectonometamorphic evolution of the region. Field observations will be combined with aeromagnetic data and a petrochronologic study integrating phase equilibrium modelling methods (U-Pb on zircons and monazites, as well as Lu-Hf and Sm-Nd on garnets) presented as P-T-t-D paths. This method, applied to anatectic domains, can not only be used to determine prograde and retrograde metamorphic ages, but also the residence time of the CZ under partial melting conditions. Finally, comparisons between the P-T-t-D paths and numerical thermomechanical models will allow a deeper understanding of the tectonic processes responsible for the evolution of the SECP.

G59

Crustal growth history of the Core Zone: New U-Pb zircon constraints from the GEM-II Hudson-Ungava project

David Corrigan, Natasha Wodicka (GSC-O), Chris McFarlane (UNB), Isabelle Lafrance, Daniel Bandyayera and Carl Bilodeau (MERN)

The Core Zone has recently been the target for new geoscientific mapping by the *Ministère de l'Énergie et des Ressources naturelles du Québec* (MERN), with systematic mapping at 1:250,000 scale expected to be completed within the next few years. In the summer 2014, the Geological Survey of Canada initiated collaborative research with the *Ministère de l'Énergie et des Ressources naturelles* (MERN) and Newfoundland and Labrador Geological Survey, through the national Geo-mapping for Energy and Minerals (GEM-2) program, with the goal of complementing research initiatives and enabling geological correlations at a broader scale, in Labrador and Nunavut. This poster presents one component of this collaboration, which is the generation of a number of high-precision U-Pb zircon, badelleyite, monazite and titanite analyses on selected protoliths that will greatly improve our understanding of the crustal growth history of the Core Zone, as well as its tectono-metamorphic evolution. Results so far have permitted the delineation of three distinct crustal blocks of different composition and age, bounded by zones of high strain. From west to east they consist of: *i)* A Neoarchean-age block that includes the a ca. 2.7 Ga Tunulik belt greenstone belt and associated intrusions, recently identified by the MERN during 2013 and 2014 field seasons; *ii)* An earliest-Paleoproterozoic-age block that includes the Ntshuku volcanics and Pallatin intrusions, consisting predominantly of juvenile ca. 2.50-2.35 Ga crust that includes mafic to potassic plutonic complexes, as well as predominantly mafic volcanic and siliciclastic rocks, and *iii)* ca. 3.2 to 2.6 Ga migmatites and orthogneiss of granitic to tonalitic composition forming the Ungava Complex. The George River shear zone and Moonbase shear zone appear, at first glance, to separate these three crustal domains. The isotopic dating has also helped define a new ca. 2.38 Ga intrusive suite that forms large map-scale tectonized blocks in the Ntshuku domain. These yet-unnamed intrusions are predominantly gabbroic but include syenite, clinopyroxenite, monzogabbro, monzodiorite and k-feldspar megacrystic diorite (granodiorite?) locally with rapakivi texture. They are also characterized by the presence of blue quartz and are locally cut by orthopyrozene-bearing pegmatite, also containing blue quartz, all suggestive of high-temperature, predominantly anhydrous conditions of emplacement. We postulate that this mafic to potassic mafic magmatic suite may have produced an initial metasomatic enrichment in the upper mantle-lower continental crust, favoring further enrichment and eventual formation of the Strange Lake REE deposit during a second magmatic event, about 1 Ga later, during the Mesoproterozoic.

G60

Interpretation of new aeromagnetic data and implications for geothermal power from a suite of radiogenic units beneath the Appalachian sedimentary cover

Aurélie Gicquel, Lyal Harris (INRS-ETE) and Pierre-Arthur Groulier (Memorial University of Newfoundland)

Radiometric measurements in the Escoumins region of eastern Grenville Province, north of the Saint-Lawrence River, yielded elevated values (of uranium, thorium and potassium) in pegmatites (uraniferous or allanite-bearing pegmatites) found mainly in granitic domains. The aeromagnetic signature changes according to bedrock type: higher values in granitic areas and lower values in areas of quartzite. The radiogenic units were affected by ductile dextral strike-slip faulting along a 040° direction, parallel to the St. Lawrence River. The new aeromagnetic data indicate that these dextral strike-slip faults continue to the other side of the river, as do the uranium- and thorium-rich units, where they would correspond to more mature areas of sedimentary rocks (sandstones, quartzites, conglomerates and limestones of Cambrian to Ordovician age) on the south side of the St. Lawrence. The continuation of these units beneath the Cambro-Ordovician sedimentary rocks of the St. Lawrence Lowlands could result in locally higher temperatures, making it a potentially favourable setting for geothermal energy.

G61

New geological data on the Escoumins volcano-sedimentary belt and its surroundings: NTS 22C05, 22C06 and 22C11

Pierre-Arthur Groulier, Aphrodite Indares, Greg Dunning (Memorial University of Newfoundland), Abdelali Moukhsil (MERN) and Lyal Harris (INRS-ETE)

The 2015 mapping program covering the southern part of the central Grenville Province in Québec (NTS map sheets 22C05, 22C06 and 22C11) improved the documentation of the Escoumins volcano-sedimentary belt (EVSB), which has recently been recognized as the vestige of a Pinwarian back-arc system (1493 ±3 Ma). The rocks of the EVSB mostly belong to the Saint-Siméon Group, which is subdivided into three formations: an assemblage of metapelite, greywacke and quartzite at the base (Saint-Paul-du-Nord); a mafic volcanic sequence that becomes bimodal toward the top, with a predominant felsic component (Moulin-à-Baude); and, at the summit, an assemblage of quartzite-greywacke interbedded with sills and basaltic flows (Port-aux-Quilles). To the west, structurally below the Saint-Simeon Group, lies the Tadoussac Complex (gabbro, gabbronorite, diorite, tonalite, granodiorite and granite), which may represent a subvolcanic batholith at the base of the Saint-Simeon Group.

Our work revealed more recent intrusions within and adjacent to the EVSB, some aligned with the regional structural grain, some not. Among them is a suite of potassic to ultrapotassic alkaline intrusions, oriented north-south, that appear to follow a zone of crustal weakness. The EVSB was metamorphosed to amphibolite facies, locally exhibiting low-pressure granulite facies conditions along its margins.

From a structural viewpoint, the supracrustal rocks are found in synforms separated by shear zones and by domes of intrusive rocks, some related to the Tadoussac Complex. Structural data and magnetic gradient maps reveal at least three phases of pre-Grenvillian to Grenvillian deformation: D1 associated with a N-S compression phase, D2 associated with isoclinal faults oriented N-S, and D3 associated with open folds oriented E-W. These structures are cut by brittle faults related to the Saguenay and Saint-Lawrence grabens.

The economic potential of the belt is significant based on our discovery of several new targets in volcanic rocks (presence of disseminated sulphides) and intrusive subvolcanic rocks (presence of primary magmatic sulphides), as well as later mineralization (sulphide veins, molybdenite dyke) and a mineralized breccia associated with a brittle fault of the Saint-Lawrence graben. Different types of alteration were also identified: argillic in felsic components of the volcanic sequence, and sericite-chlorite-garnet-carbonate-quartz-epidote-cordierite-biotite in mafic components, which indicate a potential for VMS deposits. Finally, granitic facies with sillimanite-magnetite nodules and veins indicate IOCG-type alteration (iron oxide-copper-gold deposits).

G62

Strategic metal resources for the 21st century: The natural and anthropological metal cycle

Laurie Wolff, Michel Cathelineau and Anne-Sylvie André-Mayer (Université de Lorraine, France)

Global population growth (an estimated 9 billion people by 2050), the boom in and spread of new technologies and the growing needs of emerging economies such as China and India, are all contributing to an ever-increasing demand for rare metal resources. Given the potential threats to the supply of these metals (risk of disruption or shortages), the development of techniques and strategies for recycling metals has become a major economic and geopolitical challenge for all European countries. Unfortunately, recycling alone is not sufficient, and securing access to raw materials is essential. To meet the challenges that lie in strategic metal supply, the Laboratory of Excellence "Strategic Metal Resources in the 21st Century - RESSOURCES21" has brought together a multidisciplinary team of researchers from the geoscience department of the University of Lorraine, the French National Center for Scientific Research – CNRS, and the French National Institute for Agricultural Research – Inra.

The LabEx RESSOURCES21 research project represents an integrated scientific and educational approach for the understanding, exploitation and environmental management of strategic metal resources for the 21st century.

RESSOURCES21 addresses many challenges in terms of geology, mineral processing or environmental and ecotoxicological impact. Particular emphasis is placed on understanding the processes that lead to the formation of metal deposits, developing innovative tools for ore processing, and enhancing our understanding of the environmental impact of these metals once scattered throughout the ecosystem.

In the context of investigating the processes of metal concentration, the LabEx RESSOURCES21 teams are focusing their research on several groups of metals: metals required for use in the photovoltaic sector (Ga, Ge, In); rare metals associated with felsic peraluminous magmatism (Nb, Ta, Sn, W); concentrations of metals in laterites developed on ultrabasic rocks (Co, Sc).

The LabEx RESSOURCES21 team is currently developing two main integrated projects from source and exploration to environmental issues:

- **Life cycle of Ni and related chemical elements (Co, Sc, Mn) – program 2014-2017 (900.000€ excluding salaries)**

The studies proposed in this project aim to contribute to a better understanding of the behaviour of the Ni-Co-(Sc) system and the lithospheric and biogeochemical cycles of these metals.

- **Rare Earth Elements REE and associated metals (Nb-Ta, U-Th) - program 2015-2018 (900.000€ excluding salaries)**

This program is dedicated to the study of rare earth elements from their concentration in the crust to their environmental impact in the Proterozoic Grenville province (Québec).

G63

REE transfer from the mantle to the birch tree: An example from the Proterozoic Grenville Province, Québec

Laure Giamberini and Anne-Sylvie Andre-Mayer (Université de Lorraine, France)

This research program, part of RESSOURCES 21 and associated with the DIVEX Rare Earth Project, proposes to study, in the same location, rare earth elements (REE) over a significant proportion of their life cycle, from exploration for new deposits to pre-mining environmental analyses.

This is both a multidisciplinary and interdisciplinary project, involving aspects of structural geology, isotope tracing, geochemistry, petrology, pedology, ecology, ecotoxicology, molecular biology, basic data processing and biostatistical analysis. This global approach will enable us to study REE from their primary fractionation in the mantle-continental crust, the weathering/alteration of REE-bearing minerals (carbonates and silicates), their release in soils, and their presence in aquatic systems, in parallel with a study of REE-bearing phases.

The area of interest is the Grenville Province for the following reasons:

- It encompasses a segment of lower to intermediate continental crust where primary REE fractionation in the mantle-crust may be investigated;
- It contains numerous REE anomalies in magmatic rocks, occurring in the form of both silicates and carbonates, and in alkaline to hyperaluminous rocks;
- It hosts a number of mineral exploration prospects where anomalous REE-bearing magmatic zones may be studied in 3D;
- It is overlain by soils that developed above these anomalous rocks prior to mining activities, where the baseline distribution of REE may be determined in the critical zone;
- It is located in a northern climate where weathering/alteration mechanisms on primary REE-bearing minerals may be studied, namely solubility and critical alteration mechanisms (hydrolysis, etc.) whereby REE are released in the soil.

At the mantle-crust level, a comparison will be made with a segment of upper continental crust containing magmatic REE anomalies (although not considered economic) in order to trace extreme fractionation processes: Oldoinyo Lengai in Tanzania.

