2014-02:

GRAPHITE-RICH BLACK SHALES IN THE SEDIMENTARY BASINS OF THE ABITIBI

The origin of the gold found in the syn- to late-metamorphic (orogenic) deposits has been a continual subject of debate. Wide et al. (2008) summarized and synthesized many works that propose gold in certain deposits originating from sedimentary sequences, in particular graphite-rich, sulphide-containing black shales that are also pre-enriched in metals. In this model, the gold is progressively released from the diagenetic pyrite as metamorphism increases from green shale to upper green shale-amphibolite. The gold is transported with sulphur that stems from the desulfurization reaction of pyrite toward pyrrhotite to become trapped in the upper portion of the greenschist facies crust. Important gold deposits in Central Asia and of the American West (Carlin) are derived from this process.

Project 2014-02 has the objective to document the metal content of the major turbidite-containing basins of the Abitibi and to test the model of Large et al. (2008). These basins cover an area of 12 800 km^2, representing nearly 14 % of this Archean sub-province. What is the potential for these basins to contain primary gold? Do graphite-rich, sulphide-containing black shales represent an anomalous reservoir for metals and are they sufficiently rich in gold to represent an economic deposit? This is a methodology-based project that aims to develop geological, mineralogical, and geochemical tools for businesses to recognize argillites in sedimentary basins that are abnormally rich in metals and gold.

The first part of the study summarizes the main geological characteristics of the 23 turbidite-containing basins of the Abitibi region having an area >100 km^2. Use of INPUT-type airborne-measured electromagnetic anomalies covering the entire Abitibi region provides a means of assessing the relative amount of graphite-rich argillites and, indirectly, determine the redox character and the potential sources of metals in these basins. Argillite layers are very good conductors and respond particularly well to channels 4, 5, and 6. The content in argillite is estimated for each of the 23 basins by calculating the sum of channels 4, 5, and 6 per unit of surface area. The Blondau and Taibi formations (Lamarck Fault Sector) are the basins most rich in graphite-rich argillite (**Figure 1**). The basins situated toward the middle of the Abitibi region contain a good amount of these layers. The youngest basins to the south of the belt are very poor in argillites, highlighting a decrease in redox character with the decreasing basin age.

The second part of the study takes place in the township of Dieppe (along the Québec-Ontario border and the Casa Berardi mines), specifically along the Casa Berardi Fault. It documents the process of gold liberation in an argillite layer that is rich in graphite and sulphides overlapping the isograd of the upper green shale (biotite) and the transition zone to amphibolite (garnet and amphibole). In thin section, pyrite nodules in the green shale are gradually transformed into pyrrhotite with the increased metamorphism as one moves westward across the region. The mineral chemistry determined by LA-ICPMS (laser induced coupled plasma mass spectrometry) indicates that the nodules of diagenetic pyrite (Py1) contain a suite of polymetallic elements including gold encapsulated in the heart or the edges of the nodules (**Figure 2**). With the increased

metamorphism, the PY1 gradually turns into Po (sterile) and into cubic and metamorphosed PY2, particularly in the shadow areas of pressure in the nodules. Through refining, metals form new minerals (sphalerite, chalcopyrite) and free gold is found as inclusions in the fractures of the Py2 or in the quartz, or associated with the chalcopyrite. This is the first demonstration of the Large et al. model for the Abitibi.

The third part of the project concerns the geochemistry of graphite-rich black argillites and grey siltstones of turbidite basin in the Abitibi. The sulphide and graphite-rich black argillites are defined by the sulphur and graphitic carbon contents being ≥0.5 %. A comparison of multielement spectra between the different sedimentary basins indicates that some are richer in base metals while others are richer in Au and As. Given the large abundance of input anomalies, the Blondau Formation contains many graphite-rich layers but the values for several metals are the lowest of all the study basins. A principal component analysis proposes two metalliferous indices, one for base metals and another for Au and As. Values for the base metal index increase toward the younger basins located in the southwestern portion of the Abitibi. Finally, an equation derived from multiple regression and a suite of explanatory variables (metals) allows for predicting the quantity of gold within a sample and to identify, by residuals, samples depleted or enriched in Au. This approach shows that there is a tendency toward gold enrichment in several places in the Abitibi at the limit between the green shale and upper green shale-amphibolite as predicted by the model.

