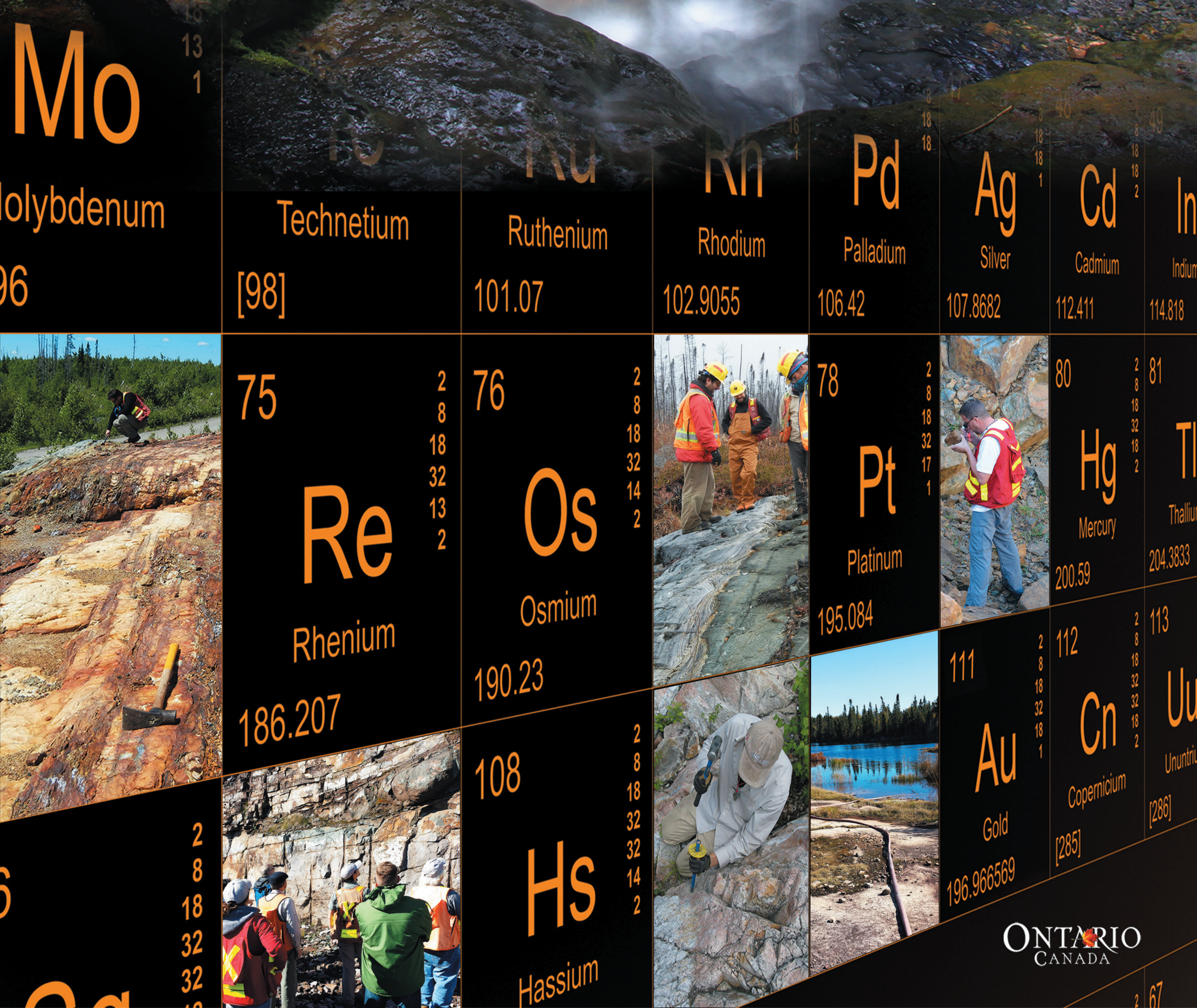
Ontario

RECOMMENDATIONS *for* Exploration

Ontario Geological Survey **Resident Geologist Program**
Ministry of Northern Development and Mines

2015 - 2016



ONTARIO
CANADA

Recommendations for Exploration

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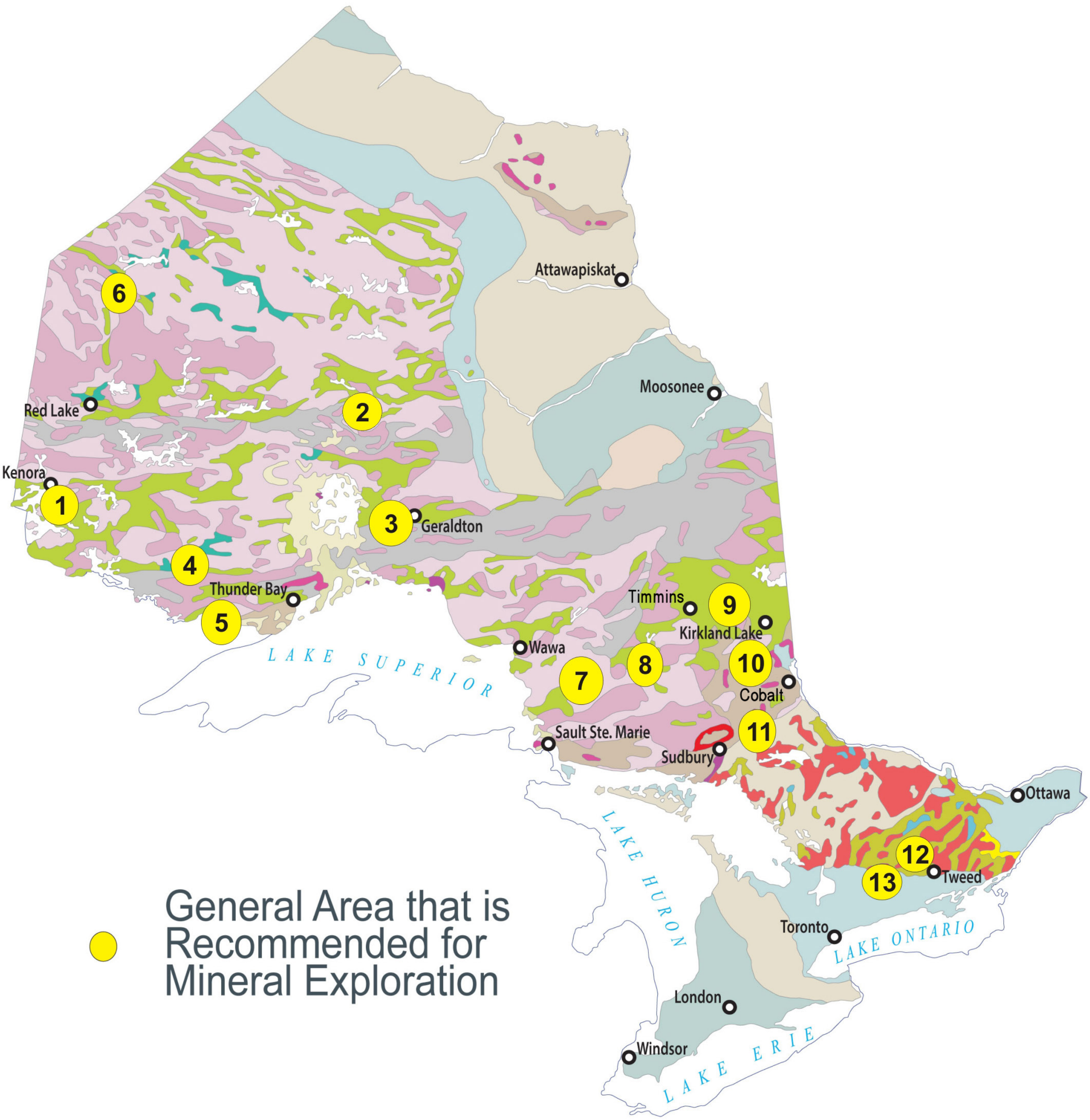

Ontario Geological Survey
Resident Geologist Program
Recommendations for Exploration 2015–2016

The Ontario Geological Survey is pleased to issue its 2016 Recommendations for Exploration. These recommendations are the product of the Ministry's dedicated and knowledgeable staff located across the province.

Each year, recommendations are developed based on the wealth of geological and exploration data available to our staff (and you) and any new information or concepts derived from the current year's activities.

Please review our current recommendations and feel free to discuss these in detail with any of our geoscientists.

Visit OGS Earth on the MNDM Mines and Minerals Division Web site (http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth) to see what else is available.

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Published January 2016

About the Resident Geologist Program

Resident Geologists are the stewards of public geological and mineral exploration information for their districts. They provide a broad range of advisory services on geological topics of interest to the public, to municipal governments and to the mineral industry.

They are the local experts on why geoscience information is important, what information is available and what is happening in exploration.

The program provides primary client services through a network of 8 field offices strategically located across the province.

Our services include

- collecting and maintaining geological data
- monitoring exploration activity
- conducting property examinations
- providing geological and exploration advice

We provide geoscience information to support

- public safety
- environmental planning
- land use planning
- mineral sector investment and economic development

We provide information and training to First Nation Communities regarding prospecting, mineral exploration and mining.

Contents

HIGHLIGHTS

- Identify different types of gold mineralization events
- More than one type of ore-forming process could exist
- Re-examine historical showings that display similar settings

Pre-Orogenic and Post-Orogenic Models for Gold Mineralization

Unique styles of gold mineralization, situated in different geological settings, have been identified at 3 gold deposits (Figure 1) in the southwestern part of the western Wabigoon Subprovince: a) the Angel Hill gold zone deposit, hosted in mafic intrusive rocks (Secord 2011); b) the Cameron Lake deposit, hosted in mafic volcanic rocks (Melling, Taylor and Watkinson 1988); and c) the Rainy River deposit, hosted in sedimentary and pyroclastic rocks (Wartman 2011).

Gold–Pyrite Association at Deposits

Stable isotope geochemistry of gold-bearing rocks from these deposits indicates that the initial precipitation of gold is closely linked to a specific generation of pyrite. Gold may occur along pyrite grain boundaries, within individual grains and along intergranular fractures in pyrite (Wyman, Kerrich and Fryer 1986). The studies on these 3 deposits suggest that not all pyrite is associated with gold, and that there may be multiple generations of pyrite. A common feature of the 3 deposits is that a specific, silica-dominated alteration event(s) is related to the precipitation of gold and could also be linked to the formation of sulphide minerals.