At the soil and aquatic level, ecotoxic thresholds will be determined for microbial and vegetation populations and for certain aquatic invertebrate species selected within natural study areas in Québec. Innovative cellular and molecular biology approaches will be used to determine the impact of REE on the environment in an integrated fashion, from the molecular scale to that of an ecosystem. These geological and ecotoxicological studies will take place in parallel with the development and testing of sensors designed to measure the total and available metal content in systems studied in the laboratory and *in situ*.

G64

Rare earth occurrences related to late-orogenic peraluminous pegmatites, Grenville Province, Québec

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The history of the Grenville Province in Québec begins with an accretionary phase in the Mesoproterozoic, along the southeast margin of Laurentia, followed by the Grenvillian orogeny from 1090 to 1020 Ma in the Allochthon (Ottawan phase) and from 1005 to 980 Ma in the Parautochthon (Rigolet phase), leading to the thrusting of terranes accreted onto Laurentia's margin. This province is characterized by a large number of alkaline and hyperalkaline complexes, syenites and carbonatites, but also by the presence of rare earth-enriched pegmatite dyke swarms. These characteristics make it a target of choice for the study of magmatic rare earth mineralization.

The Lac Okapeo area (Côte-Nord, south of Manicouagan crater, Québec) is located in the Allochthonous belt and is particularly rich in rare earth-bearing pegmatites. The dykes originate in metasedimentary rocks or in migmatitic igneous complexes representing intermediate to upper crust that underwent partial melting during an episode of metamorphism under P-T conditions reaching the granulite facies. Field observations indicate that mineralized dykes are not deformed and cross-cut the foliation in country rocks, proving the late-orogenic timing of these pegmatites. This is also confirmed by U-Pb age dating analyses on zircons, which yielded ages of about 1005 Ma, *i.e.* at the start of the Rigolet phase.

Differences in the country rocks, mineralogy and composition of the dykes are observed. Although all pegmatites show a hyperaluminous S-type granitic signature, their rare earth profiles vary, from practically no evidence of fractionation between light and heavy rare earths with a positive Eu anomaly, to strongly light rare earth-enriched (up to about 7,400 ppm) profiles with a negative Eu anomaly. The positive anomaly may be explained by the predominance of plagioclase rather than potassic feldspar in the specific dyke under study.

The dykes also exhibit different rare earth-bearing phases. Mineralization occurs in the form of allanite in dykes emplaced in igneous complexes, whereas monazite is exclusively found in pegmatites emplaced in metasedimentary complexes. Late-magmatic rare earth-bearing carbonates and silicates are also present in both settings.

Complementary isotopic analyses, to determine the model age of extraction (εHf[t]), will help determine if these pegmatites are derived from melting in the Allochthon, thus calling into question the lower limit of regional metamorphism in this part of the orogen, or from melting of the Archean margin, which underwent thrusting and remobilization during the Grenvillian orogeny (Parautochthon).

G65

Impact of an anorthosite pluton on the structure of an orogenic channel in the Parautochthonous belt to the southwest of the Manicouagan Reservoir, central Grenville Province, Québec

Sophie Jannin, Félix Gervais (Polytechnique Montréal) and Abdelali Moukhsil (MERN)

The tectonic evolution of the Parautochthonous belt, composed of rocks of the North American craton and its sedimentary cover that were deformed and metamorphosed by the Grenville orogeny, remains controversial. In the eastern Grenville, field data formed the basis for an orogenic wedge model. In contrast, in the western Grenville, the concordance between the geometry of observed crustal structures and that of structures generated by numerical models supports the proposal of an orogenic channel. Reactivation through normal movement of the Allochthon Boundary Thrust (ABT), which separates the Parautochthonous belt from the underlying Allochthonous belt, occurred during the exhumation of the former.

New structural and geochronological data from south of the Manicouagan Reservoir, in the centre of the Grenville Province (an area mapped by the MERN in 2011), corroborates the channel flow hypothesis. Normal shear zones observed in the hanging wall of the parautochthonous sheet and along the Thachic Shear Zone (TSZ) in the allochthonous sheet were synchronous with reverse deformation in the lower structural levels of the parautochthonous sheet. This orogenic channel, active between 993 ±3 Ma and 961 ±22 Ma, would have thus contained a portion of the parautochthonous sheet only in the western part of the study area, whereas in the eastern part, it would have contained a portion of the parautochthonous sheet and the base of the allochthonous sheet.

This study provides an explanation for these observations thanks to the results of airborne magnetic surveys conducted by the MERN in 2012. The first vertical derivative and the tilt derivative applied to these surveys revealed, to the east of the study area, that the TSZ in the Allochthonous belt is composed of several anastomosing segments. Farther west, near the Tétépisca anorthosite intrusion (1051 ±8 Ma), the segments reconnect; after some distance, they cut the ABT and continue into the Parautochthonous belt, not the Allochthonous belt. Thus, the Tétépisca anorthosite influenced the TSZ geometry and hence the geometry of the orogenic channel. The ABT is also affected by this anorthosite, becoming curved in close proximity and changing its dip from SE to vertical or to the north. As a result, the Tétépisca anorthosite appears to have had an effect on the major structures of the region. During the Grenville orogeny, it must have acted as a rigid pluton around which deformation adapted.

G66

Origin of sillimanite-bearing quartzofeldspathic rocks at Lac Manouane, Grenville Province, La Tuque, Québec

Pierre-Henri Trapy, Félix Gervais (Polytechnique Montréal), Louise Corriveau (GSC-Q) and Abdelali Moukhsil (MERN)

The Grenville Province in the Parent region is currently the focus of an extensive mapping program at a scale of 1:125,000 by the *Ministère de l'Énergie et des Ressources naturelles* (MERN). It encompasses units of the Wabash Complex interpreted as metasedimentary and metavolcanic, which locally include rocks with unusual mineral assemblages, modal compositions or textures. The latter may indicate the presence of a metamorphosed hydrothermal unit, in an area where intense metamorphism and deformation has made it quite complex to recognize protoliths and their alteration facies. At Lac Manouane, a heterogeneous gneissic gabbronorite unit with clinopyroxenite enclaves locally transformed into zinc-rich diopside-bearing garnetite as well as atypical quartzofeldspathic gneisses contrast with adjacent units of the Wabash Complex and orthogneisses of the Lacoste magmatic Suite. The quartzofeldspathic rocks form a succession over a hundred metres thick, consisting of a decimetre-scale band with granoblastic plagioclase and biotite overlain by massive quartz-rich quartzofeldspathic rocks with garnet and millimetre-scale sillimanite layers. This succession, along with clinopyroxenite and garnetite horizons in the gabbronorite, are parallel to the gneissic fabric and are good deformational markers. A doctorate study, undertaken in parallel with the MERN project, will involve detailed mapping and a multidisciplinary study of these formations and will likely shed light on the emplacement setting of the protoliths.

G67

Geology of the Clova area, Western Grenville, Québec (NTS 31O11, 31O12, 31O13, 31O14, 32B03 and 32B04)

Abdelali Moukhsil, Fabien Solgadi (MERN), Saïd Belkacim and Thomas Clark (URSTM-UQAT)

A new geological survey was conducted in the Clova area, located southwest of Gouin Reservoir in the Haut-Saint-Maurice region. The results, combined with the recent high-resolution aeromagnetic survey, enabled us to identify and delineate several geological units and interpret various structural discontinuities in the Grenville Province.

The map area is subdivided into parautochthonous (Archean) and allochthonous (Paleoproterozoic to Mesoproterozoic) zones. The Parautochthon encompasses biotite ± garnet ± graphite ± sillimanite ± kyanite paragneisses (equivalent to the Lac Témiscamingue Terrain in the Pontiac Subprovince), migmatites, diatexites, amphibolites, clinopyroxenites, iron formations (oxide, silicate, chert), and garnet-clinopyroxene-rich mafic to ultramafic rocks (equivalent to Abitibi Subprovince greenstones) referred to as garnetites ("pyrigarnite" ± plagioclase). The metamorphic grade reaches the amphibolite facies with mineral assemblages containing hornblende + plagioclase + garnet + clinopyroxene ± quartz in mafic rocks and sillimanite + biotite ± kyanite ± muscovite in paragneisses. The Allochthon comprises Labradorian (Dugré Suite; 1674 Ma) and Pinwarian (Hibbard Suite, 1468 Ma) plutonic rocks including opdalite, enderbite, charnockite, jotunite and monzodiorite; the Elsonian (1450 to 1365 Ma) Lacoste magmatic Suite consisting of orthogneiss, monzogranite, diorite and tonalite; Elsonian supracrustal rocks such as the Wabash Complex (<1.20 Ga) and the Ascension Suite (<1.28 Ga) formed of garnet ± graphite ± sillimanite paragneiss, quartzite, marble, calc-silicate rocks and minor amounts of (felsic to mafic) garnetite; the Bouchette Suite composed of gabbronorite, gabbro and minor amounts of anorthosite and leuconorite; the Cabonga metamorphic Suite consisting of graphite ± sillimanite paragneiss and magnetic syenite with clinopyroxene and biotite, associated with gabbronorites, pyroxenites and olivine websterites of the Roc Suite. Rock units in the Allochthon are metamorphosed to the prograde medium-pressure granulite facies (orthopyroxene + clinopyroxene + plagioclase + garnet in mafic rocks and sillimanite + garnet + K-feldspar + quartz in biotite paragneisses), but have locally undergone retrograde metamorphism at the amphibolite facies (amphibole + plagioclase + garnet). All rock units within the map area are intruded by granitic pegmatite dykes and mafic dykes.

Metamorphosed hydrothermal alteration zones were identified in many different parts of the region. They consist of quartzofeldspathic gneisses with pyrite, pyrrhotite and traces of chalcopyrite; nepheline gneisses associated with carbonate rocks and syenite (Lesueur alkaline Suite, 1006 Ma); garnet-rich mafic rocks (garnetite, amphibolite); and whitish sillimanite-garnet-bearing felsic rocks.

Rock units in the area are strongly deformed and exhibit isoclinal folding and dome-and-basin structures. The interpretation of aeromagnetic maps enabled us to trace major faults, most of which were also observed in the field. In addition to the Allochthon Boundary Thrust (ABT), these faults correspond to discontinuities: reverse, normal and oblique faults as well as shear zones. They generally form wide mylonitic corridors trending NNE-SSW to E-W.

In addition to previously known mineral occurrences (*e.g.*, Langlade), the mapping survey resulted in the discovery of several exploration targets for mineral commodities such as rare earth elements, iron oxides, titanium, phosphate, nickel and copper, as well as architectural stone and industrial minerals (graphite, sillimanite). The recognition of metamorphosed hydrothermal alteration zones (garnetites) and the presence of Archean iron formations suggest the region's mineral potential may have been underestimated.

G68

Geology and economic potential of the Lac Jeannin region, Southeastern Churchill (NTS 24B)

Isabelle Lafrance and Benoit Charette (MERN)

This new 1:250,000 geological survey was conducted in the summer of 2015 in the Lac Jeannin area, roughly 200 km north of Schefferville. Situated in the southeastern part of the Churchill Province, the mapped region includes the Core Zone and the Rachel-Laporte Zone, the latter of which is considered the metamorphosed equivalent of the Labrador Trough.

