Identifying mineral exploration targets in the eastern Grenville Province

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In the rush that followed the discovery of the Voisey's Bay Ni-Cu-Co deposit, large areas of the eastern Grenville Province were staked. As was inevitable, a considerable number of these claims have now been dropped, but, rather than this being regarded as an indication of lack of potential, the release of these regions should now be taken as an opportunity for more systematic mineral exploration at a less frenzied pace. In many cases, dropped claim blocks were not visited and assessment work never carried out. This is not entirely surprising, given that the geological database remains sparse for many areas and, except along the coast, dense forest, vast swamps and poor access render this region hostile to mineral exploration. The thesis of this presentation is that known or inferred mineralization targets, when placed in the context of the geological evolution of the eastern Grenville Province, encourage continued exploration.

The geological history of the eastern Grenville Province can be classified into eight stages: (i) pre-Labradorian basin formation, (ii) Labradorian (1.71-1.60 Ga) accretionary orogenesis, (iii) Pinwarian (1.51-1.45 Ga) orogenic(?) activity, (iv) Elsonian (1.45-1.23 Ga) anorogenic events, (v) Elzevirian (1.23-1.18 Ga) orogenesis, (vi) Adirondian (1.18-1.09 Ga) events, (vii) Grenvillian (1.08-0.97 Ga) collisional orogenesis, (viii) post-Grenvillian events. Each stage created an environment conducive to some form of mineralization. The pre-Labradorian basin (back-arc or small ocean) collected detritus from pre-Labradorian Laurentia and probably also from pre-Labradorian crust recently recognized in the southern part of the eastern Grenville Province. The detritus is now preserved as extensive regions of dominantly pelitic gneiss, with minor calcareous and quartzitic gneiss and mafic volcanic rocks. If not starved, the basin was certainly underfed, either implying low-lying flanks incapable of providing material or that only distal parts of the basin remain. High sulphide content, as indicated from numerous gossans in well-exposed coastal areas, suggest an anoxygenic environment. The pelitic gneisses show anomalously high Cu contents and are associated with Cu-U-Mo-As-(Co) lake-sediment anomalies. U, Mo and Cu (up to 2.8%) mineralization have been discovered in places. Present data suggest a spatial association for the Cu mineralization with pillowed mafic flows, pointing to a deep, volcanically active setting. Also, the non-metallic potential of the pelitic gneisses (e.g., muscovite and sapphire) should not be forgotten.

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Labradorian orogenesis can be divided into pre-, syn- and post-accretion sub-stages. The pre-accretionary stage generated calc-alkaline rocks between 1.68 and 1.66 Ga. Mylonitization and migmatization dated between 1.66 and 1.65 Ga are evidence of the syn-accretion stage. The post-accretion stage produced the 1.65 Ga Trans-Labrador alkali-calcic batholith, coeval felsic volcanic rocks, and post-collisional (1.65-1.62 Ga) layered mafic-felsic plutonic suites. Present data offer little inducement to explore the pre-accretionary calc-alkaline plutonic rocks; perhaps dearth of mineralization can be linked to their juvenile crustal status. In contrast, the syn- and post-collisional rocks offer a wealth of targets. The syn-accretionary felsic volcanic rocks along the northern fringe of the Trans-Labrador batholith host numerous epithermal Cu-Zn-Pb-U showings (one containing over 2.5% Cu), have anomalous Au values, and contain indications of Mo mineralization. Coeval quartzofeldspathic gneisses in southeasternmost Labrador, believed to have a similar felsic volcanic protolith, show traces of Cu and Mo mineralization and have associated Cu-Zn-U-Mo-Ag-As lake-sediment anomalies. From the layered mafic-felsic intrusions, minor Ni-Cu sulphide and Ti(Fe) oxide mineralization and anomalous platinum-group-element values have been reported. These intrusions, in particular, remain underexplored despite recent staking. They provide well-defined targets for grassroots exploration, especially in the twin contexts of being related to a major tectonic interface and having been emplaced into sulphide-rich supracrustal rocks (both factors deemed to be important controls in locating the Voisey's Bay deposit).