Atypical Pre-Orogenic Greenstone-Hosted Gold Model

The interpreted paragenetic sequence for gold deposition in these 3 gold deposits is atypical of common greenstone-hosted orogenic gold deposits. The setting of these 3 gold deposits is more similar to the type of deposits that "form prior to the major phase(s) of orogenesis, involving compressional to transpressional deformation, regional metamorphism, and postvolcanic granitoid magmatism during which the orogenic gold deposits form" (Groves et al. 2003, p.4). Robert and Poulsen (2001), Groves et al. (2003), Robert et al. (2005, 2007) provide detailed descriptions of the geological setting of "atypical" greenstone-hosted gold deposits and their affiliation with orogenic settings. A pre-orogenic depositional environment must include rocks with inherent or deformation-induced original permeability that facilitated hydrothermal fluid movement. For example, permeability would be relatively high in fragmental rock units as opposed to massive flows. Wartman (2011, p.30-32) noted that in the Rainy River deposit: "Zones of higher permeability (i.e. flow tops and breccias related to dacitic lava flows) and areas of intense deformation have elevated gold values, up to 10,000x greater than gold values in the surrounding rock". There is the possibility of pre-orogenic mineralizing events, commonly related to an atypical greenstone-hosted gold model, existing at these 3 gold deposits.

Post-Orogenic Mineralizing Events

The term "orogenic" used in this recommendation is restricted to deposits composed of quartz-carbonate veins and wall-rock replacement associated with compressional or transpressional geological structures,

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Gold Mineralization Models, *continued*

such as reverse faults and folds. These mineralizing events overprint pre-existing deformation, alteration, metamorphism and, particularly, any pre-orogenic mineralization (Robert et al. 2005, 2007). Two of the 3 gold deposits discussed here—the Cameron Lake deposit (Ball 2012) and the Rainy River deposit (Hardie et al. 2012; Schandl 2006)—have overprinting post-orogenic mineralizing events.

Recommendations

A key to success when examining the mineral potential is to understand and detect the different types of gold-mineralizing events. Most gold occurrences display a single style of mineralization, but Robert et al. (2007) indicated that, at several deposits, “the diversity of styles of mineralization, wall-rock alteration assemblages, and overprinting relationships require more than one episode of gold mineralization and more than one ore-forming process”.

The composition of the host rocks is important to the formation of sulphides and gold deposition. At the Cameron Lake deposit, Melling (1988, p.62) noted that “magnetite, although an abundant accessory [mineral] in the host rocks to the deposit, is rarely present within the altered gold-bearing zones … the fluid-wall rock reactions which led to gold deposition involved sulfid[iz]ation of the Fe-bearing minerals, especially magnetite”. Sulphide-bearing rocks that are overprinted by quartz veins could have a pyrite–gold association. Scanning electron microscope analysis of gold-bearing rocks is a good method to determine if there is a gold–sulphide association.

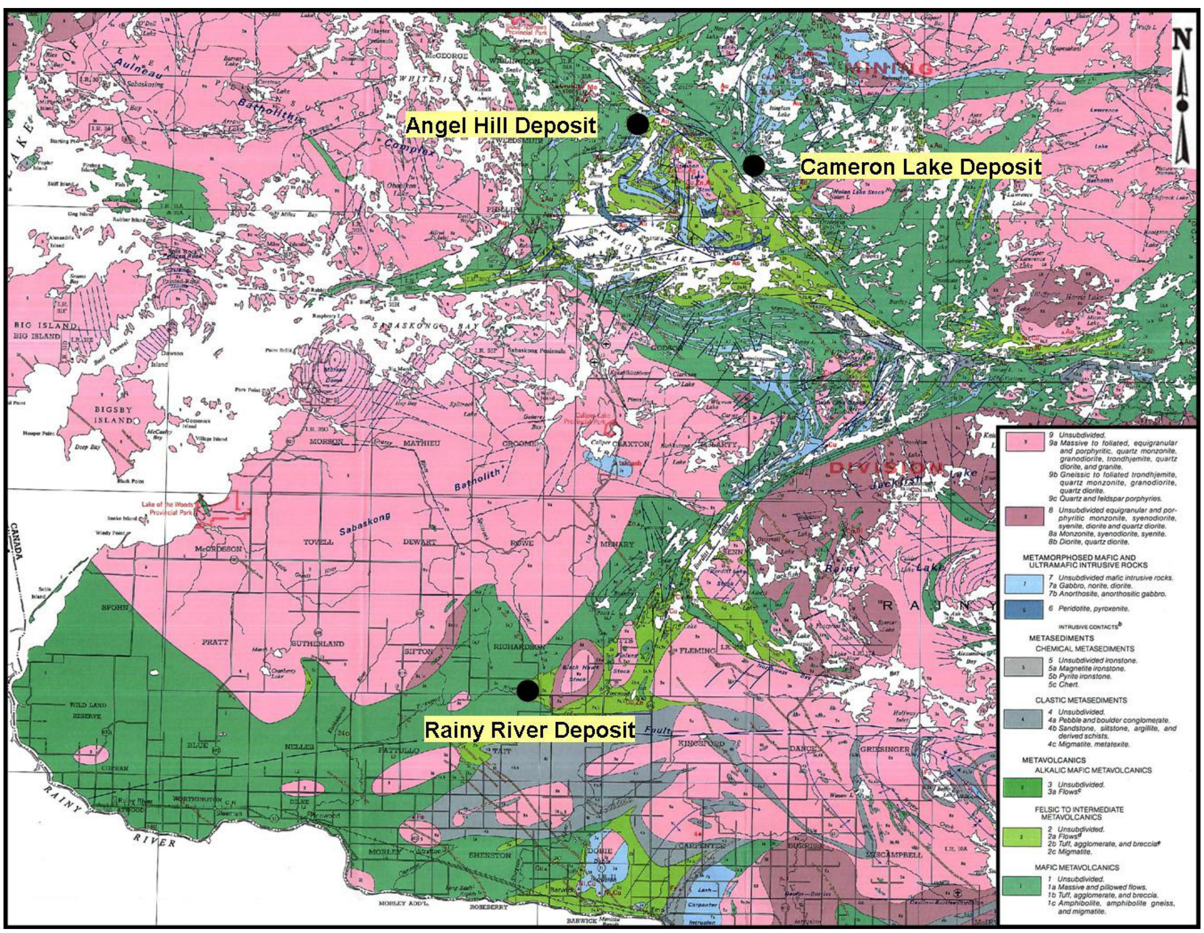

Figure 1. Locations of the Angel Hill (gold zone) deposit, the Cameron Lake deposit and the Rainy River deposit (*modified from* Blackburn 1978).

Gold Mineralization Models, *continued*

Nonetheless, atypical pre-orogenic greenstone-hosted gold mineralization is difficult to recognize because of the overprinting effects of subsequent orogenic metamorphism, deformation and alteration. Secord (2011, p.85) mentioned that stable isotope geochemistry can be used "to investigate if the texturally distinct sulphide minerals and fluid phases represented separate isotopically distinct generations and to gain insight into the relationship between mineralising fluids and ore forming minerals". Oxygen isotope compositions of hydrothermal minerals can provide information on the temperature of mineralization and the source of ore-forming fluids. Sulphur isotope compositions can yield constraints on the source rocks from which these fluids were derived (McCuaig and Kerrich 1998).

Gold mineralization may be related to silica-rich alteration events and the formation of sulphides. The spatial relationship between sulphides and quartz, as observed in slab-cut rock samples, may suggest multiple mineralizing events. Explorationists are encouraged to examine and sample sulphide-rich and silicified zones that may lack quartz-carbonate veins or discrete, mineralized structures. The presence of significant deposits in the western Wabigoon Subprovince that display an "early gold" mineralizing event suggests that there are many, as yet unrecognized gold targets in this area.

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HIGHLIGHTS

- **Historical exploration results highlight significant zinc-copper-rich, VMS-style mineralization in a relatively underexplored area.**
- **New OGS mapping confirms extensive VMS-style alteration zone trending toward known base metal–mineralized zones.**

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Volcanogenic Massive Sulphide Potential in the Discovery Lake Area, Fort Hope Greenstone Belt, Eastern Uchi Subprovince

Several disseminated base metal sulphide occurrences have been identified and explored in the Petawanga Lake area, approximately 30 km southwest of Eabametoong First Nation (Fort Hope). The group of occurrences, referred to as the Boylen or Discovery ("Disco") Lake occurrences, lie immediately east of Discovery Lake within the southwestern portion of the Fort Hope greenstone belt (cf. Puumala 2009) (Figure 1). Discovery of sulphide mineralization in the early 1960s by M.J. Boylen Engineering initiated exploration efforts in the area for volcanogenic massive sulphide (VMS)-style mineralization. Geological mapping, ground geophysical surveys and diamond drilling were conducted from 1972 to 1995 by several workers (Mason and White 1995). Pro Minerals Inc. was the latest operator on the property, conducting surface and borehole pulse electromagnetic (EM) surveys in 2010 (Ralph and Kennedy 2011). The Discovery Lake occurrences and surrounding area remain open for staking at the time of publication.

Edwards (1991) interpreted the geology of the Discovery Lake area as consisting of 3 distinct geological domains: the Cormac volcanic rocks, the Central felsic volcanic rocks and the Western volcanic rocks, bounded to the south, east and north by late granitoid intrusions. Volcanic rocks consist of medium-grained mafic flows, pillowed mafic flows, mafic tuffs with associated reworked tuffs, debris flow sedimentary rocks and interflow sedimentary rocks (Edwards 1991). Alteration in the Discovery Lake area is characterized by chlorite-garnet, amphibole-chlorite-garnet and staurolite-garnet assemblages, representing possible metamorphosed equivalents of VMS-related footwall alteration zones (Edwards 1991). These alteration zones exhibit calcium and sodium depletion trends with moderate to strong iron enrichment. Rocks favourable to VMS mineralization and possible alteration zone equivalents were also identified to the southwest of the Boylen occurrences in the Attwood Lake area by Wallace (1981) and were confirmed by recent mapping by Azar and Ferguson (2014). Mineralization in the Discovery Lake area is reported to be hosted in reworked felsic volcanic rocks, interflow sedimentary rocks and amphibolite units occurring within the core of a southwest-plunging syncline (Edwards 1991). Specific details on each of the 6 occurrences (*after* Parker 1998) are outlined in Table 1. The Ryley–Cormac and NJZ-76 occurrences were visited by Resident Geologist Program staff in 2015, confirming rock type, mineralization and alteration described below. Assays of a grab sample of silicified intermediate volcanic material from the NJZ-76 occurrence returned values of 0.45% Cu and 0.22% Zn.