The Core Zone represents ancient Archean craton, deformed and remobilized in the Paleoproterozoic during the New Québec and Torngat orogenies to the west and east, respectively. In the study area, the main units of the Core Zone are the following: tonalite, granite and granodiorite gneisses; migmatitic rocks ranging from metatexites to anatectic granites, much of which appears to have had a sedimentary protolith; metasedimentary rocks; Paleoproterozoic felsic to intermediate intrusions that disrupt the regional tectonometamorphic fabric; and late multi-kilometre intrusions of gabbro and ultramafic rocks. The Rachel-Laporte Zone is primarily composed of metasediments, metabasalts and metagabbros. Lithologies similar to those of the Core Zone were also observed, such as a deformed granodiorite porphyry in the northern part of the region, as well as Wheeler Dome gneisses and migmatites in the southern part. These lithological assemblages may represent thrust faults.

Several mineralized zones, tens to hundreds of metres wide, were observed in the mapped region. The sulphide-bearing sites in the Rachel-Laporte Zone are of particular interest because their settings are similar to those of showings found in the less metamorphosed volcano-sedimentary sequences of the Labrador Trough. Mineralization also occurs as fine disseminations and veinlets of pyrrhotite + pyrite ± chalcopyrite in metabasalts, metasediments, metagabbros or graphitic argillites. Several semi-massive to massive sulphide zones, tens of metres wide by hundreds or more than a thousand metres long, were also discovered in the volcano-sedimentary sequences. Fragmentary facies were noted in the massive sulphides. In the Core Zone, several rusty zones of disseminated sulphides were found in different rock types, namely: 1) variably migmatized and locally graphitic paragneiss; 2) mafic to ultramafic intrusions exhibiting local evidence of hydrothermal alteration and remobilization; 3) a strongly altered volcanic sequence (epidote + potassium feldspar); 4) a late intermediate to felsic intrusion; and 5) amphibolites associated with metasedimentary rocks.

G69

The geological potential of limestone, dolomite and marble in Québec

N'golo Togola (MERN)

The carbonate units of the Paleozoic St. Lawrence Lowlands Platform and the Appalachian Province not only represent important sources of aggregate material, but also contain workable layers of high-purity limestone and dolomite that can be used for industrial purposes or as soil amendments.

In the **Appalachian Province** of southern Québec, the finely crystalline **limestone** units of the Corey and Lambton formations (Philipsburg Group), the microcrystalline limestone of Stries Pond (Philipsburg Group), as well as the limestone units of the Bonsécours Formation, constitute the main source of limestone with high calcium contents. The **limestone** units of the Deschambault Formation (Trenton Group) in the **St. Lawrence Lowlands** also represent another noteworthy source of limestone with high calcium content.

The **dolomite** units of the White Brook and Dunham formations (Oak Group), and the formations of Morgan Corner, Wallace Creek and Rock River (Philipsburg Group), as well as the dolomitic limestone of the Sayabec Formation (Chaleurs Group), constitute an attractive source of rock for the production of agricultural amendment with high magnesium content (Petryk 1987, Jacob and Petryk, 1989). In the **St. Lawrence Lowlands**, dolomites of the Beauharnois Formation (Beekmantown Group) may also constitute an interesting source for the production of agricultural amendment with high magnesium content (Petryk 1987, Jacob and Petryk, 1989).

The **Grenville Supergroup** contains calcitic or dolomitic marble that form narrow, irregular bands of homogenous composition. These marbles have a high degree of whiteness with very few impurities. Exploitable layers may be used to produce white aggregate, agricultural lime and industrial limestone with high calcium content (Jacob, 1987). The **calcitic and dolomitic marble** units associated with metasedimentary rocks of the Grenville Supergroup (Grenville Province) have good potential for the production of mineral fillers or soil amendments. Generally, these marble units contain less than 90% carbonates (Jacob, 1987). The calcitic marble units may constitute a potential source of high-purity calcite for the production of mineral fillers, whereas the dolomitic marbles with high magnesium content could be used as soil amendments.

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G70

Geology and economic potential of the northern part of the Labrador Trough and the Rachel-Laporte Zone, Kuujjuaq region (NTS 24K)

Carl Bilodeau (MERN)

A new geological survey was conducted in the summer of 2015 in the north-central part of the Labrador Trough, roughly 60 km northwest of Kuujjuaq. The region is located between the Superior Province to the west and the Core Zone to the east, as well as Rivière Koksoak to the south and Lac aux Feuilles to the north. Project objectives were to improve the existing geological map for this part of the Labrador Trough and the tectonic Rachel-Laporte Zone, and to investigate the mineral potential of this region known for its nickel, copper, platinum and gold mineralization. Related research included the analysis of detrital sources using sedimentary rock geochemistry, U-Pb dating on zircons and Sm-Nd analysis; the characterization of a layered metagabbro intrusion belonging to the Core Zone; and the petrogeochemical study of an orbicular gabbro in the Rachel-Laporte Zone.

The Labrador Trough constitutes the western part of the New Quebec Orogen, the expression of the collision between the Archean Superior Province to the west and the Core Zone of the Churchill Province to the east. The Kuujjuaq region exposes rocks of the second volcano-sedimentary cycle, composed of continental margin sediments (e.g., banded iron formations), platform sediments, and volcano-sedimentary rocks from a marine environment that include basalts, black shales and turbiditic sequences. Nearly the entire sequence is injected by gabbro sills.

The nature of the Rachel-Laporte Zone—whether it represents the more metamorphosed equivalent of the Labrador Trough, the edge of the Core Zone or an exotic terrane—is often the subject of debate. In light of recent observations, the zone constitutes a different volcano-sedimentary environment from that of the Labrador Trough, but its emplacement is directly related to the latter. By comparing the REE and trace element signatures of the black shales, the iron formations and the carbonate rocks, we were able to further advance the hypothesis of a connection between these two zones.

Our work confirmed several geological contacts and harmonized some of the stratigraphic lexicon, and also led to the discovery of several mineralized outcrops. The main types of mineralization observed were volcanogenic massive sulphides, disseminated sulphides in sediments (meta-arenites, graphitic schists, black shales and associated iron formations) and mafic-ultramafic rocks, as well as Fe-Ti-V deposits in the layered and metamorphosed mafic intrusion of the Core Zone.

G71

Geology of surficial deposits in the Southeastern Churchill Province: Preliminary results of the 2012–2015 sampling and mapping programs

Hugo Dubé-Loubert, Virginie Daubois (MERN), Martin Roy (UQAM), Roger Paulen (GSC-O) and Jessy Rice (University of Waterloo and GSC-O)

Regions affected by major Quaternary glaciations continue to present difficulties for bedrock mapping projects and mineral exploration. The Southeastern Churchill Province is covered to a great extent by a thick layer of Quaternary sediments that masks large areas of the underlying rock. In this type of setting, drift prospecting tools serve as a complementary component to bedrock mapping projects.

In the summer of 2012, the *Bureau de l'exploration géologique du Québec* initiated a Quaternary mapping project that included the sampling of glacial (till) and fluvioglacial (esker) sediments. The sampling component was accompanied by 1:250,000 mapping of surficial deposits and an inventory of glacial erosion marks.

The programs of 2012, 2013, 2014 and 2015 yielded nearly 1,200 till and esker samples. The ICP-MS method was used to analyze the fine fraction from the matrix of till samples, and heavy mineral concentrates were prepared to obtain indicator minerals associated with various types of deposits (diamonds, base metals, sulphides, etc.). Following this, selected indicator minerals were geochemically characterized using a Zeiss EVO-MA15 HD 2013 electron microscope and an EDS-SDD spectrometer at the IOS laboratory.

This poster presents our mapping and geochemical results, including indicator minerals, for the surveys of 2012 (Lac Saffray) and 2013 (Lac Henrietta), as well as preliminary results for the years 2014 (Lac Brisson) and 2015 (Lac Jeannin).

G72

Drift prospecting in the Clova area, Western Grenville Province (NTS 31O13, 31O14, 32B03 and 32B04)

Virginie Daubois (MERN)

The Haute-Mauricie region, in the Grenville Province, was strongly affected by the great Quaternary glaciations, which left in the area a thick cover of unconsolidated sediments. The number of bedrock exposures is very limited and as a result, it is quite difficult to assess the mineral potential of this region. The migration of the vast outflow domes of the Laurentide Ice Sheet has also created, in this region, a complex yet poorly studied sequence of glacial movements. In fact, glacial sediment sampling and mapping of Quaternary surficial formations and ice flow movements are practically non-existent in this area. The Gouin project, a Quaternary survey focussing on the Clova area, is designed to fill this gap in geoscience knowledge to the south of Gouin Reservoir, by sampling glacial and fluvioglacial sediments and mapping surficial formations at a scale of 1:50,000 (in NTS sheets 31O13, 31O14, 32B03 and 32B04).

During the 2015 field campaign, 128 till samples, weighing 10 kg each, were collected along a square grid with a regular spacing of about 6 km × 6 km, for a total of about 30 to 35 samples per NTS sheet. In eskers, 29 samples weighing 15 kg each were collected and screened directly in the field to recover and analyze the ‹8-mm fraction. Several anomalies (Ni-Cu, Fe-Ti, REE) based on analytical results from lake sediment samples appear to outline a strong potential for this area. Sampling of till and esker formations respectively provides a local and regional outlook on the mineral potential and, combined with bedrock mapping, may be used to define and constrain these anomalies.

In addition to drift prospecting, this project also involves detailed mapping of surficial formations at a scale of 1:50,000, to improve our understanding of the glacial setting that shaped the region's geomorphology. To locate the source of mineral anomalies by drift prospecting, a good understanding of the glacial history of the region is also required. Systematic mapping of glacial erosion marks like striations, grooves, and glaciated rock surfaces was also carried out within the scope of this project. The ice flow sequence in this region was studied to improve our understanding of the glacial history of the Haute-Mauricie region.

Preliminary maps of surficial formations and ice flow movements were generated based on the results of fieldwork. The results of geochemical analyses and heavy mineral concentrate analyses from glacial and fluvioglacial sediments will be released over the course of 2016.

G73

Architectural stone in the regions of Estrie (Saint-Sébastien), Mauricie (Saint-Alexis-des-Monts), Saguenay – Lac-Saint-Jean, Capitale-Nationale (Laurentides Wildlife Reserve) and Gaspésie

N'golo Togola and Ricardo Escobar (MERN)

During the summer of 2015, field work was conducted in the regions of Estrie (Saint-Sébastien; 21E04, 21E10, 21E14, 21E15), Mauricie (Saint-Alexis-des-Monts; 31I05, 31I06), Saguenay – Lac-Saint-Jean (22D05, 22D07, 32A08), Capitale-Nationale (Laurentides Wildlife Reserve; 22D03, 22D04, 21M06, 21M14) and Gaspésie (22H02, 22H03, 22A15). One of the objectives of this project is to promote architectural stone in Québec.

The field work took place from June 15, 2015, to July 10, 2015. Over the course of this period, 45 quarries were visited, including 14 new architectural and crushed stone quarries. Each visited quarry was systematically sampled. The work was used to update the data for existing architectural stone quarries, and to describe new quarries of architectural stone, crushed stone, industrial stone and gemstones in an effort to produce detailed fact sheets for every quarry.

In the Saint-Sébastien area (Estrie region), the extracted rock facies comprise a granite and a granodiorite belonging to the Saint-SébastienSainte-Cécile pluton. Several crushed stone quarries were visited in the Lac-Mégantic and Courcelles areas.

In the Mauricie region, Saint-Alexis-des-Monts area, the extracted rock facies consist of porphyritic quartz mangerites belonging to the Saint-Didace Massif.