The Pinwarian period involved widespread plutonism and thermal effects. In the southern part of the eastern Grenville Province, plutonism included emplacement of the Upper Paradise River AMCG (anorthosite-monzonite-charnockite-granite) intrusion and smaller quartz monzonite to granite bodies, in contrast to more northerly regions where the only Pinwarian activity was either dioritic or comprised minor granitoid dykes. The undated Kyfanan Lake layered mafic intrusion in southeastern Labrador may be part of the Pinwarian event. From a continent-scale tectonic viewpoint, an inboard continental arc setting is suggested by extrapolation from the west, whereas an anorogenic setting seems more likely by extrapolation from the east. The granitoid rocks have yet to be explored, but massive Ti(Fe) oxide mineralization has been discovered in the layered mafic intrusion, which also features Ni-Co-V-(Ag) lake-sediment anomalies.

Elsonian events opened with extensive Michael-Shabogamo mafic magmatism (1.46-1.42 Ga) in the northern part of the eastern Grenville Province that was coeval with AMCG massif emplacement (Harp-Michikamau-Mistastin) north of the Grenville Province. By 1.42 Ga, AMCG plutonism was also active within the Grenville Province and continued until at least 1.30 Ga, thus overlapping with the time of emplacement of the Nain Plutonic Suite, host to the Voisey's Bay deposit, farther north. Between 1.33 and 1.31 Ga, alkalic and peralkalic magmatism (Red Wine Intrusive suite and Letitia Lake Formation) also occurred at the northern margin of the eastern Grenville Province. The end of Elsonian activity was characterized by mafic volcanism (Seal Lake Group) and dyke emplacement both at the northern margin of the eastern Grenville Province and well within it (Wakeham Supergroup). Evidence of mineralizing activity during the early Elsonian is meagre, but the 1.33 to 1.31 Ga alkalic and peralkaline rocks contain Nb-Be and minor Cu mineralization and show anomalous Y and Zr values. The Seal Lake Group is well known for its numerous Cu occurrences, and the Wakeham Supergroup contains Cu-Au showings. By analogy with other regions, Sn-W mineralization might be expected in late granitoid fractionates of AMCG suites. The apparent termination of anorogenic events in eastern Laurentia at 1.23 Ga coincides with the onset of Elzevirian orogenesis in the southwest Grenville Province, provoking the speculation that some form of compressional orogenesis was also initiated farther east. Geochronological data lend some support to this notion, but are inadequate to develop a comprehensive model for the event's nature. In any case, no mineralization has been linked to this period, so far.

As the name 'Adirondian' (newly coined) suggests, events from 1.18 to 1.08 Ga have been extensively documented in the southwest Grenville Province, but similar activity extended the full length of the Grenville Province and reached southern Greenland. Huge AMCG suites are the most obvious Adirondian contribution and were mostly emplaced between 1.17 and 1.12 Ga. Mylonitization, dated to the same period, indicates tectonism was compressional during at least part of this time. In the eastern Grenville Province, the commercial Lac Tio Ti deposits and Cu-Ni-Co mineralization in the Havre-Saint-Pierre (Allard Lake) AMCG suite, together with the subeconomic Ti-Cr-V deposit at Magpie, and Cu mineralization in the Atikonak (Lac Fournier) AMCG suite leave little doubt that these rocks are highly prospective.

The 1.08 to 0.97 Ga stage of evolution of the Grenville Province has been widely attributed to collisional orogenesis. Magmatism associated with this event is ascribed to concomitant crustal thickening, which, in the east, produced rocks ranging from monzogabbro to granite, including some nepheline- and aegerine-bearing syenites and alkali-rich mafic dykes. In the central Grenville Province, some anorthositic rocks were also emplaced and similar intrusions will, most likely, be eventually recognized farther east. U mineralization has been correlated with granitoid rocks of this age in both eastern Quebec and southern Labrador, but prospecting for other commodities (e.g., Sn-Ta-W) should be considered. Post-Grenvillian events in the eastern Grenville Province are mostly linked to the rift-drift stage of Iapetus Ocean development, and involve formation of the Lake Melville rift system and emplacement of the Long Range dykes. Elsewhere, some of the most economically important mineralization in the Grenville Province (e.g., Nb in the St. Honoré carbonatite) is connected with this period, or later reactivation. Similar rocks should be present in the east and, in particular, unexplained small circular aeromagnetic anomalies coinciding with major tectonic lineaments deserve examination.

It is commonly maintained that the best place to look for a new deposit is next to an existing mine. In reality, for world-class deposits, the best place is where sound mineral exploration reasoning dictates and nobody has looked before. The eastern Grenville Province falls in the latter category.