New Insights into the geology of the basal Huronian Supergroup in the Elliot Lake area: Implications for Mineral Exploration

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Although detailed mapping (1:31 680 to 1:15 000 scale) of the Proterozoic and Archean rocks in the Elliot Lake area took place in the early 1960s and early 1990s, respectively, mapping from these 2 different vintages was never fully integrated. Recent exploration in the area for U and Ni-Cu-PGE has only served to underscore the need for an improved and updated geological map of this area, particularly adjacent to the Archean-Proterozoic unconformity. To address this need, in the summer of 2009 the Ontario Geological Survey began compilation mapping (1:20 000 scale) along the south limb of the Quirke Lake syncline (Figure 1). Initial results are outlined in Easton (2009a, 2009b). The purpose of this presentation is to highlight the results related specifically to the geology of the basal Huronian Supergroup and the implications of those results with respect to exploration. Key results are:

1. Discovery of additional East Bull Lake suite intrusions proximal to the unconformity.
2. Improved understanding of the timing of diking in the Archean basement proximal to the unconformity
3. Improved understanding of the basal Huronian volcanic rocks (Thessalon Formation) and how they can be distinguished from Archean volcanic rocks.
4. Improved understanding of the Livingstone Creek and Matinenda formations of the basal Huronian Supergroup.

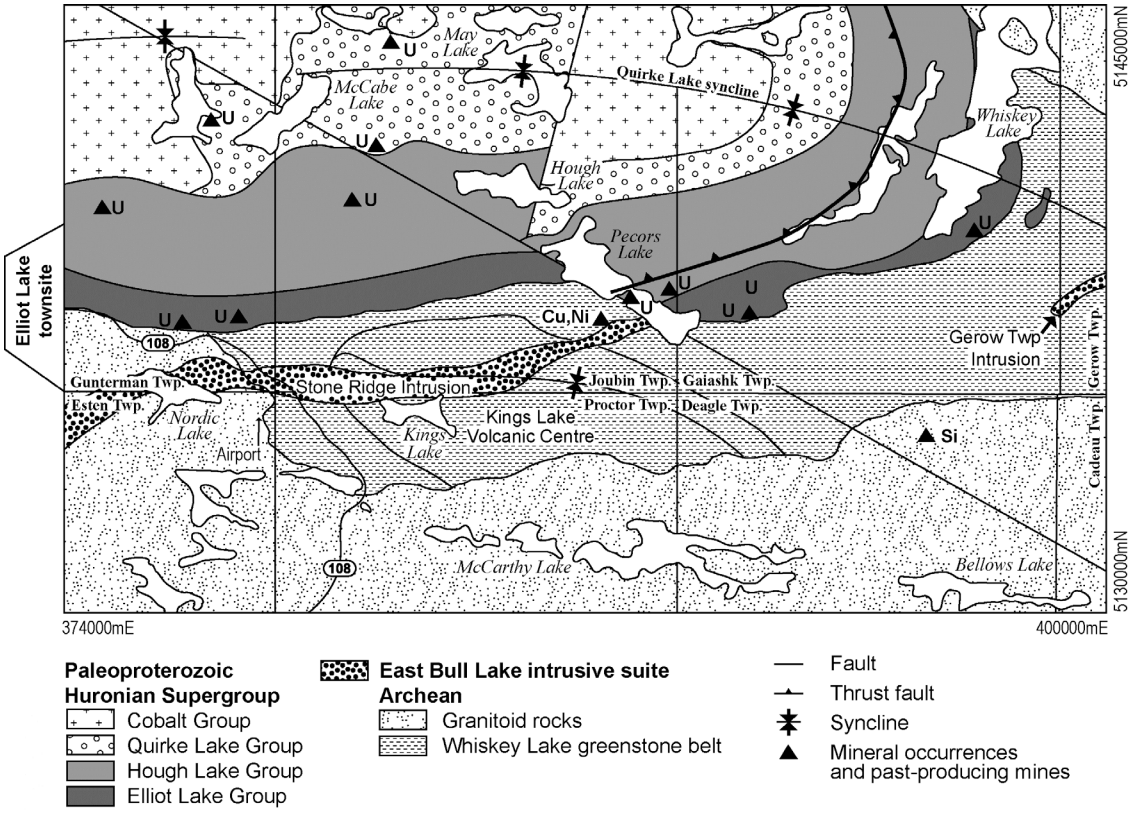

Figure 1. Simplified geological map of the Pecors-Whiskey Lake map area showing location of new-found East Bull Lake intrusions. For clarity, Nipissing gabbro intrusions and many faults are not shown. Abbreviations: Cu = copper, Ni = nickel, U = uranium. Note: uranium occurrences include subsurface occurrences defined by diamond drilling. The Universal Transverse Mercator (UTM) co-ordinates are provided using North American Datum 1983 (NAD83) in Zone 17. From Easton (2009).