In the Lac-Saint-Jean region, we visited quarries in the Métabetchouan and Chambord areas. The extracted rock facies comprise a fossiliferous limestone of the Simard Formation (Trenton Group) and a porphyritic monzogranite with potassium feldspar phenocrysts. We also visited the gemstone site (quartz crystals) in the Lac-à-la-Croix area.

In the Saguenay region, we visited the quarry in the borough of La Baie where they extract porphyritic hypersthene monzodiorite.

In the Laurentides Wildlife Reserve (*Réserve faunique des Laurentides*; Capitale-Nationale region), an architectural stone quarry in the Lac Scott area extracts hypersthene monzodiorite belonging to the Parc des Laurentides Complex. Crushed stone quarries were also visited.

In the Gaspésie region, we visited an industrial stone quarry to the south of Grande-Vallée (Lac à l'Eau Claire area), as well as a gemstone site (agate) in the Mount Lyall area, and several crushed stone quarries in the Lac Fer à Cheval and Lac D'Amours and Gaspé areas.

G74

Technological applications of high-purity quartz

Dominic Fragasso and Denis Blackburn (MERN)

This poster focuses on the technological applications of high-purity quartz. It lists the purest sources of quartz (massive quartz, quartzite, sandstone, quartzose sand) that can meet industry requirements. It describes the chemical and physical requirements for each type of application and explains the processes whereby silica is transformed into ferrosilicon and metallurgical-grade silicon, and how metallurgical-grade silicon is purified to reach high-tech markets such as semi-conductors for computer applications and photovoltaic solar panels. The process to manufacture semi-conductors for computer and solar applications is also explained.

G75

Characterization of Ni-Cu mineralization in the Soisson Suite showings, southeastern Churchill Province, Québec

Jean-Philippe Fleury (UQAM)

Nickel-copper showings were discovered by WMC International in the early 2000s following an airborne magnetic survey over the southeastern part of the Churchill Province. In the summer of 2015, during regional mapping at 1:250,000 by the *Ministère de l'Énergie et des Ressources naturelles* (MERN), two showings (NTS map sheet 24B16) were the subject of detailed work and sampling as part of a final-year project that aimed to differentiate the facies associated with mineralization in the intrusion, and to characterize the mineralized zones.

Three different facies were observed in the area: a gabbronorite, a gabbro and monzonite, all of which are characterized by subophitic texture and very homogenous composition. These rocks are enclosed in migmatized paragneiss of Paleoproterozoic age.

The gabbronorite is a medium-grained rock with subophitic texture, composed of adjoined plagioclase lathes and idiomorphic pyroxene crystals. The gabbro unit is characterized by a leucocratic appearance and commonly has very few mafic minerals. The monzonitic (mangerite) facies is distinguished by the presence of potassium feldspar, which imparts a dominant pinkish grey colour, and orthopyroxene.

The A14-1W and A14-1E showings, 3.5 km apart, are found along the edge of a late kilometre-scale mafic intrusion of Mesoproterozoic age, undeformed and unmetamorphosed, associated with the Soisson Suite (Lafrance *et al.*, 2014). Both mineralized zones appear to contain alteration zones that may indicate some amount of sulphide remobilization. Showing A14-1W (in the western part) is associated with a light grey plagioclase-rich rock with an anorthositic appearance. Mineralization occurs as veinlets or disseminated masses of pyrrhotite and chalcopyrite (3%) over a thickness of 2 m. Further east, showing A14-1E is enclosed in a gabbronorite unit that is cut by an unidentified strongly potassic altered facies, poor in mafic minerals but fairly rich in quartz. The mineralized zone is found at the contact of this altered facies. It is generally present as masses or disseminations of pyrrhotite and chalcopyrite (1 %), with a small semi-massive brecciated zone containing quartz fragments. The setting and age of these mineralized zones appear similar to those of the Voisey's Bay area to the east.

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G76

Petrographic and geochemical characterization of alkaline rocks of the Fayot Suite, Churchill Province

Marie-Odile Chartier, Philippe Pagé (UQAC), Isabelle Lafrance and Benoit Charette (MERN)

A mapping survey carried out in the summer of 2014 by the *Ministère de l'Énergie et des Ressources naturelles* (MERN) in the Southeastern Churchill Province (NTS sheets 24A and 24H) led to the identification of a new lithostratigraphic unit, the Fayot Suite. The latter consists of five kilometre-scale alkaline mafic intrusions located within the footprint of the DePas Batholith and the Rivière George Deformation Zone. Anomalous rare earth element concentrations (up to 1,256 ppm) suggest this suite may show economic potential. The intrusions assigned to the suite are characterized by the absence or low content of quartz, and by a minor nepheline component. In addition, potassic feldspar appears to be more abundant than plagioclase.

The objective of this undergraduate project, undertaken at the Université du Québec à Chicoutimi (UQAC) in collaboration with the MERN, is to assess the economic potential of alkaline mafic rocks of the Fayot Suite for rare earth elements. The first step consisted in defining the typical genetic setting of the alkaline rocks. A petrographic characterization based on polished thin sections led to the identification of primary and late (metamorphism and alteration) mineral phases, a visual estimate of modal proportions, and a description of textures and structures observed in rocks of the Fayot Suite. In addition, the results of mineral chemistry analyses (by microprobe) of the dominant primary phases and whole-rock geochemistry of samples from three intrusions were used to determine and discuss the characteristics and potential of these intrusions. Finally, a comparison with known rare earth element deposits such as Strange Lake and Lac Brisson was carried out within the scope of this study.

G77

Nature and origin of rocks belonging to the mafic-ultramafic Nuvulialuk Suite, Southeastern Churchill Province, Québec: Petrologic and geochemical characterization and implications for regional geology

Rocio Pedreira Perez, Philippe Pagé (UQAC), Daniel Bandyayera (MERN) and Sarah-Jane Barnes (UQAC)

The mafic-ultramafic Nuvulialuk Suite lies near the Blumath deformation corridor, an ancient suture zone at the contact between the Core Zone and the Torngat Orogen in the southeastern part of the Churchill Province (map sheets 24H10 and 24H15). The suite consists of several multi-kilometre mafic-ultramafic bodies oriented north-south, metamorphosed to various degrees and distributed parallel to the Blumath deformation corridor. These mafic-ultramafic rocks are in contact with tonalitic and granitic gneisses of the Ungava Complex and the Paleoproterozoic clastic sedimentary sequence of the Lake Harbour Group.

A sampling and mapping program focused on these mafic-ultramafic bodies in the summer of 2014 (roughly 150 observation points). The mafic-ultramafic Nuvulialuk Suite comprises four facies: i) peridotite, ii) pyroxenite, iii) gabbro and iv) amphibolite. To date, our observations have shown that the peridotite facies exhibits complex and varied textures, leading us to believe there are two sub-groups, which is also supported by the trace element geochemistry study. The first sub-group may be of mantle origin, whereas the second may represent ultramafic cumulates. The pyroxenites appear to be cumulates produced by fractional crystallization. The gabbros are fairly massive and undoubtedly represent more mafic cumulates. The amphibolite facies has not been studied in enough detail to determine whether they represent more intensely metamorphosed gabbros or metavolcanic facies.

The ongoing work aims to refine our initial observations on the nature of the peridotite facies. To do this, we will compile petrographic descriptions of the facies, focusing in particular on textures, the degree of metamorphism and alteration, and the intensity of deformation. We expect to observe contrasts between rocks of mantle origin and those of crustal origin. Moreover, mineral chemistry and whole rock geochemistry data should also facilitate the discrimination between these two groups of rocks.

The total base metal and platinum group element contents of the mafic-ultramafic Nuvulialuk Suite are generally low (24–9170 ppm Ni; <1–581 ppm Cu; 10,83–50,09 ppb PGE), and Ni seems to be controlled by silicate phases. However, in spite of these initial findings, disseminated sulphide layers have been observed in places within the peridotite facies (Phiroda showing).

G78

Thermobarometric study of the Rachel-Laporte Zone: Is the metamorphism distinct from the Core Zone?

Marc-Antoine Vanier (UL), Benoit Charette, Isabelle Lafrance (MERN), Loïc Labrousse (UMI Takuvik-CNRS-UL), Carl Guilmette and Antoine Godet (UL)

The Southeastern Churchill Province (SECP) is subdivided into three geological domains broadly oriented north-south: the Torngat Orogen (TO) to the east, the Core Zone (CZ) in the centre and the New Quebec Orogen (NQO) to the west. The currently accepted model describing the evolution of the SECP suggests that during the Paleoproterozoic (pre-1.88 Ga), the CZ corresponded to a distinct microcontinent separated from the Superior and North Atlantic cratons by two oceans. An episode of oblique convergence led to the successive closure of these oceans, culminating in two continental collisions, first with the North Atlantic craton to form the TO (1.87-1.82 Ga), then with the Superior craton to form the NQO (1.82-1.77 Ga). This geodynamic model was proposed however at a time when very little data was available on the SECP. The new data acquisition program undertaken by the *Ministère de l'Énergie et des Ressources naturelles* (MERN) will make it possible to test this model, particularly with regard to the two tectonometamorphic episodes of continental collision (NQO and TO).

The first studies on the SECP outlined a regional metamorphic gradient ranging from the greenschist to the amphibolite facies in the NQO, to the upper amphibolite facies (anatexis) in the CZ. The transition from greenschist to upper amphibolite facies is observed in supracrustal rocks along the western boundary of the Rachel-Laporte Zone (RLZ), a subdivision of the NQO. Metamorphism in the RLZ is inferred to be contemporaneous with convergence that resulted in the NQO (1799-1783 Ma), whereas widespread anatectic conditions in the CZ presumably took place earlier (1805-1810 Ma).

The objective of this undergraduate project is to characterize and quantify metamorphic conditions in the transition zone from the greenschist to the upper amphibolite facies in the RLZ, in an attempt to provide new constraints on the metamorphic variations between the NQO and the CZ. To this end, samples were collected along an east-west transect during a geological mapping survey carried out by the MERN in the summer of 2015. Mineral assemblages in these metasedimentary and amphibolitic samples will be documented and used to calculate pressure and temperature (P-T) conditions based on multiphase equilibrium. Mapping of P-T conditions will help identify either a sharp transition or a continuum in the metamorphic gradient between the RLZ and the CZ, and provide insight on the geodynamic implications for this region. This project is part of a multidisciplinary research study aimed at understanding the tectonometamorphic evolution of the SECP.

