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# Mines from every angle

**QUÉBEC  
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AND MINERAL RESOURCES

**ABSTRACTS OF ORAL  
PRESENTATIONS AND POSTERS**

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*on fait avancer le Québec*

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## 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 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 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  $\pm$  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-phryic 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).