2013-03: The relationship between gold mineralisation and metamorphic isograds in the Abitibi region

Since the 1980s, several authors have shown that syn- to late metamorphic (orogenic) gold deposits, such as the majority of non-volcanogenic gold mineralisation found in veins and shear zones in the Abitibi, are emplaced in greenschist facies rocks close to the limit of upper greenschist and lower amphibolite facies. The mineralised zones in the Sigma-Lamaque, Lapa, Casa Berardi and Detour Gold mines, among others, coincide with this limit. The limit is considered to be critical because of the increased fluid and mobile sulphur production, decreasing salinity, and the transition of rheological behaviour from brittle to ductile.

To apply this devolatilisation model of the crust, it is absolutely necessary to know the position of metamorphic isograds across the Abitibi for gold exploration. Yet, the only metamorphic map of this Archean greenstone belt, the largest in the world, is by Joly from 1978. The map is imprecise, incomplete for some areas of the Abitibi, and does not identify the upper greenschist isograd. The main objective of this project is to produce a new map of the metamorphic grade distribution for the entire Abitibi region (Figure 1).

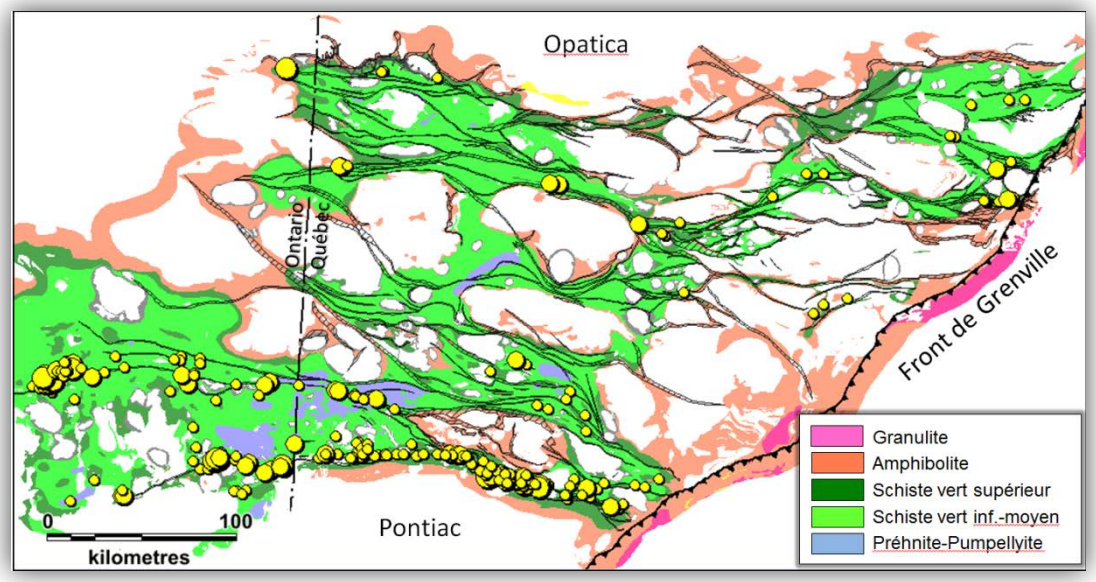

Figure 1. New metamorphic map of the Abitibi with the position of gold deposits and showings hosted in veins or in shear zones.

Three types of information were used to create the map: 1) a variety of works on the metamorphism compiled from *ministère des Ressources naturelles* maps (SIGÉOM) and reports, specific studies carried out by the OGS in Ontario, and articles from specialised journals for the southern Abitibi; 2) metamorphic minerals observed in outcrop or drill core and described macroscopically or in thin section contained in the SIGÉOM database or supplied by the industrial partners of the consortium. Tens of thousands of descriptions were entered, processed and analysed in terms of assemblage and well-known metamorphic reactions that characterise the main isograds; and lastly 3) different approaches based on the volatile content of the volcanic rocks were proposed and tested to evaluate with some success the possibility of

using geochemistry and the LithoModeleur software as a complementary tool to mineralogy for tracing isograds.

Next, the metamorphic map was used as an exploration guide in a variety of contexts. It was established early that the vast majority of the vein and shear-zone hosted gold mines, deposits and showings, as most of the gold produced or in reserve, are located less than 2 km from deformation corridors (Figure 1). This fertility envelope surrounding the deformation corridors was then combined with spatial relationships from the metamorphic map. It is known that iron formations only contain gold mineralisation if they reached upper greenschist – amphibolite facies metamorphism because of the sulphidation reactions and the competency contrasts (Homestake 40 Moz, Dakota for example). Overlap between the upper greenschist and amphibolite surfaces, the 2 km fertility envelope and the Abitibi iron formations allows us to exclude 77% of the area occupied by iron formations and thus better focus exploration. Another approach was to identify deformation corridor segments that show a contrast in metamorphism across and border the sedimentary basins. The metamorphic contrast and the sedimentary basins proxy the presence of large vertical movements (normal or reverse) and the longevity of certain structures (for example, early faults reactivated by the orogeny), two components known to favour the creation of orogenic gold deposits. Statistics show that only 38 of the 252 Abitibi fault segments show these two characteristics; there is 3.9 times more gold per square kilometre in these zones than in the other fault segments. Lastly, to assess the theory that gold precipitates in greenschist facies rocks close to the upper greenschist and amphibolite facies boundary, the amount of gold per unit area and the absolute gold tonnage were calculated for the upper greenschist and amphibolite facies, and at 1 km intervals away from the upper greenschist isograd (Figure 2). The histogram in Figure 2 shows that most of the gold is located in the upper greenschist facies and mostly in the first 2 km measured horizontally from the upper greenschist isograd.

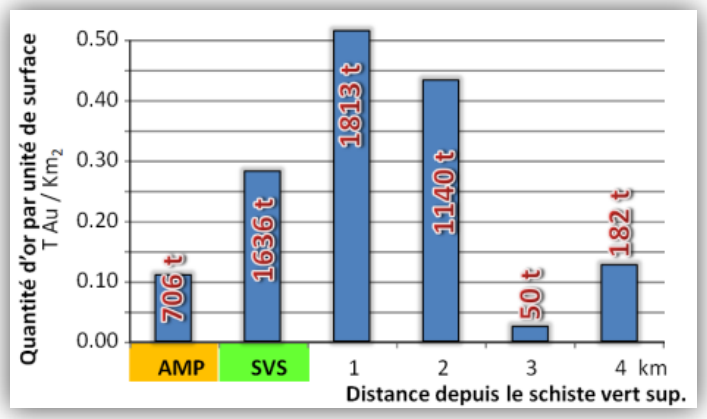

Figure 2. Histogram showing the amount of gold per km^2 for the entire Abitibi region contained in amphibolite and greenschist facies in intervals of 1 km from the upper greenschist isograd.

Project 2013-03: Summary	
Objectives	• To update the knowledge base on the metamorphism of the biggest greenstone belt in the world. • To propose exploration guidelines for orogenic gold mineralisation using a new metamorphic map.
Results and Innovations	• New, detailed metamorphic map for the Abitibi region (Quebec and Ontario). • An overlap between the metamorphic map, faults, sedimentary basins and iron formations allowed the targeting of areas of interest for gold exploration by significantly reducing the area needing to be explored depending on the chosen deposit model.