G79

From auriferous fenitization to orogenic mineralization in a synvolcanic pluton: Example of the Boyvinet Stock in the Lac Shortt region

Édouard Côté-Lavoie, Damien Gaboury (UQAC-LAMEQ) and Laury Schmitt (SOQUEM)

The Boyvinet stock in the Lac Shortt region (SOQUEM and MDN) contains low-grade gold mineralization associated with quartz veinlets and alteration zones. The stock was long thought to be syenite, however its geochemical characteristics indicate calc-alkaline affinity with negative Nb and Ta anomalies and fractionation defined by La_N/Yb_N = 22. The basalt country rocks are chemically comparable with the stock, leading to a synvolcanic interpretation. Hydrothermal alteration is expressed as assemblages of the following minerals in variable proportions: albite, hematite, carbonates, silica, chlorite, pyrite and magnetite. Altered zones (n=25) are characterized by strong gains in Si (<30%), Na (<33%), K (<200%) and Ca (<25%), and losses in FeO (<8%). Gold enrichment is related to alteration zones, but the mineralogical assemblages are variable, including albite-hematite-pyrite and carbonates-silica-chlorite-pyrite. Pyrites (n=53) were analyzed by LA-ICP-MS at LabMater (UQAC). Zonation was evident between the porous cores and the recrystallized borders. The cores (n=50) are enriched in gold (average of 5.5 ppm; <95.5 ppm) and Bi-Te-Cu-Ag-Sb. The borders (n=40) are depleted in gold (average of 0.22 ppm; <1.32 ppm) and enriched in As-Ni-Co-Se. Metallic assemblages of Bi-Te-Cu-Ag-Sb are typically of magmatic origin, whereas As-Ni-Co-Se assemblages are characteristic of metamorphic fluids. Grains of native gold were also observed along late fractures in pyrite. Fluid inclusions (n=24) were analyzed by solid probe mass spectrometry at LAMEQ (UQAC). Two groups of fluids were distinguished: those in barren white quartz veinlets (n=10) and those in gold-bearing quartz-carbonate veinlets (n=14). The first group is aqua-carbonic (average values of H_2O: 87.4% and CO_2: 0.1%) with traces of gas (N_2: 1.66%, H_2: 0.2% and C_2H_6: 0.6%). The second group is also aqua-carbonic, but richer in gas (H_2O: 82.5%, CO_2: 14.2%, N_2: 2.4%, H_2: 0.6% and C_2H_6: 0.32%). In both cases, the fluids are of metamorphic origin. Two superimposed mineralizing processes are proposed: magmatic and metamorphic. Primary fenitization of the country rock by regional alkaline magmatic fluids resulted in gold enrichment and early albite-hematite-pyrite alteration. This interpretation is supported by the presence of several late alkaline intrusions in the region and by the Lac Shortt carbonatite. Orogenic mineralization was superimposed on the fenitization, with local development of quartz-carbonate-pyrite veinlets and overprinting of primary pyrite borders.

G80

Vectorial interpretations of multi-parameter data at the Bracemac-McLeod VMS deposit, Matagami mining district, Québec

Nathalie Schnitzler, Alexandre Bourke, Pierre-Simon Ross (INRS-ETE), Robert Boucher and Robert Namour (Glencore)

The INRS mobile laboratory for the physical, chemical and mineralogical characterization of rocks (LAMROC) acquires multi-parameter data on exploration drill core in a non-destructive manner and directly on the storage site. The laboratory can measure, nearly simultaneously and at high spatial resolution (a few millimetres), density based on gamma-ray attenuation, mineralogy by infrared spectrophotometry, geochemistry by X-ray fluorescence (XRF), and magnetic susceptibility. These data complement the geologist's description and contribute to the spatial discrimination of lithologies and alteration patterns related to the emplacement of volcanogenic massive sulphides (VMS) or other types of deposits.

This project, which received funding from the FRQNT-DDSM and logistical support from Glencore Exploration, focuses on the Bracemac-McLeod deposit located in the Matagami VMS district, in the north part of the Abitibi Subprovince, Québec. Nine exploration drill holes were analyzed for a total of more than 6,000 metres of drill core distributed within an area encompassing the McLeod deposit and up to 1 km further east. Measurements were taken systematically, every 20-30 cm, at specific points determined by the geologist. In addition, infrared spectrophotometry analyses were carried out on 22 drill holes distributed within and around the deposit, with measurements every 10 m.

Given the sheer volume of data and the diversity of parameters (several thousand measurement points, with more than 20 variables), a wide variety of methods may be used to study and interpret the data. In this presentation, a vector approach is used to interpret mineralogical and geochemical data. Certain minerals are identified by infrared spectrophotometry. Our study focuses on the composition of white micas and chlorites, which is measured by the position of absorption peaks associated with Al, Fe and Mg. In the case of VMS deposits, alumina depletion or enrichment in white micas may serve as an indicator of proximity to the ore deposit. The same is true for iron or magnesium variations in chlorites. By comparing these indicators, vectors pointing toward the mineralization can then be traced. A similar vector approach can also be adopted with XRF data. Geochemical vectors can be traced based on the evolution, in space, of certain element concentrations. The objective of this project is to test these interpretation methods with data collected in the LAMROC laboratory.

G81

Evaluation of thermal properties in the SLL sedimentary basin: Laboratory measurements and well-log approach

Maher Nasr, Jasmin Raymond and Michel Malo (INRS-ETE)

An evaluation of the thermal properties in the Saint Lawrence Lowlands (SLL) basin was carried out, specifically focusing on thermal conductivity and thermal capacity. Direct and indirect methods were used to estimate these parameters. The ultimate goal of this characterization is to find a favourable site to develop a pilot project to produce electricity from deep geothermal sources.

Firstly, the thermal characteristics of the basin were studied on 45 samples collected on surface, in different geological formations in the SLL. Thermal conductivity was measured directly using a needle probe in the laboratory, whereas thermal capacity was estimated based on microscope observations. Average values were then calculated for each unit of the basin and for each parameter.

Secondly, thermal conductivity profiles were established based on well-log records. The objective of this indirect method is to reduce the uncertainty related with estimated values for this parameter. Two approaches were used. Pressure and temperature corrections were applied to produce thermal conductivity profiles. The heat equation (Poisson's equation) was then resolved using a finite difference approach to determine the density of terrestrial heat flow and establish a temperature profile for each well.

The results of fieldwork demonstrate that clayey formations such as the Utica and Sainte-Rosalie groups, are the most insulating with thermal conductivity values on the order of 2.5 W/(m K) and a specific thermal capacity of nearly 850 J/(kg K). On the other hand, sandy formations appear to be the best units to conduct heat. Potsdam sandstones for example, with a thermal conductivity reaching 6 W/(m K) and a specific heat capacity of 730 J/(kg K), represent potential reservoirs.

The heat flow map shows estimated values ranging from 40 mW/m^2 to 140 mW/m^2. High temperature values are observed between the Logan Fault and the Saint Lawrence River. Certain elevated values located near the Logan Fault appear justified whereas others, supported by very little data, warrant further investigations.

Upcoming work will focus on the most favourable areas along the Logan Fault.

G82

Geochemistry of basalts hosting the auriferous Lalor VMS deposit, Snow Lake, Manitoba

Vincent Dubé-Bourgeois, Pierre-Simon Ross (INRS-ETE), Patrick Mercier-Langevin (GSC-Q) and Antoine Caté (INRS-ETE)

The Lalor deposit, mined by Hudbay Minerals, is situated in the Snow Lake mining camp of Manitoba. Lalor is a bulk tonnage auriferous VMS (volcanogenic massive sulphide) deposit with reserves of 11.87 Mt at 1.88 g/t Au, in addition to a zone of 2.46 Mt at 5.36 g/t Au. It was emplaced during the Paleoproterozoic in a felsic bimodal volcanic arc tectonic setting. The rocks hosting the mineralization were subjected to amphibolite facies metamorphism, as well as several phases of deformation. The rocks in the vicinity of the Lalor deposit, particularly those in the footwall, were strongly altered by the same hydrothermal activity that gave rise to the mineralization. The changes in the rocks resulting from the alteration and subsequent metamorphism impose certain limitations on the processing and use of geochemical data.

A Master's project at INRS-ETE aims to study the geochemistry of the volcanic rocks hosting the Lalor deposit and to model the petrogenesis in order to understand their mode of formation and shed new light on the petrologic and tectonic setting of the largest deposit in the Snow Lake camp. This project complements a PhD study by Caté *et al.* on the architecture, volcanology, protoliths, alteration, metamorphism and structural geology of the Lalor deposit. The host rocks belong to the Chisel Sequence, which contains a large number of VMS. Eleven lithological groups with transitional tholeiitic to calc-alkaline affinity were recognized using immobile element ratios, such as Zr/Ti or Nb/Yb, and extended trace element diagrams. The results presented here concern two basalts: M1 (Moore Basalt) in the footwall and hanging wall of the deposit, and M3 (Treehouse Basalt) found mainly in the hanging wall. These basalts are geochemically different: M1 is more fractionated and of calc-alkaline affinity, whereas the composition of M3 is closer to mid-ocean ridge basalt (MORB) and the affinity is transitional tholeiitic.

The tectonic classification diagrams demonstrate stronger rare earth fractionation at Snow Lake than for the rest of the Flin Flon belt. This may be due, among other things, to a lesser degree of partial melting. Furthermore, according to the literature, the magma was derived from an enriched source. One of the possible explanations for this enrichment was contamination of the mantle by crustal material, which would have also influenced the metal content at Lalor.

Geochemical modelling is underway to determine the source(s) of the basalts and their petrogenetic evolution. This work will help refine the auriferous VMS model and improve the various exploration guides for this type of deposit.

G83

Highlights of advanced exploration and mining development in the Abitibi-Témiscamingue in 2015

Pierre Doucet and Jeanne Lavoie-Deraspe (MERN)

Radisson Mining Resources completed a resource estimate for the 36E and Kewagama zones on its O'Brien-Kewagama Project.

Falco Resources conducted a drilling program on its Horne 5 Project. Drill hole H5-15-01 yielded 31.2 m grading 2.03 g/t Au, 10.16 g/t Ag, 0.46 % Cu and 0.04 % Zn.

Sphinx Resources drilled 4 holes on its Preissac property. Drill hole SR-15-06192 cut a section of 0.5 m grading 1.41 % Ni, 0.05 % Cu, 0.04 g/t Pt and 0.30 g/t Pd.

Midland Exploration drilled 7 holes on its Patris property during the winter of 2015. An interval of 1.0 m in drill hole PAT-15-05 yielded 0.10 g/t Au, 82.6 g/t Ag, 0.22 % Cu and 1.0 % Pb.

Three drilling phases are planned in 2015 for the Croinor Project of Monarques Gold Corporation. Drill hole CR-15-447 cut a section of 3.0 m grading 7.09 g/t Au.

An environmental impact assessment is underway at the Akasaba West Project of Agnico Eagle Mines and should be ready in 2015.

At the Lamaque South Project, in January 2015, Integra Gold finished updating the preliminary economic assessment of March 2014. The update resulted in lower production costs and preproduction capital, and a higher recovery rate. A new resource estimate was also produced for the Triangle and Parallel zones.

Trenches were excavated over the New Beliveau deposit on the Val-d'Or East Property held by Adventure Gold. Four high-grade zones were discovered; the best intersection was 6.4 g/t Au over 19.7 m, including a section of 10.6 g/t Au over 11.5 m.

In 2015, exploration of the Deep 1 Zone added at least six years to the life of the Goldex mine belonging to Agnico Eagle Mines.

On the Marban Block Project, NioGold Mining planned a 70,000-metre drilling program for 2015. By August, 99 holes had been drilled.

On the Kiena Property, Wesdome Gold Mines conducted a winter program to explore the extension of the S50 Zone near the mine shaft, and the Presqu'ile Zone to the west. The best grades were 5.83 g/t Au over 12.6 m (hole S771) in the S50 Zone, and 26.85 g/t Au over 5.9 m (hole S780) in the Presqu'ile Zone.

G84

Lightning strikes: A new exploration tool?

Patrick Houle (MERN)

Is it possible for lightning to strike twice in the same location? And if it does, is there a link with geology? Why do certain forested regions in Québec experience more frequent forest fires? Why are they more likely to be struck by lightning than other regions?

