Regional targeting of IOCG deposits in Québec

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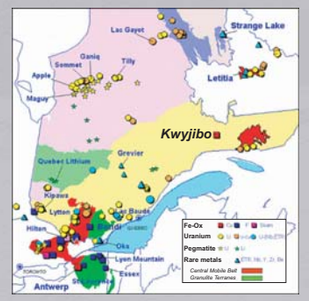
1. Abstract

IOCG deposits formed mainly during Proterozoic and Cretaceous times. The Salobo deposit in Brazil (789 Mt @ 0.96% Cu and 0.52 g Au/t) is the world only known Archean ore deposit of this type. This occurrence opens up many new territories in Canada to exploration, particularly in the Archean Superior Province. Iron oxide deposits constitute giant targets characterized by: 1) an abundance of iron as magnetite and/or hematite (100-2,000 Mt @ 30-65% Fe); 2) a vast system of potassic and sodic hydrothermal alteration; 3) a characteristic suite of elements (Cu, Ce, U and Co); and 4) a structural control along major lineaments. These features collectively represent excellent regional-scale geophysical and geochemical targets.

An integrated geophysical, geochemical, structural and metallogenic GIS approach is presented at the scale of the province of Quebec and Labrador. The objective is to generate regional exploration targets using data from public databases. The primary exploration guides were: 1) superimposed magnetic and gravimetric anomalies; 2) a suite of indicator elements in stream and lake bottom sediments; 3) a proximity to a geophysical lineament or an intersection of lineaments; and 4) a spatial association with intermediate to felsic intrusions.



Worldwide, most iron oxide deposits belong to metallic provinces (e.g. Great Bear zone, Tennant Creek, Kiruna, and Salobo). Therefore, compiling known iron oxide occurrences and related deposits (skarns, pegmatites, rare metals, etc.) from a broad region can help define favourable areas for exploration. This exercise was done for north-eastern North America. Low-Ti iron oxide deposits in this area can be divided into two types: IOCG (with copper, gold, uranium and REE) and Fe-only. The only IOCG occurrence, Kwyjibo, lies in the Grenville province in Quebec. Fe-only deposits are rich in magnetite-apatite or hematite, and are located in New York state and New Jersey.

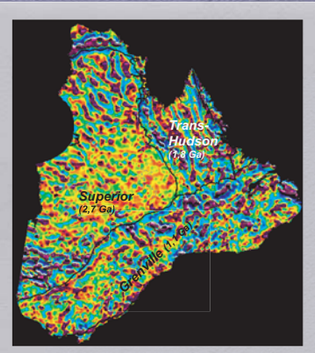
In-situ fragmentation breccia at Kwyjibo, Grenville Province, Québec

Altered host rock fragments in a breccia characterized by a magnetite matrix at Kwyjibo. The alteration consists of Albite and Alanite (rare earth mineral of the Epidote group).

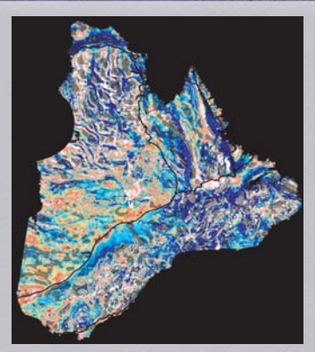
Chalcopyrite, pyrite, pyrrhotite, molybdenite, arsenopyrite, fluorite, and calcite in massive magnetite (Kwyjibo).

2. Geophysical Anomalies

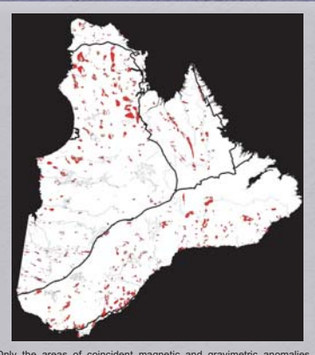
In geophysical terms, the most important characteristic of iron oxide deposits is obviously the large mass of iron oxides (e.g., >100 Mt of ore @ 30-50% Fe). The geophysical approach used consists in isolating positive gravimetric anomalies and identifying positive magnetic anomalies within the gravimetric signature. This allowed us to recognize gravimetric anomalies possibly generated by large volumes of iron in the form of hematite and/or magnetite.



