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Uranium: a breath of optimism

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Québec’s mining industry is showing a renewed interest for uranium after 22 years of relative inactivity. Although most uranium production is concentrated in Saskatchewan and the majority of exploration expenditures are focused in that province, Québec still represents a promising territory for uranium exploration. The mineral exploration work that has covered large expanses of the province has only limited significance for current uranium exploration due to the lack of radiometric, geochemical and geological data relevant to the commodity. However, thanks to a recent geochemical survey of lake bottom sediment in the Far North, a mapping project in the northern part of the Superior Province, and judicial use of the SIGEOM database, it is now possible to plan field exploration programs for territories that were never examined in the 1960’s and 70’s.

Uranium deposits in Québec

Québec experienced two waves of exploration for uranium. The first took place in the 1950’s and 1960’s and was accompanied by the completion of large regional airborne radiometric surveys by the Geological Survey of Canada. These surveys only covered southern Québec. The second period began in the mid-1970’s and ended in the early 1980’s. Since then, exploration for uranium has practically ceased. Beginning in the fall of 2004, known uranium deposits aroused the interest of several junior and senior companies that had returned to Québec.

In Québec, several types of uranium deposits are known (Clark and Wares, 2004; Sidex 2004; SIGEOM-Gîtes; Boily and Gosselin, 2004; Gosselin et al., 2003; Masse, 1974):

- Sandstone-hosted stratiform deposits of sedimentary origin (Sakami Formation [e.g., Lac Gayot (Fearless One) and Lac Bert deposits]; Chioak Group in the Labrador Trough [e.g., Chioak showing]);
- Unconformity-related deposits, like those of the Athabaska Basin (e.g., Rivière Camie and Lac du Castor deposits in the Otish Basin);
- Epithermal vein-type deposits with copper and/or associated with albitization (e.g., Sagar showing, in the Labrador Trough);
- Uranium–gold deposits in conglomerates, like those of Elliot Lake in Ontario (Apple Formation in the Superior Province);
- Iron oxide-type with uranium, copper and gold associations, like Olympic Dam in Australia (e.g., Nipissis [Kwijibo] showings on the North Shore);
- Deposits associated with pegmatites and granitoids (e.g., Grenville Province showings in the Mont-Laurier–Grand-Renous region and the Baie-Johan-Beetz and Aguanish, regions on the North Shore);
- Palabora-type deposits associated with carbonatites or alkaline igneous complexes (e.g., the Oka carbonatite or the Strange Lake deposit in the alkaline complex of Lac Brisson).

Québec’s potential

Most of the showings worked between the 1960’s and 1980’s did not turn out to be economical. Nonetheless, a potential for economic uranium deposits definitely does exist in Québec.

- The Paleoproterozoic sedimentary rocks in the Otish Basin, Sakami Formation and those bordering the Labrador Trough (Chioak Group) represent highly favourable zones for unconformity-type (Athabaska-type) and stratiform sandstone hosted-type deposits. It would thus be interesting to also evaluate the potential of the Wakeham Group in the Grenville Province.
- The Labrador Trough is a perfect example for vein-type deposits associated with albitization. The potential for the Ungava Orogen (Ungava Trough) and the Grenville Province are still to
Deposits associated with pegmatites (alaskites) and Rossing-type (Namibia) peraluminous granitoids are well known in the Grenville Province and examples are also documented in the Superior Province. It would be interesting to know if any are present in the Core Zone (hinterland) between the eastern limits of the Labrador Trough and the Torngat Orogen. The presence of migmatized metasediments, a trail of sizeable granitic intrusions (e.g., the De Pas batholith), and uraniferous anomalies in lake bottom sediments warrant further investigation of this extensive territory.

With respect to the uranium potential in the Appalachians, only a few showings are known (e.g., Saint-Armand and Sainte-Anne-du-Lac near Thetford-Mines). However, this geological province warrants further attention due to its position near major transport infrastructures and North American markets.