Recent studies conducted in the United States appear to indicate that the location of lightning strikes on the ground is not random. Lightning strikes apparently form swarms that tend to reoccur over time. Their location is not solely related to infrastructure (buildings, wells and pipelines) nor is it exclusively controlled by topographic relief, or vegetation, or water depth (less than 120 metres). In fact, although lightning is essentially an atmospheric phenomenon, the location where it touches ground is more strongly controlled by variations in ground currents, which are modified by the presence, at shallow depths in the Earth's crust, of faults, resistive oil and gas fields, conductive mineral deposits, geothermal systems, kimberlite pipes, methane gas, anisotropy, fluids, and geology.

Consequently, since the density of lightning strikes varies in space and that these variations are to a certain extent consistent through time, it may be interesting to combine basic mining data with the location of lightning strikes on the ground, allowing for a certain margin of error. This poster shows the first series of potential exploration targets based on the statistical processing of Hydro-Québec's georeferenced database of lightning strikes (2007-2015) and magnetic maps from SIGÉOM. It also attempts to determine if geological and geophysical applications may be found using existing and future lightning detection networks. Based on this pilot project, if a meteorologist cannot understand atmospheric phenomena without knowing the effects of oceanic currents, how can a geologist understand the subsoil without taking into account underground electrical currents and phenomena such as lightning?

G87

Automated identification of drill core texture patterns for geometallurgical applications

Laura Pérez-Barnuevo, Sylvie Lévesque (COREM), Claude Bazin (UL), Daniel Michaud (COREM) and Hugues Longuépée (ArcelorMittal Mines Canada)

Traditionally, the primary assessment of "how well" or "how bad" a specific ore domain of the mine will behave during mineral processing has been based on the experience of mine geologists and visual assessments of drill cores. In the last years, driven by the emergence of Geometallurgy, a great effort has been made to complement these observations with quantitative data to characterize the ore resources as early and as accurately as possible.

During the examination of drill cores, it is possible to observe different textural patterns between ore and gangue minerals, which suggest a different behaviour during mineral processing. Aiming at providing a new methodology for drill core characterization linked to mineral processing performance, this work has been carried out with two different objectives: firstly, to quantify the potential link between the texture patterns observed in drill cores and their mineral processing performance; and secondly, to develop a methodology for the automated identification of drill core texture patterns. To carry out this work, samples from the Mount-Wright iron ore deposit (Québec, Canada) were used.

To achieve the first objective, drill cores from the deposit were visually examined to identify recurrent textural patterns. Samples from each identified texture pattern were processed to detect potential differences in terms of grindability and metallurgical behaviour. Preliminary results show a similar trend in terms of comminution energy consumption, production of fines and recovery for samples showing the same texture pattern. Therefore, a classification of drill core texture patterns against mineral processing performance may be established for this deposit.

Based on this classification, a methodology for the discrimination of the identified texture patterns has been developed. The method is based on the acquisition of drill core digital images and their processing to compute some textural indicators. These textural indicators are used in a further stage to discriminate between texture patterns by the application of discriminant function analysis. Preliminary results show that a success rate higher than 95% is achieved in the discrimination between the considered texture patterns. Therefore, through the identification of a particular texture pattern, this methodology may enable an early prediction of the ore behaviour during mineral processing, resulting in mine planning improvement and potential optimization of mineral circuits.

G88

Comparative study of methods and sample preparation techniques for the determination of rare earth element concentrations in various environmental and mineral matrices

Laurence Whitty-Léveillé, Keven Turgeon, Dominic Larivière and Claude Bazin (UL)

Rising prices for rare earth elements (REE) constitute an unprecedented opportunity for prospective global markets, as more than 30 countries host rare earth deposits, including marginal deposits where economic viability relies on these high prices. This situation will inevitably lead to increased pressure on analytical laboratories to deliver both a higher level of sensitivity and greater accuracy in the determination of REE concentrations. Digestion of rare earth minerals prior to the application of the usual spectrometry or atomic spectroscopy techniques is a laborious task, as lanthanide oxides are known for their refractory nature; sample dissolution must therefore take place in harsh digestion conditions. This presentation focuses on a comparison between three different digestion techniques (borate fusion, microwave digestion, and acid digestion) and between four different analytical methods: neutron activation (INAA), microwave plasma atomic emission spectroscopy (MP-AES), inductively coupled plasma optical emission spectrometry (ICP-OES), and inductively coupled plasma mass spectrometry (ICP-MS). Borate fusion proved to be the most effective technique to digest the four tested rare earth mineral matrices. Although ICP-OES, MP-AES and ICP-MS all yielded similar results, the latter method showed the lowest detection limits and a better reproducibility for all analyzed elements, a critical aspect for the detection of rare earth elements.

G89

Rare earth elements (REE) extraction from silicate ores

Jean-François Boulanger, Laurence Whitty-Léveillée, Keven Turgeon, Claude Bazin and Isabelle Bombard (UL)

Rare earth element (REE) ores contain up to ten times more value than common gold ores. Despite this, financing REE projects remains difficult in part due to the number of processes required to valorize the products and the relatively low yield of these processes. Direct REE ore leaching without the production of a concentrate can reduce the capital and operating expenditures through process simplification and increase revenues through REE recovery improvement. Various existing REE projects are compared in terms of contained vs. recovered value in the raw ore. A silicate REE ore is used to test various hypotheses regarding whole ore processing and to develop a simplified flowsheet. Characterization has shown that REEs make up 0,6% of whole-ore, that they are contained in allanite, an REE silicate mineral, and that the gangue was mostly feldspar, another silicate. This presents an opportunity for direct leaching, given the low acid consumption of the gangue minerals. An atmospheric leach of crushed whole-ore containing 0,6% REE using 200kg of sulphuric acid per tonne was first conducted followed by filtration. Impurity removal and REE precipitation using oxalic acid recovered approximately 80% of REEs, yielding a concentrate containing 97% rare earth oxalates+ThO_2. Such a process would avoid construction and operation of a complex mineral processing plant and neutralisation-precipitation circuits, as well as the losses associated with these processes.

G90

Solvent extraction applied to rare earth element separation

Keven Turgeon, Jean-François Boulanger, Laurence Whitty-Léveillé, Dominic Larivière and Claude Bazin (UL)

Rare earth elements (REE) are increasingly used in technologies. Since Québec hosts a few economically interesting rare earth deposits, it seems relevant to develop an expertise in REE extraction in the province. Processing yields REE-enriched solutions that also contain other elements. Separating REE from impurities and isolating individual elements is mainly achieved by solvent extraction. This type of separation technique uses an extractor that shows distinct selectivity values for each REE. Since the selectivity difference is generally very small from one REE to the next, it is necessary to proceed with several consecutive phases of solvent extraction to achieve adequate separation of each element. The amount of REE produced in one extraction is dictated by the extraction equilibrium constant for this element. Several solvent extraction tests are performed in parallel and the resulting data is processed to determine extraction equilibrium constants. The results of solvent extraction tests generally include some redundancy which is not taken into account in conventional data processing. A procedure is proposed to take advantage of this data redundancy to calibrate measurements by taking into account pH variations during extraction. Equilibrium constants derived using the proposed method show a better reproducibility than values estimated using conventional data processing techniques. This new processing technique, developed for MP-AES, may be used to analyze most REE and impurities. Reconciled equilibrium constants are used to determine separation factors and their related uncertainty for the various REE. Separation factors can then be used when designing a processing plant, to determine the number of extraction phases required to achieve adequate separation of rare earth elements.

G92

Geo-environmental characterization and modelling of a mining project at the deposit appraisal stage, applied to a Cu-Au deposit

Denys Vermette, Isabelle Demers, Mostafa Benzaazoua (UQAT-IRME) and Raphaël Mermillod-Blondin (Agnico Eagle Mines)

The mining industry generates a large volume of waste rock during mining operations, which is generally stored in piles. Waste rock typically includes the various rock types hosting the ore deposit, each of which is characterized by a specific chemical and mineralogical composition. Although these rocks have little value, they nonetheless contain some amount of metals that are potentially hazardous to the environment.

Water infiltrates piles of waste rock and, in the presence of oxygen, comes into contact with the minerals they contain, setting off geochemical alteration reactions. The oxidation of sulphide minerals (pyrite, pyrrhotite) initiates the acidification of drainage water and the dissolution of certain metals, leading to acid mine drainage. However, if there are enough neutralizing minerals (carbonates, silicates), it is possible to produce neutral drainage. In addition to these processes, drainage water may contain heavy metals (Cu, Mo, Co, Ni, Se) at concentrations that exceed standards and do not comply with existing regulations for the mining industry. Thus, the characterization of waste rock becomes essential for accurately evaluating, during the early phases of development work, their contamination potential.

The objective of this research project is the geoenvironmental characterization and modelling of waste rock for a Cu-Au ore deposit at the deposit appraisal stage in order to optimize waste rock management at the surface. Geochemical data from drill core samples collected during exploration work, along with environmental analyses (TCLP, SPLP, % sulphides, % carbonates) and mineralogical observations, were the basis for selecting 11 waste rock samples. These samples were then subjected to mini-alteration cell tests to predict the quality of the leachate produced by each of the lithologies under study. The results will be used to develop a geoenvironmental model of the ore deposit based on a similar approach commonly used in geometallurgy. This approach requires that data from metallogenic, mineralogical and geochemical studies be integrated into a 3D georeferenced model. The model will define and characterize the geo-environmental units that are specific to the deposit according to their potential for acidification, neutralization and metal leaching.

This kind of environmental risk planning is not current practice in the mining industry. The use of geoenvironmental models leads to better waste rock management, which will in turn facilitate and lower the cost of rehabilitation, while improving the social acceptability for the mining project.

G93

Development of a predictive kinetic method for contaminated neutral drainage using complexing agents: Project implementation and preliminary results

Maude Lévesque Michaud, Benoît Plante and Bruno Bussière (UQAT-IRME)

There are several predictive methods to characterize the contamination potential of mine water released by waste rock and mill tailings stored at surface. As these methods were designed to predict acid mine drainage, they are not necessarily applicable to contaminated neutral drainage. The method we are developing consists of adding a complexing agent to the rinse water in kinetic tests to limit the sorption and precipitation of dissolved metals generated during the weathering of the mine waste. Tests were conducted on slightly reactive mine waste (i.e., few sulphides) collected from the BlackRock Metals project in Chibougamau. The mining operation at this iron-vanadium-titanium project, currently at the development phase, will take place in two open pits, and the site will include a waste rock pile and a tailings pond.

The main stages in the project are as follows:

- compile the geological information on the deposit and the host rocks in order to determine the lithological units to sample;
- characterize each sample using physical, chemical and mineralogical methods, including the determination of the main potential contaminants;
- assess the geochemical behaviour of each sample using kinetic tests, with and without complexing agents, at both the field (barrel) and laboratory scale (humidity cells and mini-alteration cells).

Before undertaking the project, it was necessary to determine the materials to sample based on the proportions of each lithological unit that would end up in the waste rock pile. Four main units were selected: pyroxenite from the hanging wall, anorthosite from the footwall, anorthosite from internal layers and late intrusions (diabase, gabbro and diorite). Each sample consisted of 60 metres of drill core (10 intervals of 6 metres each) that collectively provided representative spatial coverage of the deposit. A low-grade ore sample was also collected for testing in case the ore is temporarily stored at surface during mining operations. The complexing agent component of the laboratory testing was conducted on a sample of processing tailings generated during pilot-plant tests. The stage of sample selection, preparation and characterization is now over, whereas field and laboratory kinetic tests are underway.