In conclusion, it is estimated that there should be two horizons of graphite-rich argillites of 40 ppb Au, estimated to be 5-m-thick, and 10-km-long (such as those studied in the Dieppe Township) and having a depth of 5.6 km to produce a 60-t deposit such as that of Casa Berardi. If the Large et al. model applies along the Casa Berardi Fault at the margin of the Taibi basin, it cannot be applied to the Cadillac-Larder Lake Fault to the south of the Abitibi. The quantity of gold along this transcrustal fault cannot be explained by the Large et al. model as there is an almost complete absence of graphite-rich black clays in the basins of southern Abitibi (Cadillac Group, Mont-Brun Formation, and the Pontiac sub-province).

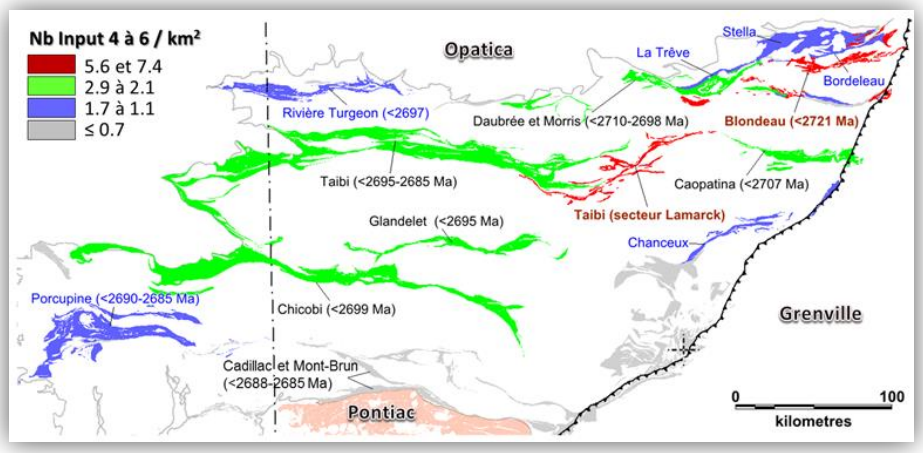

Figure 1. Map of the turbidite basins of the Abitibi showing the quantity of input anomalies (Channel 4, 5, and 6) per km^2. The basins in red and green are those containing the most layers of graphite-rich argillites.

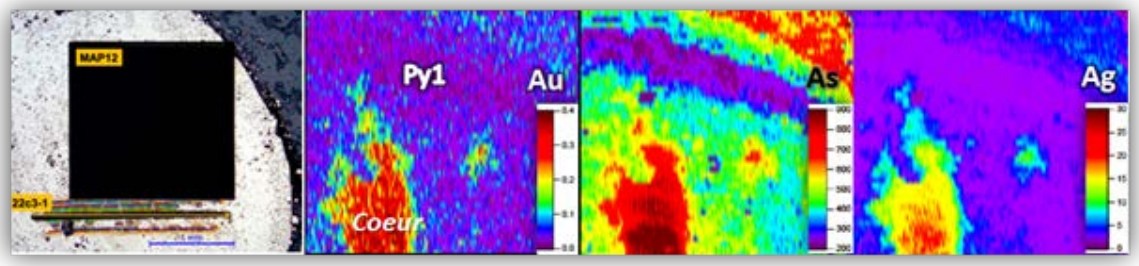

Figure 2. Microphotograph (left image in reflected light) of a PY nodule of green shale near the Douay deposit showing the LA-ICPMS mapped location of Au, As, and Ag on the coloured images on the right-hand side.

Project 2014-02: Summary sheet	
Objectives	➢ Methodological study aimed at testing the Large et al. model in the turbidite basins of the Abitibi. ➢ Propose geochemical tools to assess the metal content and Au anomalies in sulphide and graphite-rich argillite layers for the different sedimentary basins.
Results and innovations	➢ Demonstration of the Large et al. model through 1) analyses by microscope and LA-ICPMS on nodules of pyrite and pyrrhotite from a graphite-rich argillite layers along the Casa Berardi Fault, township of Dieppe and, 2) by a geochemical approach for different basins in Abitibi and in relation to metamorphism. ➢ Applicable model for exploration along sedimentary basins bordered by major faults and containing horizons of sulphide and graphite-rich argillite layers that are abnormally rich in metals (Casa Berardi Fault and the Taibi Basin, for example), which excludes the case of the Cadillac Fault.