Finally, there may be a potential for uranium deposits associated with felsic volcanic rocks with subalkaline to hyperalkaline affinities (e.g., Michelin deposit in Labrador). The Wakeham Group (Grenville Province), some of the volcanic units in the New Québec Orogen and the Appalachians represent target areas for this type of deposit.

History of uranium economics

The great depression experienced by the uranium market can be attributed to a number of factors, including the major accidents at nuclear facilities in the United States (1970) and the ex-USSR (1986) that slowed or completely halted the construction of new nuclear facilities in these and several other industrialized countries. New supply sources of secondary plutonium and uranium made their appearance on the market in the 1990’s following the nuclear disarmament of the two superpowers, the recycling of uranium and plutonium fuel rods, and the liquidation of uranium inventories (Comb, 2004; World Nuclear Association, October 2004).

Between 1970 and 1984, the uranium market was dominated by a primary production that exceeded the needs of nuclear reactors. The production was based on erroneous forecasts of a sharp increase in nuclear energy production (Sidex, 2004). Right up until 1990, the primary production of uranium oxide ($U_3O_8$) largely exceeded demand. After 1990, $U_3O_8$ production declined in proportion to demand (Comb, 2004), and stockpiles were even liquidated between 1985 and 2003.

Starting about two years ago, the spot price for $U_3O_8$ increased dramatically to attain US$30/lb in October 2003 (source: Ux Weekly; Bonnel and Chapman, 2005). It was in 1976-1977 that the price of $U_3O_8$ attained its historic high at just over US$100/lb (price in 2004 dollars or ~ US$43/lb in current dollars). This high was followed by a rapid decline, beginning in 1980, to bottom out at under US$8/lb in 2001. Spot prices account for about 15% of the uranium market, whereas 85% of transactions are carried out in the form of long-term contracts, generally at a higher cost than the spot price (Sidex, 2004).

Today

In the years since the Kyoto summit, prominent industrialized countries have made efforts to reduce their greenhouse gas emissions, which are partly responsible for the climate changes noted by scientists for over a century. With the exception of hydro-electricity, solar energy and wind energy, nuclear energy releases the least amount of greenhouse gases compared to fossil fuels (World Nuclear Association, February 2005). In order to meet their Kyoto commitments and reduce their dependence on oil and natural gas to meet their energy needs, many industrialized countries have decided to construct new nuclear power plants. Furthermore a rising demand in energy needs by emerging countries like China, India and some in southeast Asia, the progressive depletion of several currently mined deposits is anticipated shortage between now and the next 10 to 15 years. The current production of primary uranium represents 55% of the needs of operating nuclear reactors (World Nuclear Association, October 2004). Collectively, these are the necessary ingredients for an upsurge of uranium spot prices, which would lead to a renewed interest on the part of mining companies to dedicate some of their exploration expenditures for uranium.
**World production of uranium**

World production of uranium attained 36,300 tonnes in 2003 (Bonel, 2005). World reserves for ore with a production cost of less than US$40/kg are estimated at nearly 2 Mt uranium, representing more than a 30-year supply for existing reactors (Sidex, 2004). The Canadian production for 2004 amounts to 13,676 tonnes of U₃O₈ concentrate and is equivalent to 30% of world production. This production is evaluated at CA$800 million. Uranium resources with low production costs (Reasonably Assured Resources and Category I Estimated Additional Resources) amount to 590,000 tonnes U₃O₈ and corresponds to 12% of world production. For comparison, global reserves with low production costs are twice that of Canadian reserves. Canadian production comes entirely from Saskatchewan (Athabaska Basin). In 2003, about $13 million dedicated to off-site mineral exploration, mainly in Saskatchewan (World Nuclear Association, August 2005). At the present time, Québec does not produce uranium.

**References**


Other suggested readings on uranium deposit types in Canada and the world:


Distribution of Ni-Cu-PGE mineralization in the Cape Smith Belt (Ungava Orogen): avenues of exploration

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The Cape Smith Belt offers exceptional mineral potential. This area of Northern Québec is the target of an ever-increasing number of exploration activities. The most recent results obtained by exploration companies confirm the excellent potential for discovering of new Ni-Cu-PGE showings. Until now, exploration was mainly concentrated in the southern part of the belt. Other more northern sectors, however, also deserve to be explored. With this in mind, the Ministry recently defined the geological trends for each part of the Cape Smith Belt (Raglan Trend).