Geological setting

The southern half of the study area is underlain by the Whiskey Lake greenstone belt, a 40 km long by 10 km wide, metamorphosed Archean greenstone belt, located about 25 km east-southeast of Elliot Lake. The Whiskey Lake greenstone belt is bounded to the west, south and east by Archean granitoid rocks. To the north, the belt is unconformably overlain by metamorphosed Paleoproterozoic supracrustal rocks of the Huronian Supergroup present within the Quirke Lake syncline (Figure 1). Economic uranium mineralization within the Elliot Lake area is confined to pyrite-bearing, quartz pebble conglomerate horizons, deposited within ancient fluvial channels in the Ryan and Manfred members of the Matinenda Formation.

Whiskey Lake greenstone belt

Previous work by Jensen (1994) and Byron et al. (1994) established the volcanogenic massive sulphide (VMS) potential of the Whiskey Lake greenstone belt near Kings Lake (Figure 1). Key features related to VMS potential in this area are the presence of submarine mafic and felsic volcanic rocks, the presence of FII and FIII rhyolites, and the presence of both exhalite horizons and subvolcanic intrusions.

Archean basement

Key observations in the Archean mafic and felsic basement rocks south of the unconformity include the following.

1. Several near surface feeders to vesicular Huronian flows (tholeiitic andesites) were identified. Some of these feeders are located at least 2 km further south than currently exposed Huronian flows, suggesting that Huronian volcanism once covered a much larger area.
2. The majority of the mafic dikes in the Archean are part of the Matachewan (~2.473 Ga) dike swam, representing roughly 90% of the dikes in the eastern part of the area, and 60% in the west. Along with the discovery of new East Bull Lake suite intrusions in the area, and the Huronian feeder dikes, these observations indicate that a large volume of mafic magma was injected into the crust in the region at circa 2.473 Ga, making this regional mafic magmatic event a favourable Cu-Ni-PGE target (in addition to previous indications of this potential).
3. No true paleosols were observed, however, paleo-saprock, representing intense in-situ weathering of Archean granitoid basement rocks is present locally. These paleo-saprocks exhibit both elemental enrichments and depletions consistent with intense weathering (e.g., a granodiorite changes from 69 to 52 wt. % SiO_2, 16 to 20 wt. % Al_2O_3, and 3 to 10 wt. % total Fe_2O_3 from fresh to intensely weathered). The exploration implication is that the unconformity is in place (not faulted) and that regional weathering of basement may have been important as a uranium source.

East Bull Lake intrusive suite

Two new East Bull Lake intrusive suite bodies were discovered cutting the Archean basement rocks south of the unconformity. The first of these, the Gerow Township intrusion, is located within the eastern part of the Whiskey Lake greenstone belt. It was previously mapped as an Archean intrusion, but was not well exposed when mapped in 1991. Recent logging has improved exposure, and the body is compositionally layered, and is similar to the much larger East Bull Lake and Agnew intrusions in texture and composition. Sulphide burns are common in leucogabbroic rocks near contact of the body, but no well defined breccia zones were observed along the contact. Such breccia zones are common in areas of high tenor Cu-Ni-PGE mineralization in the East Bull Lake and Agnew intrusions. Assay results from the body are pending. The exploration implication is that there may be more East Bull Lake suite bodies to be found in Whiskey Lake greenstone belt., all of which have Cu-Ni-PGE potential.

The second intrusion is different, and may represent a previously unrecognized style of East Bull Lake intrusion. The Stone Ridge intrusion is an east-trending, ~15 km long, 0.7-1.0 km wide, sill previously mapped as Nipissing gabbro (2.22 Ga) (Figure 1). The intrusion is cut by mafic dikes of the Matachewan swarm (2.473 Ga), clearly establishing that the body is not Nipissing in age. The sill consists of a texturally and compositionally homogeneous leucogabbronorite to norite. Flow indicators suggest that the main feeder to the body may be located in the Esten Lake area (west end). Chemical data indicates the body is sulphur-undersaturated and combined Pt-Pd in unmineralized rock is uniformly 40-50 ppb. Significantly, Dyer (2010) reports a Ni-Cu-PGE lake sediment geochemical anomaly associated with this intrusion. The exploration implication is that many of the isolated "Nipissing gabbros" that are hosted solely by Archean rocks in the Elliot Lake area may actually be East Bull Lake intrusive suite bodies. Although both East Bull Lake and Nipissing intrusions can host Cu-Ni-PGE mineralization, the exploration models differ for the 2 types of intrusions.