Exploration for VMS-style mineralization is warranted in the area immediately surrounding the Boylen occurrences as well as the area to the southwest towards Attwood Lake. Considerable attention should be paid to the widespread alteration system and the structures controlling mineralization. Assessment files for all work conducted on the property

VMS Potential: Discovery Lake Area, *continued*

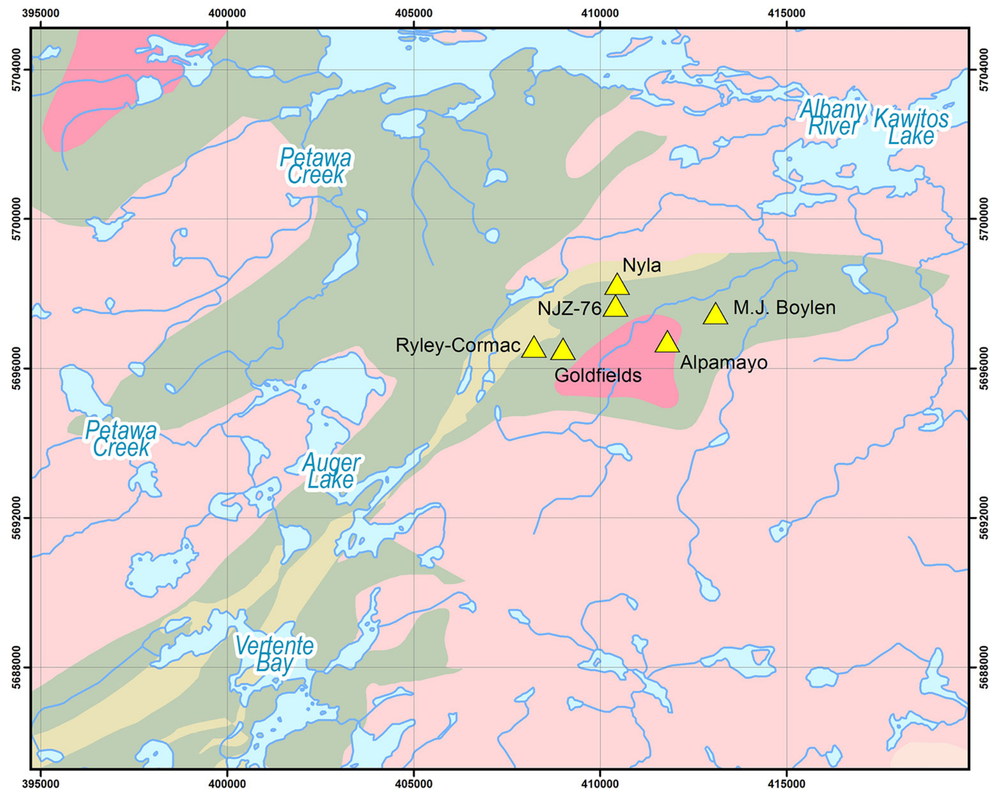

Figure 1. Geology map showing the locations of Mineral Deposit Inventory (MDI) occurrences in the Discovery Lake and Attwood Lake areas, Fort Hope greenstone belt (bedrock geology *from* Ontario Geological Survey 2011). Universal Transverse Mercator (UTM) co-ordinates provided using North American Datum 1983 (NAD83) in Zone 16.

Table 1. Descriptions of, and assay results from, the 6 occurrences in the Discovery Lake area (some information *after* Parker 1998; MDI data *from* Ontario Geological Survey 2015).

Occurrence (UTM Zone 16, NAD83)	Mineral Deposit Inventory (MDI) Number	Assay Highlights	Description of Occurrence
Ryley–Cormac (642600E 5786650N)	MDI52P08NW00006	4.27% Zn, 0.28% Pb over 3 m, 11.92% Zn, 1.1 ounces Ag per ton (grab)	Discontinuous, silicified biotite-rich zone with trace chalcopyrite and sphalerite (possible exhalative)
Goldfields (653418E 5783778N)	MDI52P08NW00004	0.62% Zn, 15.7% Cu, 2.75 ounces Ag per ton, over 0.31 m	Pervasive stringer chalcopyrite and chlorite garnet alteration in quartz-phyric felsic volcanic rock
NJZ-76 (642600E 5788000N)	MDI52P08NW00007	0.79% Cu (grab)	Disseminated chalcopyrite, pyrite, pyrrhotite in mafic flow with pervasive chlorite alteration
Nyla (653197E 5785998N)	MDI52P08NW00008	1.63% Zn (grab)	Thin bands of fine-grained sphalerite in biotite-rich metasedimentary rock
Alpamayo (652788E 5786326N)	MDI52P08NW00005	up to 5.85% Cu (grab)	Chalcopyrite-bearing chlorite pods within granite
M.J. Boylen (648311E 5787395N)	MDI52P08NW00003	0.82% Cu over 3.6 m; 4.01% Cu, 0.20 ounces Au per ton over 0.61 m; 0.685% Cu (grab)	Amphibole-chlorite, magnetite-chlorite and garnet alteration in mafic pillowed flows

VMS Potential: Discovery Lake Area, *continued*

are available from the OGS online data warehouse—GeologyOntario (www.ontario.ca/geology), or through the OGSEarth application (www.ontario.ca/ogsearth), or in the Resident Geologist's files in the Thunder Bay Regional office. Ontario Geological Survey publications (Table 2) covering the Discovery and Attwood Lake areas include bedrock geological maps, airborne geophysical surveys and mineral deposit compilations that provide an excellent framework for the area's mineral potential.

Table 2. Ontario Geological Survey publications covering the Discovery Lake and Attwood Lake areas.

Publication	Title	Author	Year	Scale
Annual Report Map (ARM) 38b-01	Fort Hope Area, District of Kenora (Patricia Portion), Ontario	E.M. Burwash	1929	1:190 080
Annual Report 1929, v.38, pt.2	Geology of the Fort Hope gold area, District of Kenora (Patricia Portion)	E.M. Burwash	1930	
Map 2436	Attwood Lake, Thunder Bay District	H. Wallace	1980	1:31 680
Report 203	Geology of the Attwood Lake area, District of Thunder Bay	H. Wallace	1981	
Geophysical Data Set (GDS) 1108A	Ontario Airborne Geophysical Surveys, Magnetic and Electromagnetic Data, Grid and Vector Data, ASCII Format, Fort Hope Area (Block 4)	Ontario Geological Survey	2003	
GDS 1108B	Ontario Airborne Geophysical Surveys, Magnetic and Electromagnetic Data, Grid and Vector Data, Geosoft® Format, Fort Hope Area (Block 4)	Ontario Geological Survey	2003	
GDS 1108C	Ontario Airborne Geophysical Surveys, Magnetic and Electromagnetic Data, Profile Data, ASCII Format, Fort Hope Area (Block 4)	Ontario Geological Survey	2003	
GDS 1108D	Ontario Airborne Geophysical Surveys, Magnetic and Electromagnetic Data, Profile Data, Geosoft® Format, Fort Hope Area (Block 4)	Ontario Geological Survey	2003	
GDS 1108E	Ontario Airborne Geophysical Surveys, Electromagnetic Data, Halfwave Data, ASCII Format, Fort Hope Area (Block 4)	Ontario Geological Survey	2003	
Maps 82 225 to 82 251	Airborne Magnetic and Electromagnetic Surveys, Fort Hope Area	Ontario Geological Survey	2003	1:20 000
Maps 82 252, 82 257 to 82 259, 82 263 to 82 265, 82 270, 82 271	Airborne Magnetic, Electromagnetic and Gamma-Ray Spectrometric Surveys, Residual Magnetic Field, Electromagnetic Anomalies and Keating Coefficients, Fort Hope Area	Ontario Geological Survey	2003	1:50 000
Maps 82 281, 82 286 to 82 288, 82 292 to 82 294, 82 299, 82 300	Airborne Magnetic, Electromagnetic and Gamma-Ray Spectrometric Surveys, Shaded Image of the Second Vertical Derivative of the Magnetic Field and Keating Coefficients, Fort Hope Area	Ontario Geological Survey	2003	1:50 000
Maps 82 310 to 82 320	Airborne Magnetic and Electromagnetic Surveys, EM Decay Constant and Electromagnetic Anomalies, Fort Hope Area	Ontario Geological Survey	2003	1:50 000
Maps 82 321 to 82 331	Airborne Magnetic and Electromagnetic Surveys, Apparent Conductance and Electromagnetic Anomalies, Fort Hope Area	Ontario Geological Survey	2003	1:50 000
Maps 82 332, 82 334 to 82 336, 82 338 to 82 340, 82 343, 82 344, 82 348, 82 349	Airborne Magnetic and Gamma-Ray Spectrometric Surveys, Ternary Radioelement Image, Fort Hope Area	Ontario Geological Survey	2003	1:50 000
Preliminary Map P.3764	Precambrian Geology of the Miminiska Lake Area, Fort Hope Greenstone Belt	S. Buse	2012	1:50 000
Preliminary Map	Precambrian Geology of the Attwood Lake Area, Fort Hope Greenstone Belt	B. Azar	*In prep.*	1:50 000

VMS Potential: Discovery Lake Area, *continued*

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HIGHLIGHTS

- **New high-resolution airborne magnetic survey data available for a vast, underexplored and easily accessible area located in the Quetico Subprovince north of Lake Superior.**
- **Numerous magnetic targets display potential for the discovery of copper-nickel-PGE, REE, rare metals and diamond.**

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Copper-Nickel-Platinum Group Elements, Carbonatite and Diamond Potential in the Quetico Subprovince North of Lake Superior as Highlighted by New High-Resolution Geophysical Data

Airborne magnetic and radiometric surveys that were flown during 2014 (Figures 1 and 2; Ontario Geological Survey 2015a, 2015b, 2015c) have provided new public-domain high-resolution airborne geophysical coverage of a large portion of the Quetico Subprovince north of Lake Superior. The potential for the discovery of new mafic to ultramafic intrusion-hosted copper-nickel-platinum group element (PGE) deposits, carbonatite-hosted rare earth element (REE) and/or rare metal deposits, and kimberlitic rock-hosted diamond deposits throughout this area has previously been noted (e.g., Puumala et al. 2014; White et al. 2014); these geophysical data sets provide new tools that can be used to identify exploration targets for these commodities.