The distribution of Ni-Cu-PGE mineralization in the Raglan Trend displays two distinct sub-trends: north and south. The north trend is clearly richer in nickel than the south trend, but the latter contains higher levels of platinum and palladium. The trends also display different Ni/Cu ratios, with values of about 1 for the south trend and values ranging from 2 to 54 for the north trend. It is reasonable to assume that mineralized occurrences within the two trends were not fed by the same feeder dyke system. The magmas associated with the north trend are more primitive than those associated with the south trend.

The north trend consists of Ni-Cu-PGE showings along the Raglan horizon located at the interface between the Povugnituk and Chukotat groups. It includes a string of 19 massive sulphide lenses of which the most important are the Katinniq, Donaldson and Lac Cross deposits. These deposits are found at the base of komatiitic lavas or are associated with cumulates or ultramafic sills that crosscut the Chukotat Group.

Nickel grades are generally high and in places attain 8% over a thickness of about 10 m. Copper contents are fairly low and rarely reach 1%. Several samples of massive or disseminated sulphides display average grades of 3 g/t Pd and 1.3 g/t Pg. According to the classification of magmatic sulphide deposits, the north trend represents magmatic Ni-Cu sulphide deposits.

The south trend is mainly associated with differentiated sills of peridotite-pyroxenite-gabbro and occasional relatively zoned feeder dykes of peridotitic or gabbroic composition. It includes several mineralized showings of which the most significant are Mesamax, Expo-Ungava, TK and Méquillon. Mineralization is mostly in the form of disseminated to semi-massive sulphides, with occasional massive sulphides, located at the base of intrusions.
An alternation between massive and disseminated sulphides has been noted in places, which suggests a cyclic process for these occurrences, probably due to repeated injections of magma. Coarse-grained granular pentlandite accounts for more than 20% of the observed sulphides. It appears, however, that there is no difference in Ni-Cu-PGE grades between coarse-grained and fine-grained granular mineralization.

Mafic to ultramafic sills are locally intercalated by metasedimentary horizons. It is therefore not rare to drill a section containing several levels of massive sulphide. The continuation of a drill hole will often depend on finding stockwork sulphides in these metasediments (T. Keast, personal communication).

In contrast to the north trend, nickel grades of the south trend rarely exceed 3% Ni, although copper is often locally recorded at more than 4% over 6 m, including intervals of 8% over 0.5 m. Ni/Cu ratios for individual samples are fairly constant, hovering around 1. The relatively constant Pd/Pt ratios of about 4 in massive or disseminated mineralizations rise abruptly to 15-20 in horizons that are richer in Cu and Pd. Also observed is a positive correlation between Cu and Pd.

The highest Pd values (> 10 g/t) are generally associated with Cu-rich mineralization. The presence of massive chalcopyrite in the form of veins or thin centimetre-scale horizons suggests hydrothermal remobilization of Cu and Pd from primary magmatic mineralization.

Some of the magmatic sulphide deposits in the south trend containing low nickel grades could therefore prove to be economic due to their high Pt and Pd contents. Systematic analysis for these elements is thus strongly recommended in the south zone, even in areas with very low nickel values.

Gold mineralization:
New data from the Uran-Barry Belt

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During the summer of 2005, Géologie Québec conducted field studies at selected sites in the Urban-Barry Belt (UBB), particularly in the Lac Windfall and Lac Rouleau sectors. Newly stripped zones and recent drill cores were examined to gain a better understanding of the geological context of the gold mineralization for which the sector is known. Preliminary examination of the collected data reveals several similarities between the Lac Windfall sector and epithermal precious metal deposits.