Elliot Lake Group - Thessalon Formation metavolcanic rocks

There are 2 main flow types present within the Thessalon Formation metavolcanics (Huronian Supergroup) in the study area. Tholeiitic basalts, which are commonly pillowed, and tholeiitic andesites, which are commonly vesicular, and may represent subaerial (aa) flows. The andesites are magnetic, and have K and Th contents distinct from Archean flows in the area. In contrast, the Thessalon pillow basalts are less easily distinguished from their Archean counterparts. The presence of both submarine and subaerial flows is a significant regional change from the Thessalon area, 70 km to the east, which consists entirely of subaerial flows. The presence of submarine flows in the Elliot Lake area suggests that VMS mineralization could exist in the marine parts of the formation, especially in areas where felsic flows may also be present. Indirect evidence for VMS potential comes from an assay from a sulphide-rich flow top which gave results of 574 ppm Cu, 214 ppm Pb, and 1006 ppm Zn (Easton 2010). In addition, Na-depletion anomalies (<0.5 wt. % Na) have also been observed in some Thessalon Formation flows found in various drill cores from the area (Easton unpublished data). The origin of these Na-depletion anomalies is still being investigated, and it is possible that they reflect alteration related to uranium mineralization rather than VMS-related alteration.

Elliot Lake Group - Matinenda Formation

The Huronian Supergroup consists of 4 groups, the basalt Elliot Lake Group and the overlying Hough Lake, Quirke Lake and Cobalt Groups. The upper 3 groups are characterized by a layer-cake succession of repeated conglomerate, mudstone/limestone sandstone successions, which in the Elliot Lake are show relatively consistent thickness and facies, and are generally east-west oriented. In contrast, the Elliot Lake Group formations commonly interfinger and typically show rapid changes in thickness and facies, some of which can be attributed to topographic control during deposition. In the case of the conglomerate units, they show evidence of northwest-oriented channelization, with paleoflow from northwest to southeast. Uranium mineralization is confined to the conglomerate units, which are relatively thin and not uniformly distributed. As a result, they make for small exploration targets, and given their shallow to moderate dips and limited surface exposure, they have limited airborne gamma-ray expression.

Re-examination of the magnetic and gravity data for the Elliot Lake indicates the presence of 2 large, northwest oriented highs beneath the Quirke Lake syncline. The cores of these highs correspond to previously located paleotopographic highs in the basement, and all know uraniferous conglomerate horizons occur on the flanks of these anomalies. Dyer (2010) also reports a variety of lake sediment geochemical anomalies with the larger, more easterly of these highs. Whatever the cause of these anomalies, they appear to have influenced Matinenda Formation deposition in the area.

Previous work had identified 3 members within the Matinenda Formation in the Elliot Lake area: the Ryan (coarse sandstones, conglomerate), the Stinson (sandstone, barren), and the Manfred (sandstone, conglomerate). The Ryan member is found mainly in the south, the Manfred member in the north, and the Stinson member throughout the area. Mapping in 2009 indicated the presence of a possible 4th member, that is clay-poor, and which is referred to tentatively as the upper Stinson member. It is a white, vitreous

quartzite, and has higher SiO_2 and lower K_2O than the generally greener lower Stinson member (90-96 wt. % and <1.5 wt. % versus 85-90 wt. %, and 3-5 wt. %, respectively). U and Th content, however, does not differ between the upper and lower Stinson, suggesting similar heavy mineral populations in both units. The upper Stinson member might be useful as a stratigraphic marker horizon within the Matinenda Formation, and may also provide insight into the depositional history of the Matinenda Formation. An additional observation is that the Matinenda Formation sandstones all have negative Eu anomalies (Easton, unpublished data). This is unique to the Huronian Supergroup below the Serpent Formation, as the other formations have no Eu anomalies, a feature that has been attributed to an oxygen poor depositional environment. The cause of the negative Eu anomaly is still being investigated – it could be due to the presence of certain detrital minerals, or it could reflect oxidation of the rocks sometime after deposition.

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