To date, the new geophysical data releases have resulted in the staking of a number of claims, primarily over diamond targets, with the greatest concentration of activity occurring in the Caramat area. Nevertheless, numerous interesting geophysical targets remain available for staking. Targets with the potential for the types of intrusions noted above include locations with magnetic signatures that are notably different (i.e., higher or lower) than their surroundings, and anomalies identified using Keating coefficients (i.e., modelled as possible kimberlite targets). Some of these targets are highlighted on the total residual magnetic field and second vertical derivative magnetic maps (*see* Figures 1 and 2, respectively).

Because elevated levels of chromium in lake sediment also provide an indication of mafic to ultramafic intrusion potential, the magnetic data can be used in conjunction with existing regional lake sediment survey data to further refine exploration targeting. The location of numerous areas of elevated chromium, that were identified by Friske et al. (1991), Ontario Geological Survey (2000) and Dyer (2009), are illustrated in Figure 3. It should be noted that many of the geophysical targets and areas of elevated chromium have a close spatial association with the Gravel River fault. As a result, prospecting along the length of the Gravel River fault is recommended, with particular attention to areas where it is cross-cut by other fault structures. As shown on Figure 3, much of the area is accessible via an extensive system of logging roads and trails.

Copper-Nickel-PGE, Diamond Potential: Quetico Subprovince, *continued*

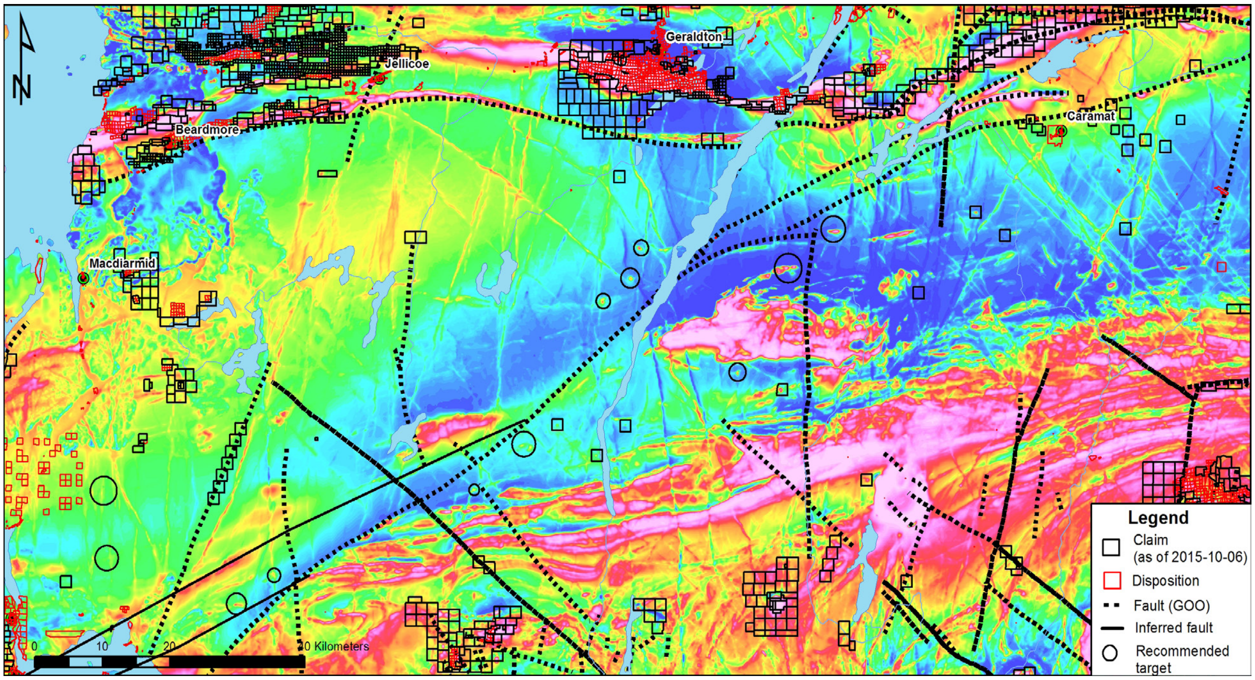

Figure 1. Total residual magnetic field map illustrating locations of anomalies recommended for prospecting (*modified from* Ontario Geological Survey 2015a, 2015b, 2015c).

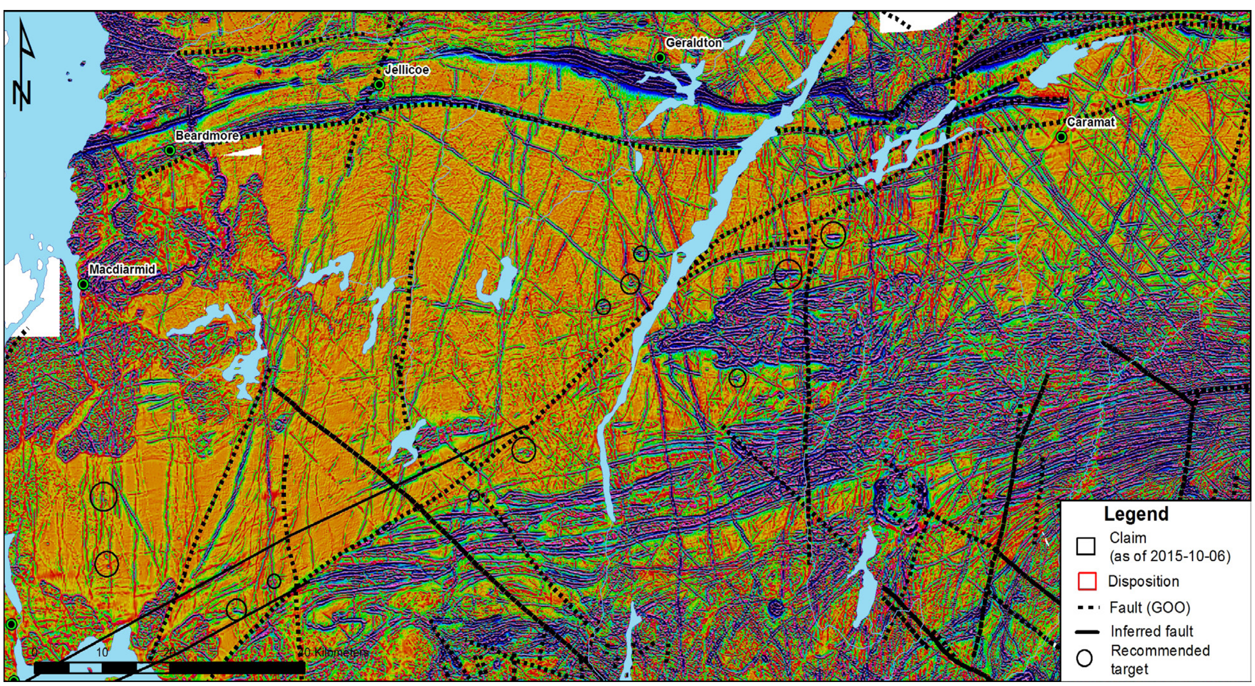

Figure 2. Second vertical derivative of total residual magnetic field (*modified from* Ontario Geological Survey 2015a, 2015b, 2015c).

Copper-Nickel-PGE, Diamond Potential: Quetico Subprovince, *continued*

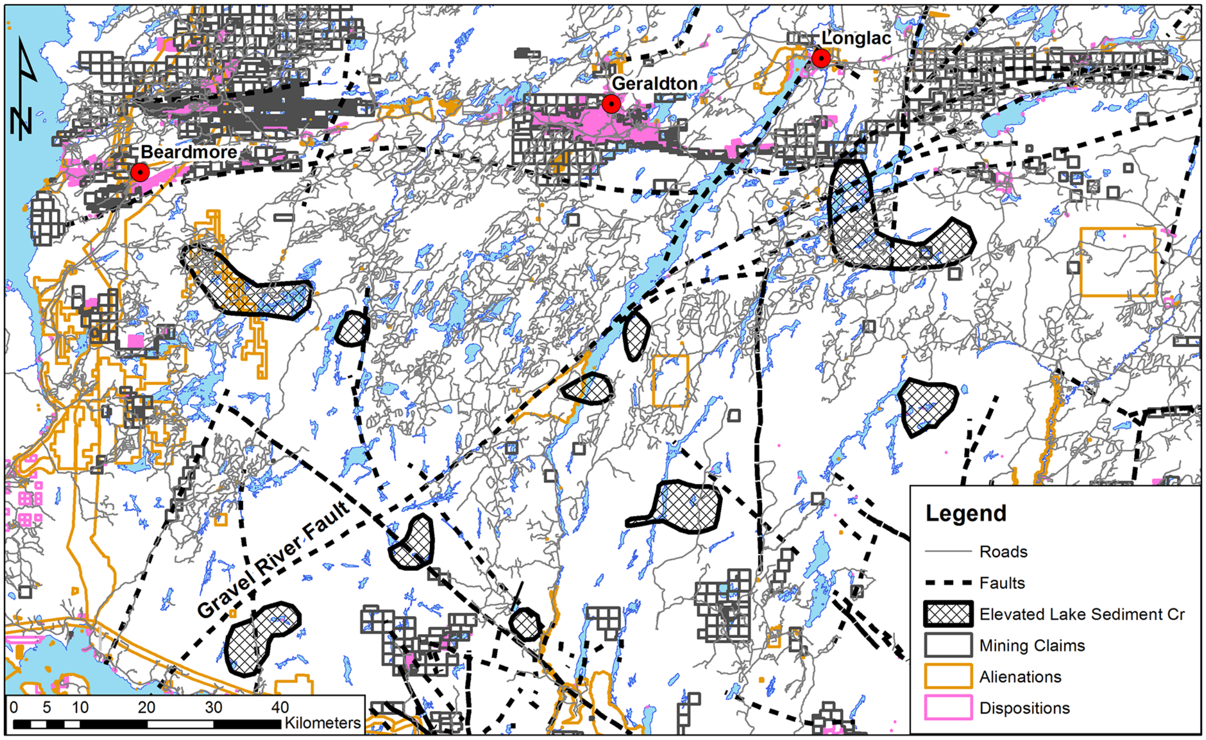

Figure 3. Areas with elevated chromium in lake sediment (*modified from* Friske et al. 1991; Ontario Geological Survey 2000; Dyer 2009).