This work supports previous studies and highlights the development of several types of auriferous mineralization during the UBB’s geological history. In particular, the hypothesis of a large epithermal
system in felsic and intermediate rocks for the Windfall and Rouleau members has significant consequences for exploration. The following features are considered particularly important:

- Epithermal-type mineralization observed thus far is associated with recognizable alteration defined by silicification, carbonatization, potassium gain, sodium depletion and the presence of tourmaline. This signature, evident in the field, can serve as an exploration guide.
- The effects of this epithermal system can be seen within a broad area which includes several rock types. This hydrothermal signature is notably (but not exclusively) expressed in the Lac Windfall-Lac Rouleau sector and the Lac aux Loutres sector. The exploration for epithermal precious metal deposits should take into account such a large volume of altered rocks.
- The structural style in the UBB features doubly plunging folds and structural imbrication from south to north which are favourable to the preservation of extensions of the main altered units at relatively shallow depths.

**Location and geological context**

The UBB is located 100 km south of Chapais (Figure 1). It consists dominantly of volcanic rocks and extends for 135 km from Lac Wilson in the west to the Grenville Front in the east. The UBB displays a prominent E-W structural trend marked by doubly plunging folds and E-W faults that produce thrusting to the north (Figure 2). Numerous felsic volcanic assemblages are present, including the Novellet (2,714 Ma), Freeman (2,701 Ma), Windfall (2,718 Ma), Rouleau, Chanceux (2,727 Ma) and Fecteau (2,791 Ma) members.

The 2005 work focused primarily on the Windfall and Rouleau members where a number of exploration companies, including Ressources Murgor Inc., Noront Resources Ltd. and Beaufield Consolidated Resources Ltd., have been active for several years. Stripping and drilling in the Windfall sector revealed pyritic stockworks crosscutting a complex of quartzo-feldspathic porphyry sills, andesites and felsic tuffs. The stockworks (Figure 3) are typically only weakly deformed and have yielded gold grades of more than 10 g/t Au. The Au/Ag ratio for the samples collected in 2005 is high, on the order of 1/1, and the host rock displays alteration that is often intense and characterized by silicification, carbonatization, potassium gain and sodium depletion. Pyrite also contains tourmaline needles and locally forms tourmaline-cemented breccia similar to that found in the Lac aux Loutres sector.

![Figure 3a](image_url)  Sample from a gold-bearing interval displaying a pyritic stockwork in an intensely silicified zone (drill hole NOT-4-27).

![Figure 3b](image_url)  Detail of the boxed area in A displaying brownish tourmaline crystals with triangular cross-sections in pyrite. Sample provided by Noront Resources Ltd.
Current information indicates that mineralization predates deformation and is syn-volcanic in origin. The early timing of the mineralization, the development of pyrite-gold stockworks in silicified zones with a potassic alteration halo, and the Au/Ag ratio of about 1 collectively suggest that these mineralizations belong to a large epithermal system or to an alteration pipe in an auriferous volcanogenic-exhalative system.

Considerable quantities of disseminated tourmaline (1-2%) and pyrite were also observed in intermediate tuffs west of Lac Rouleau, south of the Windfall sector (NAD 83–18 - 454587E - 5431846N). These tuffs coincide with a folded magnetic high that can be followed for several kilometres.

The Lac Rouleau sector has very little exposure and was mainly investigated by studying drill core. Core samples are currently being processed for lithogeochemical analysis that will help characterize this large unit. The rocks of the Rouleau Member observed in drill core were mostly lapilli or block tuffs of intermediate composition. We also observed significant carbonate alteration locally associated with shearing, as well as quartz veins and specks of visible gold. Earlier work reported reserves of 544,000 t grading 7.2 g/t Au. Preliminary evidence is compatible with vein-type mesothermal gold mineralization.

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Direction du développement minéral

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**Geochemical data presented in easy-to-read tables**

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Figure 1. Geological subdivisions and distribution of the most significant uranium showings and deposits in Québec.
Figure 1 - Carte géologique de la Sous-province de l'Abitibi montrant la localisation de la portion étudiée de la Ceinture d'Urban-Barry.
Stockwork de Pyrite