Magnetite and hematite will create gravimetric highs (in hatched pattern).



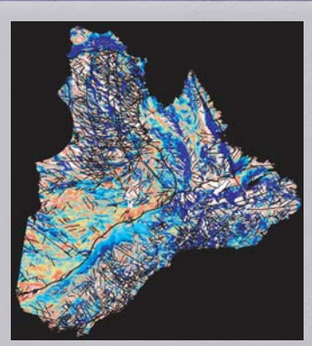
Isolating magnetic anomalies in areas known to be gravimetric highs.



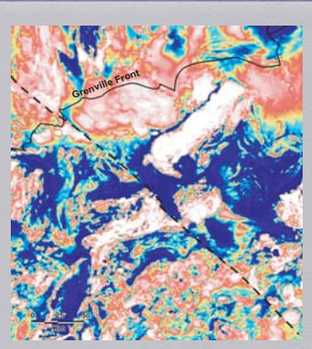
Only the areas of coincident magnetic and gravimetric anomalies are shown in red. These areas are favourable for iron oxide exploration.

3. Geophysical Lineaments

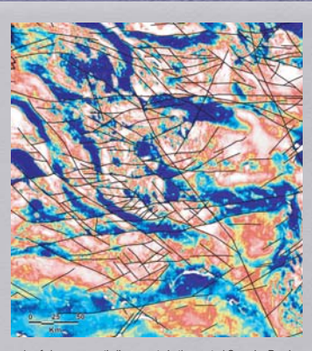
As most iron oxide deposits are structure-controlled, exploration can benefit from the identification of geophysical lineaments, in particular any rectilinear structures interpreted as late brittle faults. The intersections of lineaments also represent good plumbing networks for IOCG.



Sharp magnetic lineaments, which are interpreted as brittle faults, are herein displayed as black lines (n = 1913) on the total field magnetic map.



Example of a sharp magnetic lineament crosscutting the Grenville Front.

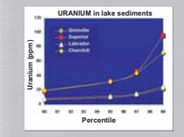


Example of sharp magnetic lineaments in the central Superior Province.

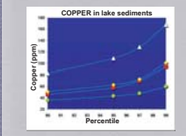
4. Geochemical Anomalies

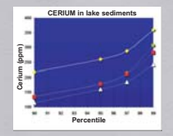
IOCG mineralizations have a distinct geochemical signature. For instance, over two thirds of IOCG deposits are associated with anomalic F, Co, Mo and REE. Elements such as Cu, Au, Ag, U, Ba, P, Cl, W, Sn, and Zn can also be anomalic. The geochemical approach used consists in compiling Cu, Ce-(La), U and Co anomalies from lake bottom sediments of the Far North, the Middle North and the Grenville (111,551 samples). The geochemical anomalies were determined for each geological province using a threshold value representing the regional background level. The 95th and 97th percentiles were taken as favourable geochemical anomalies.

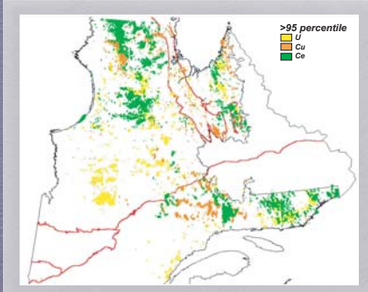
Map showing the geographic coverage of provincial datasets (red outline) for lake sediment geochemistry.