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HIGHLIGHTS

- **Large-tonnage, low-grade gold-bearing quartz veins and high-grade, quartz vein-hosted deposits are known to be associated with northeast-trending structures.**
- **The past-producing Sunbeam Mine, located on a northeast-trending lineament, warrants re-evaluation as there has been no exploration activity at the site of the old mine workings for 110 years.**

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Gold Potential in the Atikokan (Marmion Lake–Reserve Bay) Area

In the Atikokan area, gold mineralization is generally associated with large, northeast-trending shear structures and quartz-carbonate stockwork vein systems. These gold occurrences include large-tonnage, low-grade deposits, such as Hammond Reef (Measured: 175.3 million tonnes @ 0.75 g/t Au for a total 4.25 million ounces; Indicated: 54.1 million tonnes @ 0.61 g/t Au for a total of 1.06 million ounces; Osisko Mining Corporation, news release, January 31, 2013), and high-grade, quartz vein-hosted deposits, such as the past-producing Fern Elizabeth Mine. Geological mapping by Stone (2008) in the Atikokan area delineated several of these large structures. Lavigne and Scott (1995) described gold deposits in the Marmion Lake batholith.

Several properties, with gold occurrences along strike of the Hammond Reef deposit and along parallel and subparallel, northeast-trending structures in the Marmion Lake batholith, have been staked by local prospectors and are available for option. In the Reserve Bay area, 15 km southeast of the Hammond Reef, several of these structures merit further attention. In 2009, TerraX Minerals Inc. identified and explored 4 northeast-striking mineralized structures referred as the WN2/Pettigrew, Burger, Roy and Sunbeam lineaments (Figure 1). TerraX observed intermittent alteration and mineralization along the lineaments with strike lengths of up to 9 km.

The past-producing Sunbeam Mine, located on the Sunbeam lineament, is of particular interest and warrants re-evaluation. There has been no exploration activity at the site of the old mine workings for 110 years; however, the former patented mining claim that covered the Sunbeam Mine was recently forfeited and the ground was staked by local prospectors from Thunder Bay and Atikokan who currently have the property available for option.

Nahanni Mines Limited (1980s) and TerraX (2009–2013) carried out exploration programs along the trend of the Sunbeam Mine, as well as, along parallel and subparallel lineaments. Alteration and mineralization occurs in both granitic and mafic rocks, and at the contact between them. Previous sampling and drilling programs along the Sunbeam lineament have returned mostly anomalous gold values. The best assays have been obtained from the AL198 zone (southwest extension of Sunbeam Mine), returning 16.2 g/t Au (Setterfield 2013), and at the Road zone (northeast extension of Sunbeam Mine), returning 0.46 ounce gold per ton over 6 feet (Harquail 1982). In 2011, TerraX completed 3 diamond-drill holes at the AL198 zone and 3 diamond-drill holes at the Road zone, targeting the quartz vein system. At both zones, Setterfield (2013) reported a 6 to 10 m wide alteration zone with quartz-ankerite-pyrite veins up to 80 cm wide, making up approximately 5% of the zone. Alteration consists predominantly of iron carbonate with varying amounts of sericite, chlorite, hematite, silica and green mica. Gold assays tend to be higher when pyrite is present.

Gold Potential: Marmion Lake–Reserve Bay Area, *continued*

Schnieders and Dutka (1985) reported that the main Sunbeam quartz vein strikes northeast (230 to 240°) and dips northwest (45 to 66°). The vein has a strike length of more than 300 m and varies from 1 to 1.5 m in width within a shear zone up to 30 m wide. The vein is hosted by altered trondhjemite; mineralization at the main Sunbeam quartz vein consists of pyrite, chalcopyrite, galena, sphalerite, malachite and gold. A sample from Sunbeam Mine, reported by Schnieders and Dutka (1985), returned 26.16 ounces gold per ton (898 g/t Au).

Bow (1899) reported that the main shaft (No. 1) of the Sunbeam Mine was initially sunk in 1898. Carter (1905) reported that development continued until 1905, with an inclined shaft (~45° northwest) for a final length of 410 feet (125 m) or 290 feet (90 m) vertical. Lateral development was continually extended for a total of 1033 feet (315 m) of drifting and 236 feet (72 m) of stoping on 3 levels at depths 113 feet (29.3 m), 195 feet (59.4 m) and 295 feet (89.9 m). In 1904, a ten-stamp mill was established approximately 1.2 km northwest of the mine site (Carter 1904, 1905).

Schnieders and Dutka (1985) reported historical production of the mine in 1904 at 944 ounces of gold from 2400 tons mined, indicating an average grade of approximately 0.4 ounce gold per ton. Based on historical information from the Thunder Bay South District assessment files (Mining Location A.L. 282, 1902–1903), a 1903-vintage longitudinal section of the mine workings with dollar value assays for gold also indicate an average grade of approximately 0.4 ounce gold per ton. Gold values along the Sunbeam lineament are higher and more consistent at the Sunbeam Mine and show an overall improvement with depth. The Sunbeam deposit remains open along strike and at depth.

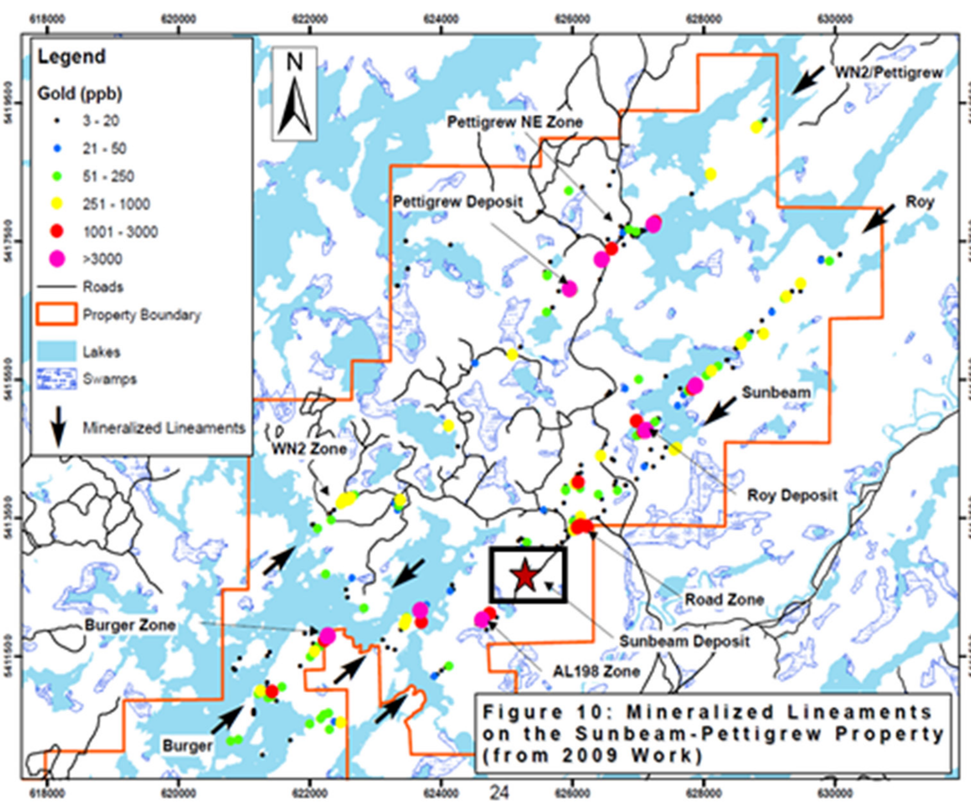

Figure 1. Northeast-trending lineaments in the Reserve Bay area, 25 km northeast of Atikokan (*modified from* Setterfield 2013).

Gold Potential: Marmion Lake–Reserve Bay Area, *continued*

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HIGHLIGHTS

- **New OGS geophysical and geochemical surveys data suggest the potential for copper-nickel-PGE discoveries.**
- **This is an area that has seen limited historic exploration activity and is largely open for staking.**

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Copper-Nickel-Platinum Group Element Potential in the Area Between Northern Light Lake and Batwing Lake

Northern Light Lake and Batwing Lake are located in a portion of the Neoarchean Wawa Subprovince that is dominated by granitoid rocks (Williams et al. 1991). These rocks are overlain to the southeast by Paleoproterozoic sedimentary rocks of the Animikie Group. All of these rocks have been crosscut by Mesoproterozoic mafic intrusions associated with the Midcontinent Rift event at *circa* 1100 Ma (Sutcliffe 1991).

Historically, exploration activity in the area was focussed on commodities including iron, silver and amethyst, mostly within the Animikie Basin. Mafic to ultramafic intrusion-hosted copper-nickel-platinum group element (PGE) deposit discoveries made throughout the Midcontinent Rift region since the early 2000s (e.g., Current Lake, Sunday Lake, Tamarack, Eagle) have more recently made the area an exploration target for these commodities.

A high-resolution regional airborne magnetic survey that was completed in 2015 (Ontario Geological Survey 2015) provides new information that will assist in the identification of new copper-nickel-PGE targets in the Northern Light–Batwing lakes area. The new geophysical data have also been complemented by the publication of a new Ontario Geological Survey (OGS) regional till sampling survey (Marich 2015).

A number of anomalies uncovered by the recent magnetic and till sampling surveys in the Northern Light–Batwing lakes area has demonstrated excellent potential for the discovery of new mafic to ultramafic intrusion-hosted, copper-nickel-PGE occurrences. The results of an earlier OGS high-density lake sediment and water geochemical survey identified several chromium, copper, nickel and PGE anomalies in lake sediments near Northern Light Lake (Jackson 2001).