G94

Evaluation of covers with capillary barrier effects composed of desulphurized tailings to control acid mine drainage in northern conditions

Fannie Lessard, Bruno Buissière (UQAT), Jean Côté (UL), Mostafa Benzaazoua (UQAT) and Louis Marcoux (Glencore, Raglan Mine)

Mine site rehabilitation is a major challenge facing mining companies, particularly those characterized by acid mine drainage (AMD). Rehabilitation is made even more complex if the site is in a northern region due to climate change, the presence of permafrost, the remoteness of the site, issues related to the availability of unconsolidated materials and severe weather conditions, all of which make it difficult to implement the selected rehabilitation method. Therefore, it is necessary to adapt rehabilitation methods to northern regions to make them more resistant to the elements. One of the more interesting approaches is to use covers with capillary barrier effects (CCBE) in order to keep the tailings permanently frozen, and to control the flow of oxygen, thereby avoiding AMD. However, this type of cover requires fine-grained material, which cannot always be found nearby. The process of environmental desulphurization thus becomes an attractive option because it transforms mill tailings into construction materials for use in mine site rehabilitation. Given the characteristics of desulphurized tailings, they could ultimately replace the fine-grained materials contained in the water retention layer of a CCBE. This research project will focus on the evaluation of a CCBE with a water retention layer composed of desulphurized tailings in order to control AMD in tailings ponds subject to polar climates. Thus far, the CCBE rehabilitation approach has only been used in temperate climates.

The study requires that desulphurized materials be produced at the processing plant of the Raglan mine, and then undergo a detailed characterization of their physical, thermal, chemical and mineralogical properties. The reactivity potential of the desulphurized tailings will be verified to ascertain the influence of possible oxygen consumption by sulphide minerals on the effectiveness of the cover. Column tests will be carried out using instrumented columns installed in a controlled-atmosphere chamber to simulate the effect of weather cycles on the flow of oxygen and water through the CCBE. The results of this work will establish the effectiveness of a CCBE-type cover as a method of final rehabilitation for the Raglan tailings ponds. The approach may also be suitable for other mine sites in northern environments.

G95

Physico-chemical qualities of groundwater in the vicinity of the Marban site: State of the area before NioGold begins mining

Patrick Vualu Ibula Mambenga, Abdelkabir Maqsoud, Benoît Plante, Mostafa Benzaazoua (UQAT) and Yan Ducharme (NioGold Corporation)

Canada is a country where mining activities play a very significant role in the economy, where investments in the mining industry are closely tied with the needs of national and international markets. Despite the economic benefits it generates, the mining industry may also, in certain conditions, cause negative impacts on the environment, in particular groundwater. An adequate assessment of the impacts of mining can only be performed if the state of the area has been examined prior to the start of mining operations.

The objective of this study is to assess the physico-chemical qualities of groundwater in the vicinity of the Marban deposit, before NioGold Mining Corporation begins mining the deposit. This study constitutes an important step in the environmental assessment of the site.

Groundwater samples were collected, prepared and analyzed in a certified laboratory. The results were interpreted using statistical tools such as principal component analysis (PCA), to determine the different geochemical signatures of local groundwater.

PCA results (correlation matrix) clearly define two groups of elements that show a strong correlation: a) a first group associated with metallic elements (aluminium, cadmium, cobalt, iron, manganese, and nickel) with the addition of nitrates, and b) a second group associated with calcium, magnesium, bicarbonate and electrical conductivity. However, sulphates appear to be completely dissociated from these groups of elements. This suggests that these elements have distinct origins and thus, that contamination related to acid mine drainage may be excluded. PCA results also reveal a contribution from surface water in certain wells given the presence of nitrates, the origin of which is intimately related to human activity and/or organic matter. In addition, two facies of groundwater were recognized, a bicarbonate facies and a sulfate facies.

In conclusion, the results of this study outline different families of groundwater present in the vicinity of the Marban metal deposit, whose chemical quality is intimately related to the nature of the aquifer. This study may be considered as indicative of the baseline conditions in terms of groundwater quality. However, due to the geochemical variability of groundwater during the hydrogeological cycle, it is recommended to conduct at least four annual groundwater sampling campaigns, which may be associated with ongoing measurements of the water's electrical conductivity.

G97

Environmental geochemistry of gallium

Antony Laberge, Charles Gobeil and André Tessier (INRS-ETE)

Gallium (Ga) is a trace element for which the number of high-technology applications has grown constantly over the past few years. This has brought with it the risk of environmental contamination, mainly related to waste incineration and the recycling of technological materials. Petroleum refineries and base metal smelters may also constitute important human sources of gallium. To date, the presence of and changes in the atmospheric fallout of anthropogenic Ga, and even the lacustrine geochemistry of this element, have been poorly documented (European Commission, 2010; Zepf, 2014; Lovik, 2015).

For this Master's research project, we propose to use diagenetic modelling to determine the net rates of the reactions that incorporate Ga into lake sediments near potential sources of contamination (smelters, incinerators); to quantify its redistribution in the sediment column following deposition; and to reconstitute the chronology of its deposition at the water-sediment interface. To accomplish this, Ga profiles of interstitial waters will be determined, and these will serve as sensitive indicators of the reactions taking place in the sediment. The Ga profiles of age-dated sediment core will also be determined for several lakes.

In this poster, we will present and discuss the results of Ga distribution in the solid phase and the interstitial water of sediments in lakes of the Abitibi region, the city of Québec area, the St. Lawrence Lowlands, and the Gaspé region.

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G99

Université de Sherbrooke: Partner in mine site revegetation without prior preparation of the site

Sébastien Roy (Université de Sherbrooke)

The mining industry in Québec is a regional and provincial economic driver that generates a wide range of mine waste in terms of grain size, mineral composition and potential for environmental contamination. In order to comply with existing laws, every company must develop a strategy to process, re-use or revegetate its tailings in order to limit the environmental impact of its activities.

Conventional approaches to mine site revegetation are costly and all too often require that organic-rich soil be transported to the site undergoing rehabilitation, thereby increasing the carbon footprint of the operations and, consequently, the company. Each site possesses a unique combination of factors that must be taking into account in the rehabilitation strategy, in addition to the challenges that may be imposed by the geographic location of the mine.

For more than a decade, Université de Sherbrooke has developed and applied practical mine site revegetation solutions, proposing less costly green alternatives that use trees and shrubs indigenous to Québec without prior preparation of the land. Efforts have focused on collaborative R&D, resulting in robust phytotechnologies that combine indigenous plans with their symbiotic bacteria. These plants are being tested at ten mine sites in Québec and two mine sites in Alberta.

Our laboratory has developed a commercial revegetation strategy inspired by natural plant succession processes. Alders, which are indigenous shrubs in all parts of Québec, associate with atmospheric nitrogen-fixing bacteria. This symbiotic relationship allows them to survive and grow well in soils, rocky substrates and sands that contain very little nutrients. As they do in natural environments, alders seasonally enrich the ground through the loss of their nitrogen-laden leaves, thus providing the site with a free and continuous source of organic matter that eventually allows other indigenous plant species to take hold.

Through well-established partnerships, these bushes are now available at nurseries, and an additional technology allows plantations to be set up on waste rock piles without any prior preparation of the site (no soil, gravel or organic-rich covers).

The success of our revegetation approach, inspired by natural processes, is readily visible at ten mine sites in the Abitibi-Témiscamingue, Saguenay – Lac-Saint-Jean and Nord-du-Québec regions.

G100

Preliminary characterization of the electrical resistivity of sensitive clays in Brownsburg, Québec

Karine Bélanger (MTQ), Ariane Locat, Richard Fortier (UL), Denis Demers (MTQ), Majid El Baroudi (UL) and Andrée-Anne Fortin-Rhéaume (MTQ)

The Ruisseau des Vases valley in the Brownsburg region of Québec is underlain by sensitive clay, and its shores are marked by numerous large landslide scars. In collaboration with Université Laval, the Ministry of Transport of Québec recently conducted a detailed study of this region to evaluate the possibility of using soil resistivity measurements to characterize zones at risk for highly retrogressive landslides.

Electrical resistivity tomography was conducted along a line across the valley, for a distance of 1.6 km. Six piezocone penetration tests, including resistivity measurements, and four sampled boreholes were also completed along the line. Preliminary results show that resistivity measurements can identify zones of leached clay. Resistivity tomography is thus a promising method for characterizing zones that are vulnerable to large landslides.

G101

Towards a better understanding of the social acceptability of mine projects

Philippe Angers and Corinne Gendron (UQAM)

Contrary to the industrial era, a project to exploit natural resources is no longer automatically deemed relevant by the population. It all depends on its values, the needs of Québec and the region itself, and the net impacts of the project including its ecological and social impacts. For instance, one can reflect on debates currently raging in Québec about the development of resources such as shale gas and uranium, or about specific mining projects (Osisko, Arnaud, etc.). These debates have forced developers to re-examine their projects and even abandon them in some cases. The social acceptability issue is therefore becoming a real condition for success, to the same extent as economic viability and technical feasibility.

Although the notion of social acceptability is increasingly used not only by government representatives but also by civil society, companies and researchers, there is no consensus yet as to its definition. The notion of social acceptability should not be reduced to the "not in my backyard" phenomenon. The latter conceives oppositional movements as an aggregate of self-centered individuals that are only concerned with the impact a project may have on their own well-being. But social acceptability is not solely a question of private interests. We define it as the "consent of a population to a project or a decision resulting from the collective judgement that the project or decision in question is better than known alternatives including status quo" (Gendron, 2014).

Debates on the social acceptability of projects to exploit natural resources focus on the economic development model that should be followed, assuming responsibility for impacts and sharing project benefits. But then who decides which economic development model should be preferred? Who decides how responsibility for impacts will be assumed and how benefits will be shared? In what manner must the mining industry take into account citizen, ecological and local concerns and take part in these new dynamics? These are the questions we will attempt to answer.

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G102

A collaborative scenario-building method that promotes the social acceptability of mining projects

Roxane Lavoie (UL)

Québec is a land of riches in terms of its mining resources. However, the start-up of a mine is not just a question of economic viability or environmental management, it is also necessary to ensure the project's acceptability for local communities. The objective of this research project is to develop a method that will promote collaboration among the various stakeholders when building mining development scenarios, to ensure that proposed solutions maximize the positive impacts for all stakeholders involved in the process. We propose using a known methodology that has not yet been used in this field but that shows strong potential: the MACBETH approach. This multicriteria analysis technique is particularly effective to facilitate group decisions. It encourages the creation of a system of shared values and the construction of models based on "fully satisfactory" and "acceptable" criteria, in order to assess proposed scenarios in terms of the degree of satisfaction of all proponents in the project. This methodology will enable stakeholders to work together on the same project, *i.e.* to build a multicriteria analysis model, and will promote negotiations in a framework that encourages the construction of a shared vision for the future of their community.

G103

Impacts of climate change on storm regimes and extreme sea levels in the Hudson Bay and James Bay region

Jean-Pierre Savard (Ouranos)

A common problem facing communities and infrastructure along the coast of Hudson Bay and James Bay is the shortage of reliable data on sea levels through time, particularly with regard to extreme levels. Storms in the region can cause many problems for the safety of local communities, the durability of coastal infrastructure, and navigational and transportation activities in general. This lack of critical information adds to the complexity of tasks such as construction and maintenance of coastal infrastructure and assessment of the risks related to flooding and marine erosion. Adequate assessment of return periods for storm-related extreme levels requires sea level measurements over extended periods of time (generally more than 20 years), which are rarely available in this region. In addition, recent research has shown that climate change will have a significant impact on storm regimes and the average sea level in this region, such that additional data on the subject will be even more important to prevent events such as: drownings, boat and canoe strandings, damage to infrastructure and shoreline erosion.