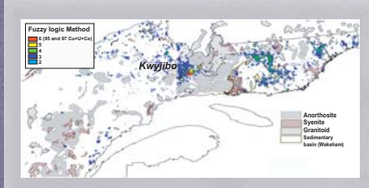
Lake sediment geochemical data were divided into subsets for each geological province. Anomalies are based on percentile thresholds. Here, element concentrations vs. percentile plots are shown for U, Cu, and Ce in the Superior, Grenville, Labrador Trough and Churchill provinces.







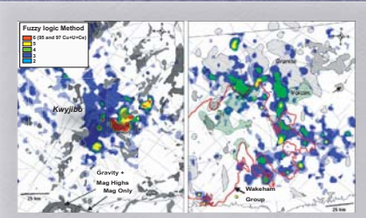
Normalized distribution of U, Cu and Ce values which are over the 95th percentile in lake sediment geochemical data.



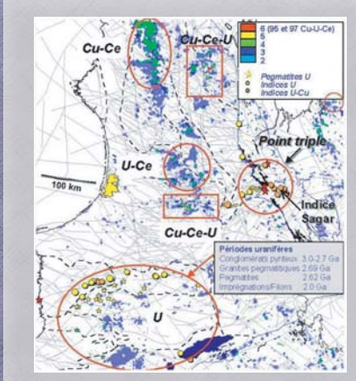
Fuzzy logic method for lake bottom sediment geochemical anomalies in the Grenville province. A value of one is given to each pixel having Cu, Ce or U concentrations above the 95th and the 97th percentile, for a possible maximum value of six. Rock types favourable for iron oxide exploration are shown as well. The greatest anomalies are found NE of Sept-Iles, in the Kwyjibo area. Most sectors displaying a fuzzy logic value =4 are found either within or near granitoids, or at the northern and eastern margins of the Wakeham Group.

5. Synthesis

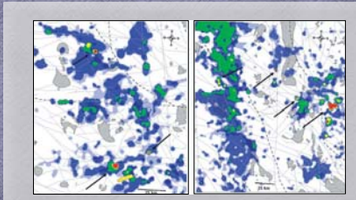
The results obtained demonstrate that the potential for discovering IOCG deposits in Quebec is good and that an integrated geological and geophysical approach can target sectors for exploration using data that is publicly available. The various approaches recognized the Kwyjibo deposit in the Grenville, which is the only known Proterozoic iron oxide deposit in Quebec. In the Superior Province, punctual geochemical targets along the margins or at the intersection of lineaments west of the Labrador Trough also indicated a potential for this deposit type. Other regional targets based mainly on geological criteria were identified at the periphery of the Proterozoic Wakeham and Mont-Laurier basins (Grenville Province). The intersection of rifts (Ottawa region) and triple point junctions corresponding to ancient Proterozoic aulacogens are also favourable, notably in Labrador (Seal Lake Group) and west of the Labrador Trough (the Lac Cambrien aborted rift).



Close-up of the Kwyjibo area and Wakeham sedimentary basin showing the combination of geochemical and geophysical targeting approaches. Cross-hatching corresponds to coincident magnetic and gravimetric anomalies. Geochemical anomalies in this area are located at the intersection of NE-SW and NW-SE lineaments, or bounded by lineaments from these families. The areas where hot colors (geochemical anomalies) and cross-hatching (geophysical anomalies) are superimposed are the most favourable sectors for IOCG exploration.



Regional exploration targets in the Superior province, using fuzzy logic on lake-bottom sediment geochemical anomalies. A value of one is given to each pixel having Cu, Ce or U concentrations above the 95th and the 97th percentile, for a possible maximum value of six. Known uranium and U-Cu showings were added, as well as interpreted geophysical lineaments. The red rectangles are examined in more details in the next figure.



Detailed view of interesting areas in the Superior Province: arrows indicate the strongest geochemical anomalies and correspond to first order exploration targets. Cross-hatching corresponds to coincident magnetic and gravimetric anomalies and grey lines to geophysical lineaments.

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