Areas where till and lake sediment anomalies for chromium, copper, nickel and/or PGEs, as highlighted by Marich (2015) and Jackson (2001), respectively, occur relative to selected features visible in the airborne magnetic survey data are illustrated in Figure 1. These features include 2 east-northeast-striking structures that have been inferred through the interpretation of magnetic discontinuities and anomalies (Puumala et al. 2015). Both features have been mapped as faults over a portion of their extent (Lodge, Ratcliffe and Walker 2014; Goodwin 1960) and may represent significant crustal-scale structures. These linear features are highlighted because most mineralized mafic to ultramafic intrusions have a close spatial association with major crustal-scale structures (Rogers et al. 1995; Hart and MacDonald 2007), and their locations can be used to target nearby magnetic anomalies for further prospecting. Positive or negative magnetic anomalies near locations where these linear structures intersect geochemically anomalous areas, faults and/or lithologic contacts present especially attractive copper-nickel-PGE exploration targets.

Copper-Nickel-PGE Potential: Northern Light–Batwing Lakes Area, *continued*

A group of magnetic anomalies have been highlighted near the western boundaries of Aldina and Sackville townships. These positive and negative magnetic anomalies (relative to the signature of the surrounding rocks) occur in close proximity to one of the east-northeast-striking structures, and also occur in proximity to the western contact of the Kekekuab Lake pluton.

As of October 8, 2015, all of the highlighted magnetic anomalies were open for staking; the majority of the areas covered by the lake sediment and till geochemical anomalies were also unstaked.

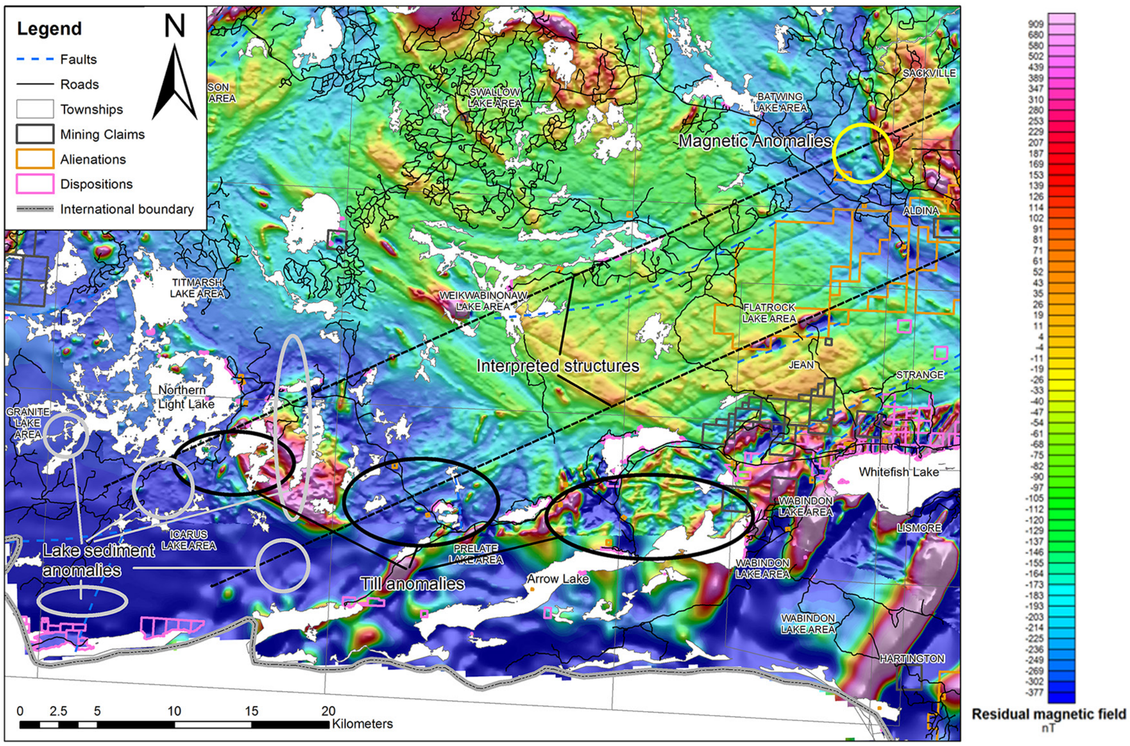

Figure 1. Residual total magnetic field image of the Northern Light–Batwing lakes area (*modified from* Ontario Geological Survey 2015), illustrating magnetic features and structures relative to the locations of till (black ovals) and lake sediment (grey circles and ovals) geochemistry anomalous areas containing elevated levels of one or more of chromium, copper, nickel, platinum and palladium. Magnetic anomalies indicated by yellow oval; structures interpreted from magnetic data are indicated by black dashed lines. For more details on the nature of the geochemical anomalies, *see* Jackson (2001) and Marich (2015).

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HIGHLIGHTS

- **Geology, structure and age analogous to the Red Lake greenstone belt**
- **Completely underexplored for base and precious metals**

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Hornby Lake—A Relatively Untouched Greenstone Belt

The western two-thirds of the Hornby Lake greenstone belt, 125 km north of Red Lake, consist predominantly of mafic to komatiitic, pillowed to massive flows with subordinate mafic and ultramafic intrusive rocks. The eastern third of the belt is underlain by a turbiditic sequence overlain by dacitic pyroclastic rocks that have an age of 2901±2 Ma (Corfu et al. 1998). Geological reconnaissance mapping (Atkinson et al. 1992; Cortis et al. 1988) defined a "back-to-back" relationship between the 2 assemblages. The contact is sharp, linear, strained and mineralized with pyrrhotite and minor chalcopyrite. The age and the overall geological setting are suggestive of the Red Lake greenstone belt volcanic stratigraphy and tectonics.

Assessment work reports detail only 2 brief exploration programs, in the period 1968–1971, which focussed on a sulphide-facies iron formation and a copper-nickel occurrence at a sheared mafic to ultramafic contact (MDI53C05NE00003: Ontario Geological Survey 2015).

The belt offers potential for

- lode gold mineralization associated with areas of high competency contrast localized at mafic–ultramafic rock contacts;
- lode gold in the sulphidized, ductile shear zone separating the 2 assemblages;
- nickel-copper mineralization associated with komatiitic flows;
- volcanogenic massive sulphide (VMS)-style base metal mineralization in the coarse-grained dacitic pyroclastic rocks in the eastern portion of the belt; and potential base metal mineralization associated with magnetite-facies iron formation in the western portion of the belt.

Gold, Nickel-Copper, VMS Potential: Hornby Lake Greenstone Belt, *continued*

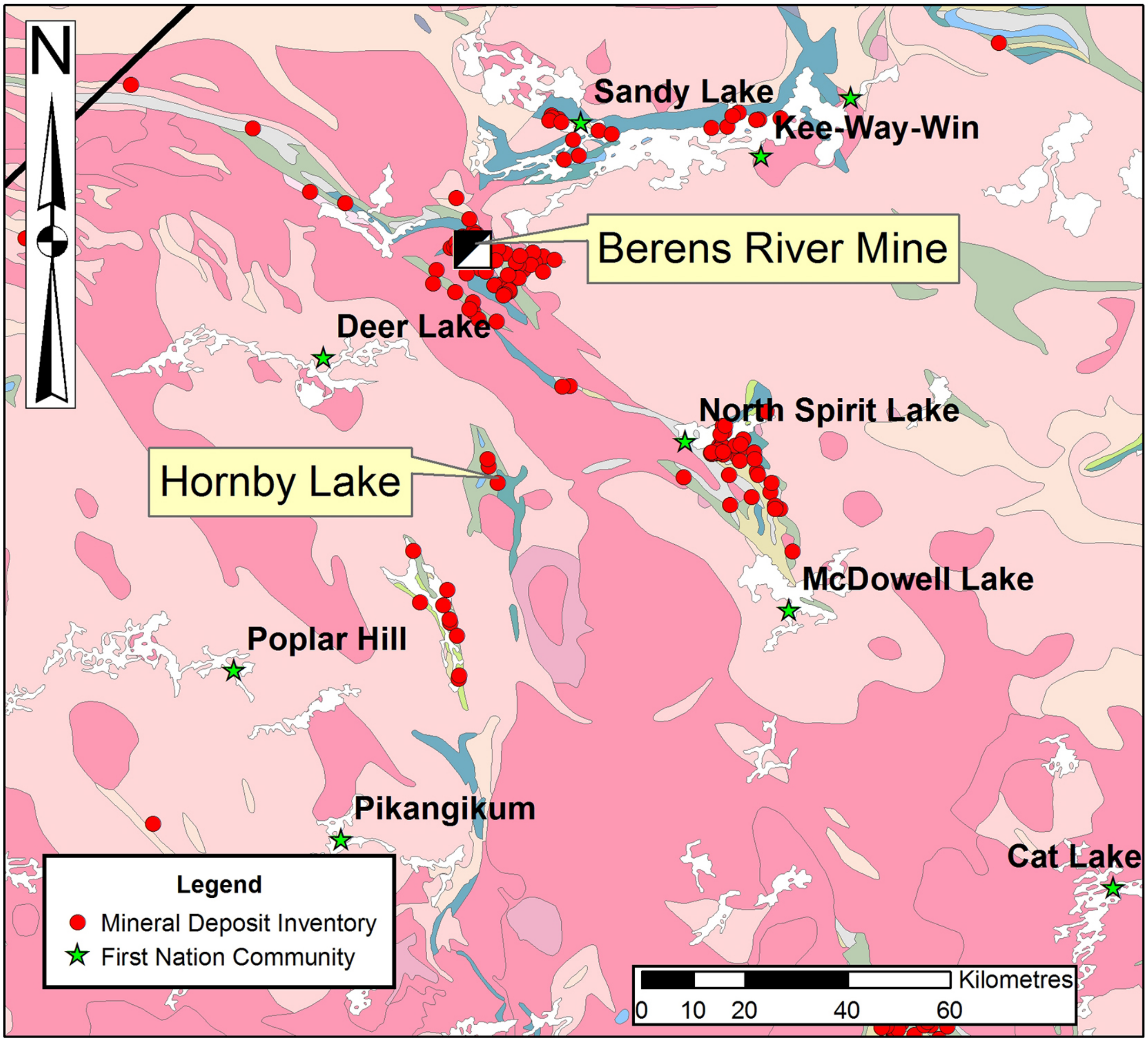

Figure 1. Location of the Hornby Lake greenstone belt, showing mineral occurrences.

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A Possible Volcanogenic Massive Sulphide Target in the Batchawana Greenstone Belt?