The objective of this project is to improve our understanding of the impacts of climate change on the current and future storm regimes and sea levels for a few select sites along the coast of James Bay and Hudson Bay. For the purposes of this project, data sets covering an extended period of time (1979-2013) and statistics on sea levels – particularly extreme levels – were produced in collaboration with NGO, private businesses and government agencies and will be available for the 21 communities along the coast of James Bay, Hudson Bay and Hudson Strait. Important basic information, for example on the expected change in the duration of the ice-free season and the risk of strong storms, waves or extreme sea levels, will be obtained to inform the population of potential safety risks.

The results of this project will make it possible to better assess the risks associated with extreme sea levels for current and future infrastructure, by providing statistics on extreme levels (high and low) for designers and engineers. This project will also contribute in raising awareness among Cree and Inuit communities about the impacts of climate change on sea levels and storm regimes, so they may adapt their infrastructure, marine modes of transport and coastal management models in order to reduce their vulnerability.

G104

Towards adaptation: Synthesis of knowledge on climate change in Québec

Robert Siron and Liza Leclerc (Ouranos)

Using cutting-edge scientific knowledge to better prepare for a changing climate

Global warming, measured for several decades now, is an indisputable fact and Québec has not been spared. Climate change has profound effects on society and the natural environment. What are the effects in Québec, and how do we face them? These questions are examined in the document *Vers l'adaptation*. Here are the highlights:

- Since 1950, average annual temperatures in Québec have increased by 1 to 3 °C, depending on the region. According to a plausible scenario for greenhouse gas emissions, these increases are expected to be 2 to 4 °C by 2050, and 4 to 7 °C by the end of the century in Southern Québec and 5 to 10 °C in Northern Québec. Consequences will include shorter snow seasons and longer heat waves, as well as greater amounts of precipitation. Therefore, it is imperative that we reduce greenhouse gas emissions and adapt to the changes underway.
- Extreme weather events will have an impact on all activity sectors. Some phenomena will become more frequent or more intense as the climate gets warmer. Therefore, we must take all necessary measures to limit these effects, and in so doing we will reduce the cost and magnitude of weather-related catastrophes, particularly by adapting buildings and infrastructure.
- Sea level is expected to rise by 30 to 75 cm in the Gulf of Saint-Lawrence, which will make shorelines susceptible to erosion and flooding. Some essential coastal ecosystems and developed areas will be at risk, and this trend is expected to continue. Land-use planning and ecosystem protection measures will be critical in controlling this phenomenon.
- Most economic activities will be affected, directly or indirectly, by climate change. Some facets of these changes will generate new opportunities, whereas others may incur substantial risk to the productivity of sectors such as agriculture, forestry, fishing, aquaculture, energy and tourism. To exercise control on these outcomes, we must integrate notions of climate change into land-use planning, natural resource consumption and infrastructure re-engineering.
- The health of Quebecers will be affected by climate change. It is expected that mortality and morbidity rates will rise, particularly in urban heat islands. In addition, the longer pollen season and higher levels of atmospheric pollution caused by forest fires may aggravate respiratory and cardiovascular problems. To compensate, special emphasis should be placed on the greening of urban areas, promoting active transportation and implementing early warning systems.
- Buildings and land, air and maritime transportation infrastructures, as well as industrial and public infrastructures, are vulnerable, often to a considerable degree, to the consequences of climate change such as coastal erosion, floods, degraded roadways and melting permafrost in the North. As a result, we must not only rethink their design and management, but also come up with innovative solutions that draw upon natural ecosystems.
- Ecosystems and biodiversity may become profoundly disturbed, for example by the arrival and spread of invasive and harmful species. In some regions we have already observed the effect of global warming on the life cycles and distribution patterns of trees, plants, migratory birds, salmonids and migratory caribou. Therefore, it is urgent that we implement conservation strategies that will maintain essential ecological services, many of which help reduce our vulnerabilities to climate change.
- Water management will also be among the major challenges arising from climate change. We anticipate water resources to be affected in terms of quality and availability. This may create usage conflicts and have a negative impact on fish habitats. To curb these effects, we must protect water sources and wetlands, and implement water conservation measures.

Québec has tools and expertise at its disposal that could significantly reduce the vulnerability of the province's population, all the while taking advantage of opportunities that may arise. Amendments to laws and regulations, the construction of infrastructure according to revised design criteria and warning systems to reduce impacts to human health are just some of the concrete examples of adaptation that have already been applied. It is no longer a question of deciding whether we should adapt, but more a question of how.

G105

Preliminary assessment of the potential for geothermal electric power in the Matapedia Valley and the Gaspé region

Anne Chabot Bergeron (UL), Michel Malo, Jasmin Raymond and Félix-Antoine Comeau (INRS-ETE)

The new technologies used in binary-cycle geothermal power plants generate profitable electricity from underground reservoirs having a minimum temperature of about 150 °C. Sedimentary basins generally represent favourable terrains for exploiting this type of deep resource. The province of Québec occupies a zone where the geothermal gradient is low to moderate due to the absence of nearby tectonic or magmatic activity. It is with this in mind that a preliminary assessment of the power generation potential of sedimentary basins in Québec was initiated. Our project examines the Siluro-Devonian basins of the Matapedia Valley and the Gaspé region. This work was conducted by members of the INRS Research Group on Sedimentary Basin Energy Resources. As a first step, temperatures at the bottom of available wells in both regions were corrected using the Harrison method. Graphs were then used to analyze the complete set of corrected temperatures and identify temperature anomalies. In particular, two wells registered corrected geothermal gradients of 42.9 and 38.5 °C/km. These gradients are roughly 15 °C/km above the average of all corrected geothermal gradients for the 20 wells studied in the Gaspésie (24.9 °C/km). Moreover, by analyzing Gulf's steady-state well – Sunny Bank No. 1 (C087) – we were able to establish the relationships between thermal conductivity, mineralogy and temperature. For example, Indian Point Formation is mainly composed of mudstone and siltstone intercalated with sandy beds. More than half its thermal conductivity measurements were below 2.5 W/(m·K), revealing that this formation acts as a cap rock. It traps heat in the underlying rocks, which increases the temperature gradient in places where the formation is thick enough. The geothermal gradient in well C087 increases from 15.5 °C/km to 19.2 °C/km at a depth of about 1,500 m. Thermal conductivity measurements are underway on 69 samples collected from both study areas. The data will be used to establish thermal conductivity stratigraphy as a function of geological formation, in addition to explaining the temperatures found at the bottoms of wells. This evaluation will be helpful in constructing a temperature profile based on composite seismic profiles up to a maximum of 13 km. Finally, the results could be used to guide deep geothermal resource estimates in the Gaspésie.

ACRONYMS

ACPE : Association canadienne des prospecteurs et entrepreneurs

AEM: Agnico Eagle Mines

AMQ : Association minière du Québec

ATIAT: Abitibi -Timiskaming Institut(e) d'Abitibi-Témiscamingue

BAPE : Bureau d'audiences publiques sur l'environnement (Gouvernement du Québec)

CCIM-Ottawa : Conseil canadien de l'innovation minière

CCSN: The Canadian Nuclear Safety Commission

CEM : Chaire en entrepreneuriat minier UQAT-UQAM

CERM-UQAC : Centre d'études sur les ressources minérales de l'Université du Québec à Chicoutimi

CGC : Commission géologique du Canada

CGC-CB : Commission géologique du Canada, Colombie-Britannique

CGC-CC : Commission géologique du Canada, Centre du Canada

CGC-O : Commission géologique du Canada, Ottawa

CGC-Q : Commission géologique du Canada, Québec

CGO : Commission géologique de l'Ontario

CGTNL : Commission géologique de Terre-Neuve-et-Labrador

CMIC: Canadian Mining Innovation Council

CNRC : Conseil national de Recherche Canada

CNRS : Centre national de la recherche scientifique

CNSC: Canadian Nuclear Safety Commission

CONSOREM : Consortium de recherche en exploration minérale

CRCMM-UQAC : Chaire de recherche du Canada en métallogénie magmatique, Université du Québec à Chicoutimi

CRCMM-UQAC : Canada Research Chair in Magmatic Metallogeny, Université du Québec à Chicoutimi

CRÉ : Conférence régionale des élus

CRÉBJ : Conférence régionale des élus de la Baie-James

CREM : Centre de recherches en exploration minérale, Université Laurentienne

CRPG : Centre de recherches pétrographiques et géochimiques, France

CRRNTBJ : Commission régionale sur les ressources naturelles et le territoire de la Baie-James

CRSNG (RDC) Conseil de recherches en sciences naturelles et en génie du Canada

CSMO-Mines : Comité sectoriel de main dœuvre de l'industrie des mines

CSST : Commission de la santé et de la sécurité du travail

DIVEX : Diversification de l'exploration minérale du Québec (Réseau de recherches géoscientifiques)

ENSG/CRPG : Université Nancy, École nationale supérieure de Géologie / Centre de recherches pétrographiques et géochimiques

FEMN : Fonds d'Exploration Minière du Nunavik

FQRNT : Fonds québécois de recherche sur la nature et les technologies

GC-DLG : Géomatique Canada - Division des levés géodésiques

GC-GSD: Geomatic Canada - Geodesic Survey Division

GEMOC: ARC National Key Centre for Geochemical Evolution and Metallogeny of Continents, Macquari University, Sydney, Australia

GEOTOP UQAM-McGILL : Centre de recherche en géochimie et en géodynamique de l'Université du Québec à Montréal et de l'Université McGill

GESRIM : Chaire de recherche CRDI (Canada) en gestion et stabilisation des rejets industriels et miniers, Université de Cadi Ayyad, Marrakech

GSC: Geological Survey of Canada

GSC-O: Geological Survey of Canada – Ottawa

GSC-Q: Geological Survey of Canada – Québec

GSNL: Geological Survey of Newfoundland and Labrador

INRS-ETE : Institut national de la recherche scientifique – Centre Eau, Terre et Environnement

LAGAGE : Laboratoire de Géologie appliquée et Géo-Environnement

LAMEQ : Laboratoire de métallogénie expérimentale et quantitative

LERME : Laboratoire d'études des ressources minérales et énergétiques

MDDEFP : Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs

MERC: Mineral Exploration Research Centre

MISA : Mines, innovations, solutions et applications

MPMPS: Mineral potential maps production system

MERN : Ministère de l'Énergie et des Ressources naturelles

NAP: North American Palladium

NRC: National Research Council Canada

NTS: National Topographic Series

OGR: Osisko Gold Royalties

OGS: Ontario Geological Survey

PDAC: Prospectors and Developers Association of Canada

RAO : Redevances aurifères Osisko

SKLODG: State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guanshui Road, Guiyang, China.

SPCPM : Système de production des cartes de potentiel minéral (MRN)

UdeS : Université de Sherbrooke

UL: Université Laval

UQAC : Université du Québec à Chicoutimi

UQAC-IRME : Université du Québec à Chicoutimi – Institut de recherche en mines et en environnement

UQAM : Université du Québec à Montréal

UQAT : Université du Québec en Abitibi-Témiscamingue

URSTM-UQAT : Unité de recherche et de service en technologie minérale de l'Université du Québec en Abitibi-Témiscamingue

Québec