HIGHLIGHTS

- **Regional lake sediment survey in 1991 revealed significant anomalies in zinc, cadmium and copper: a metal association typical of Archean volcanogenic massive sulphide deposits.**
- **Anomalous copper, zinc, cadmium and lead values reported from grab samples.**
- **Associated mafic and intermediate to felsic metavolcanic rocks display variable varying chlorite, biotite, sericite and silica alteration consistent with a VMS setting.**

In 1991, the Ontario Geological Survey completed a regional lake sediment survey of the Percy Lake area in the northeastern portion of the Batchawana greenstone belt, revealing a prominent anomaly of zinc, cadmium and copper (Hamilton, Fortescue and Hardy 1995). Historically, there was little understanding of the bedrock geology of the area in large part because of the poor access and limited outcrop exposure. In the last few years, forestry operations opened up new roads to the area. This provides opportunity for prospectors to investigate the zinc, cadmium and copper anomalies. There are numerous base metal showings in the area. Unfortunately, no volcanogenic massive sulphide (VMS) deposits have been delineated. The Batchawana greenstone belt should be considered an exploration target for VMS deposits (Grunsky 1991).

The Percy Lake area, situated in Moggy Township, is within the northeast section of the Batchawana greenstone belt. The Dismal Assemblage underlies the central portion of Moggy Township (Figure 1A). The Dismal Assemblage (2700 to 2720 Ma) consists predominantly of a calc-alkalic mafic to felsic metavolcanic sequence with intercalated metasedimentary rocks and associated syntectonic to late tectonic intrusions of diorite, tonalite and granodiorite of the Ramsey Gneiss Domain, *circa* 2668 to 2677 Ma (Corfu and Grunsky 1987).

Interbedded tholeiitic to calc-alkalic mafic metavolcanic flows and volcaniclastic rocks underlie the Percy Lake area. Interspersed with the mafic metavolcanic flows are intermediate to felsic metavolcanic flows and synvolcanic intrusions. The intermediate to felsic metavolcanic flows and the synvolcanic intrusions vary from being aphanitic to porphyritic (quartz-feldspar) in texture. The mafic volcaniclastic units include tuff breccia, lapilli tuff, amphibole crystal tuff and ash tuff. Minor argillaceous, silty, and lean oxide iron formation units are interbedded with the mafic flows.

Wilson (1983) identified a regional-scale east-northeast-trending syncline west of the Percy Lake area. On a site visit, staff of the Resident Geologist Program observed small-scale folding in the Percy Lake area, ranging from a centimetre-scale crenulation cleavage, to larger folds with amplitudes of a few metres (Figures 1B and 1C). These small-scale features may be evidence of the larger syncline to the west.

A diamond-drilling program, completed by Vault Minerals Inc. in 2006, intersected numerous quartz-calcite-feldspar fracture veins containing sphalerite, chalcopyrite and galena (Lengyel 2006). These fracture veins may reflect a structural control related to the intrusion of the surrounding synvolcanic rocks. Earlier, Avalon Ventures Ltd. (Bain 1996) reported that contorted and brecciated, siliceous, graphitic iron formation in the Percy Lake area hosts finely disseminated to semi-massive pyrite and pyrrhotite.

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VMS Potential: Batchawana Greenstone Belt, *continued*

Strong base metal lake sediment geochemical anomalies are associated with the Dismal Assemblage, particularly within the Percy Lake area. Hamilton, Fortescue and Hardy (1995) completed a regional lake sediment geochemical survey for the Ontario Geological Survey. The survey revealed significant anomalies in zinc, cadmium and copper in the Percy Lake area. This metal association is typical of Archean VMS deposits and points to the prospectivity of the underlying rocks. The mineral exploration history of the Percy Lake area is limited:

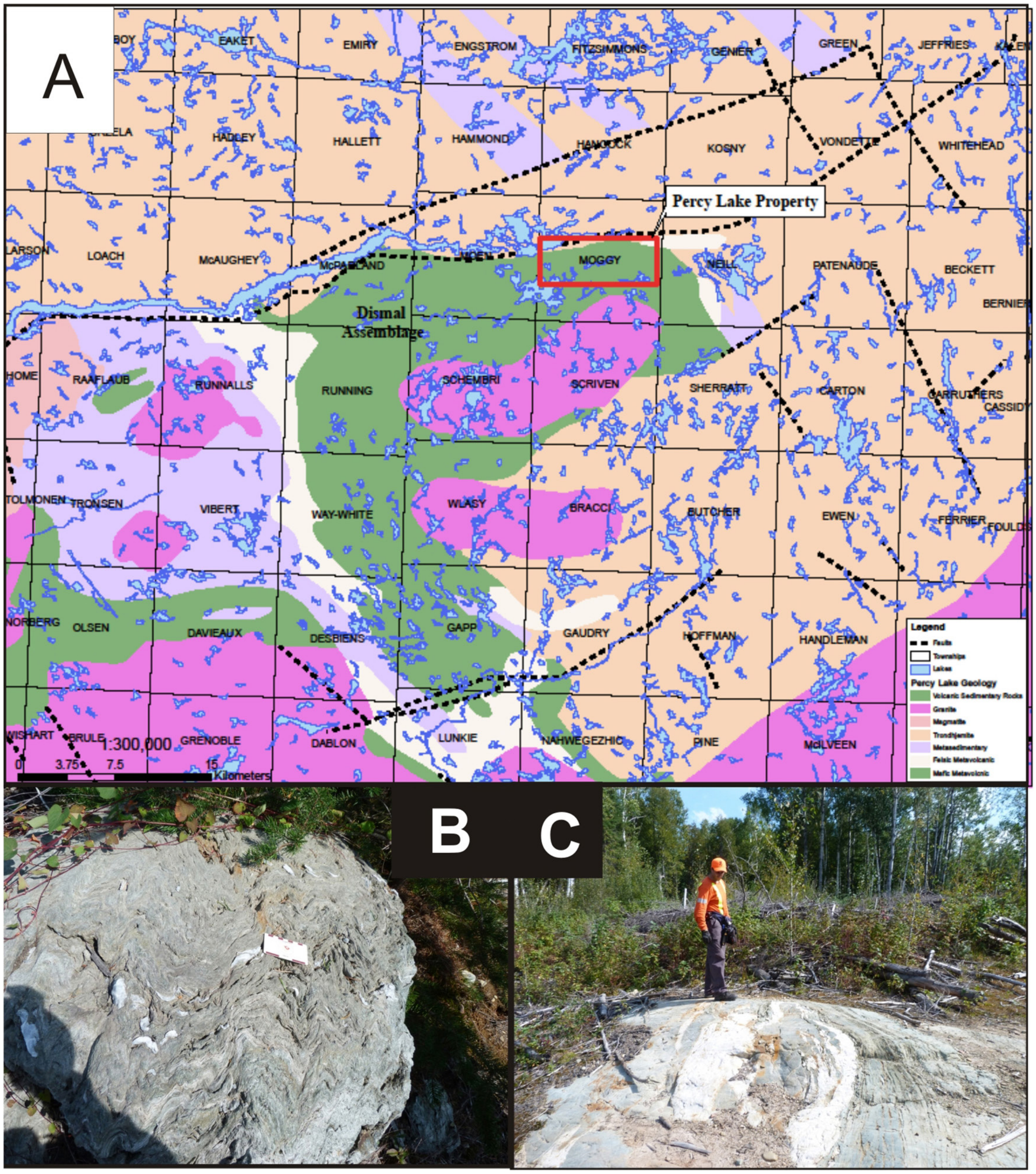

Figure 1. A) Location of the Percy Lake area in the Dismal Assemblage of the Batchawana greenstone belt (geology *from* Giblin, Leahy and Robertson 1979). **B**) Chevron and isoclinal folding observed in the mafic metavolcanic rocks in the Percy Lake area (UTM 290554E 5249289N). **C**) Shear-hosted folded quartz veining observed in the mafic metavolcanic rocks in the Percy Lake area (UTM 287536E 5248242N). Universal Transverse Mercator (UTM) co-ordinates provided using North American Datum 1983 (NAD83) in Zone 17.

VMS Potential: Batchawana Greenstone Belt, *continued*

2 exploration programs, completed in 1995 and 2006, make reference to anomalous values of copper, zinc, cadmium, as well as lead. Grab samples collected by Avalon Ventures Inc. in 1995 returned values of up to 2.86% Cu, 11.04% Zn, 1.98% Pb and 33.7 g/t Ag (Bain 1996). Geophysical surveys, completed by Avalon Ventures Inc., indicated that the copper, zinc, cadmium and lead anomalies were associated with weak to strong electromagnetic conductors and, in several cases, with a felsic metavolcanic–mafic metavolcanic contact.

In 2006, following up on the work completed by Avalon Ventures Ltd., Vault Minerals Inc. completed the first and only diamond-drilling program in the area. The drilling intersected several exhalite-bearing horizons containing yielding zinc, lead, copper and cadmium values. The adjacent host rocks display varying chlorite, biotite, sericite and silica alteration that is consistent with a VMS setting (Lengyel 2006).

Key geological, geophysical and geochemical features indicate the Percy Lake area has the potential to host VMS-style mineralization. At the time of writing, there were no unpatented mining claims recorded in Moggy Township.

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Targeting Nickel in the Timmins Area

HIGHLIGHTS

- **Favourable geology for komatiite-hosted nickel deposits along the Deloro–Tisdale assemblages boundary.**
- **Montcalm Gabbroic Complex may host another deposit similar to the Montcalm Mine, which produced 3 931 610 tonnes of ore at 1.25% Ni.**
- **The ultramafic intrusions within the Hanrahan assemblage have the potential to host a low-sulphide ultramafic nickel deposit similar to that contained in the Dumont sill, Quebec.**

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The Timmins District is known for its rich, 100 year long history of mining and exploration for gold. Nickel, although it does not have the same notoriety as gold, has also had a mining and exploration history of 100 years in the Timmins District. The geology of the Timmins District is favourable for several types of nickel deposits that vary in grade, tonnage and origin. Descriptions of the nickel deposits discovered in the Timmins District are summarized.

Komatiite

Komatiites are the extrusive equivalent of a peridotite intrusion. The komatiite lavas spread at very high temperature (~1600°C), and very low viscosity. These lavas can be easily identified by the texture represented by skeletal blades of olivine or needles of pyroxene called "spinifex". When these lavas are contaminated by a sulphur source, an immiscibility results, which allows the precipitation of metal sulphides. These metal sulphides then precipitate at the bottom of the flow (Arndt, Lesher and Barnes 2008). The nickel deposits formed are of relatively low tonnage (<5 Mt), but are of fair grade (0.5 to 3% Ni).

In Timmins, most of the past-producing nickel mines are located in the Shaw Dome. The Shaw Dome is composed of 2 volcanic episodes: the Deloro assemblage (2734–2724 Ma) and the Tisdale assemblage (2710–2704 Ma) (Préfontaine 2014). The komatiites are located at the bottom of the Tisdale assemblage in close contact to the Deloro–Tisdale assemblages boundary where many of the nickel deposits have been mined. Nickel, hosted within Shaw Dome rocks, was produced from the following mines: Langmuir #1 (MDI42A06SE00095), Langmuir #2 (MDI42A06SE00006), McWatters (MDI42A06SE00062) and Redstone (MDI42A06SE00080) (Ontario Geological Survey 2015).

Similar to the Shaw Dome, the Bartlett Dome is composed of the same 2 volcanic episodes: the Deloro (2734–2724 Ma) and the Tisdale (2710–2704 Ma) assemblages (Préfontaine 2014). The nickel potential of the Bartlett Dome is proven by the past-producing Texmont Mine in Bartlett Township.

Peridotite

Peridotite-hosted nickel deposits follow the same immiscibility phenomenon as the komatiite-hosted deposits. However, the immiscibility occurs in a magmatic chamber where sulphide-rich liquid separates itself from the magma during the cooling process. That can occur through cooling, silication, sulphur assimiliation and magma mixing (Evans 1993). These nickel deposits are hosted within a layered intrusion, with a layer of sulphides located in the lower part of the intrusive body. The peridotite-hosted nickel deposits can also coincide geographically with komatiite flows, such as the McWatters Mine, which is located in the Langmuir Township.

Nickel: Timmins Area, *continued*

The Montcalm Gabbroic Complex, in Montcalm, Nova, Strachan and Belford townships, is an example of a peridotite-hosted nickel deposit. From 2004 to 2009, the Montcalm Mine produced 3 931 610 tonnes of ore at a grade of 1.25% Ni, 0.67% Cu and 0.051% Co (Atkinson et al. 2011). The orebodies are located at an intermediate level within clinopyroxene plagioclase cumulates (Barrie 1990). The geology of the deposit reveals that the sulphides were remobilized from a more pyroxenitic rock, either deeper within the Montcalm Gabbroic Complex, or from a separate intrusion (Barrie 1990). There may be a possibility that another Montcalm deposit exists in the area.

In recent years, other peridotite-hosted nickel deposits are being targeted in the Timmins District. These orebodies have low sulphur content, but the non-sulphidic nickel is not retained in the silicates entirely, but in a nickel-iron alloy: awaruite. In Quebec, Royal Nickel Corporation's Dumont nickel project orebody displays the same characteristics. The Dumont sill is estimated to hold "approximately 6.9 billion pounds of nickel in the proven and probable reserve categories" (Royal Nickel Corporation, news release, June 17, 2013, p.6). Noble Mineral Exploration Inc.'s Project 81 explored an ultramafic intrusion in Kingsmill Township, which yielded average results, yet found the presence of awaruite (Noble Mineral Exploration Inc., news release, August 22, 2012). But there are other peridotitic plutons or sills that may be host to an orebody.

The Hanrahan assemblage is a low to medium metamorphic facies assemblage located in the eastern part of the northern Swayze greenstone belt, in Kenogaming and Penhorwood townships (Figure 1). The assemblage is composed of felsic to intermediate calc-alkalic metavolcanic rocks, encircled by an iron formation. The assemblage is cut by mafic and ultramafic intrusions. Some of these ultramafic bodies show cumulate texture and, thus, could be regarded as being sills. These ultramafic bodies comprise approximately 20% of the Hanrahan assemblage, and can be up to 15 km in length and 500 m in width (Ayer 1995).

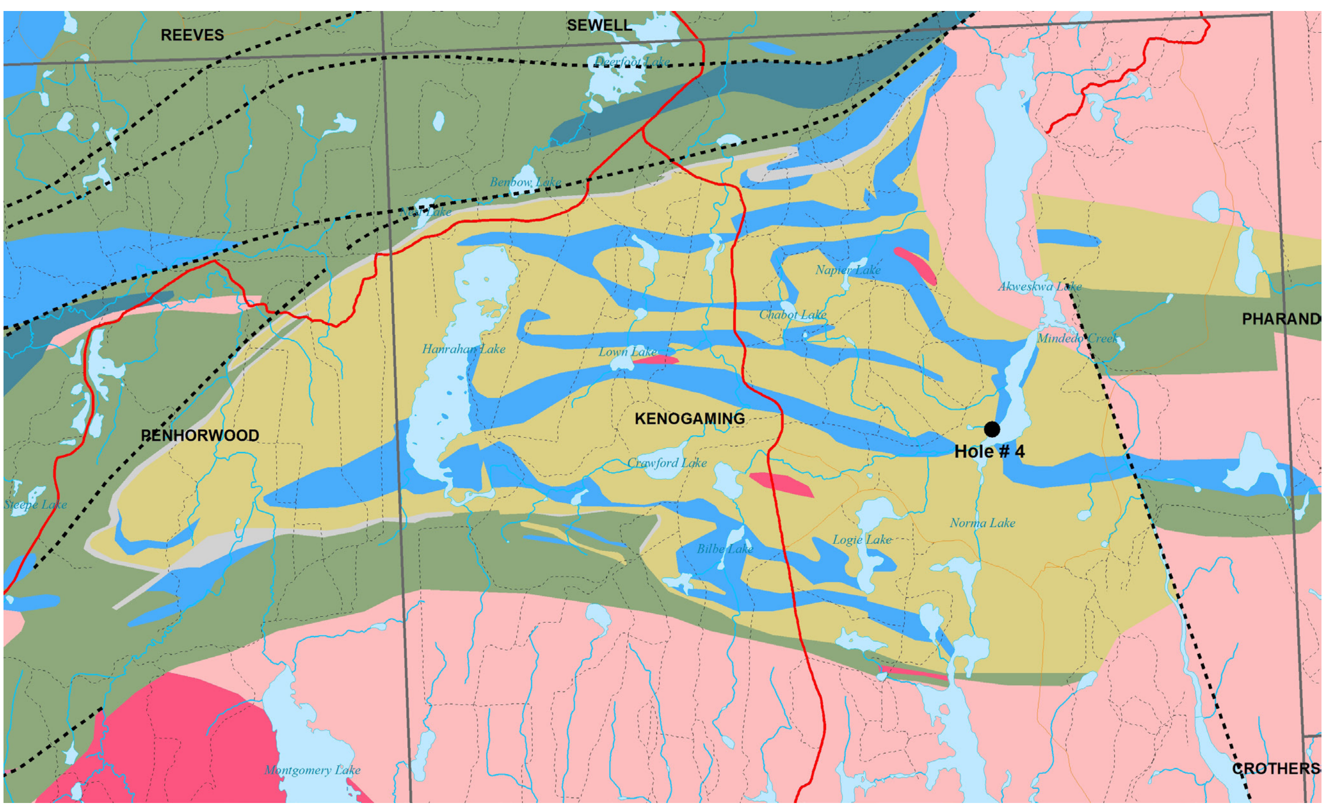

Figure 1. The location of the Hanrahan assemblage in Penhorwood and Kenogaming townships, also showing the location of International Norvalie Mines Ltd. diamond-drill hole #4 (geology *from* Ayer 1995).

Nickel: Timmins Area, *continued*

In 1971, International Norvalie Mines Ltd. drilled one of these intrusions. Samples from 1 diamond-drill hole (*see* Figure 1: #4) returned assays grading 0.2% to 0.26% Ni, over a length of 51 feet in the bedrock (International Norvalie Mines Ltd. 1971). Sections of the core from this diamond-drill hole displaying sparse sulphides are stored in the Timmins Regional Resident Geologist Office Diamond-Drill Core Library. The hole was drilled to try to duplicate results from a hole drilled in 1957 that intersected 1020 feet of rock at a grade of 0.26% Ni (International Norvalie Mines Ltd. 1971). Other samples and work within the Hanrahan assemblage demonstrate the potential of a nickel deposit in the area.

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Targeting Gold in the Timmins Area

HIGHLIGHTS

- **Largest overburden anomaly has 20 samples with >10 000 ppb gold (in concentrate), including 7 containing >100 000 ppb gold.**
- **Largest overburden gold anomaly covers 600 by 425 m area.**
- **Bedrock source has not been identified.**
- **Eight (8) other known overburden anomalies contain >10 000 ppb gold.**

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Summary

Exploration of Dundonald, Evelyn, German, Gowan, Matheson, Little and Tully townships at the eastern end of the Porcupine Mining Camp is recommended to discover the bedrock source(s) of 10 gold-rich overburden anomalies. The coarse size of native gold grains recovered by some overburden drilling programs indicates that they were derived from quartz veins containing native gold. Pyrite that generally accompanies the gold in the heavy mineral separates indicates that some of the veins will likely be hosted by mafic metavolcanic rock units, similar to those in the nearby Hoyle Pond, Owl Creek and Bell Creek deposits. The veins might also be associated with the Buskegau River and Pipestone faults, as well as the projected extension of the northeast-trending Hoyle Pond fault. Gold grains accompanied by arsenopyrite in some anomalies are likely derived from veins hosted in metasedimentary rocks.

Gold in Overburden

Pamorex Minerals Inc. discovered the largest and richest "documented" overburden gold anomaly in the Porcupine Mining Camp in 1986 (Pamour Inc. 1986). Located in Concession IV, Lot 6 (south half) of Matheson Township (Figure 1: location 1), the highest grade part of the Pamorex North anomaly extends over a 600 by 425 m area and has 20 samples that contain more than 10 000 ppb Au (in concentrate), including 7 samples with more than 100 000 ppb Au (one assayed 616 017 ppb Au), as well as pyrite.

Nine other gold-bearing overburden anomalies are known in the area south of the Pipestone and Buskegau River faults and are listed in Table 1.

There are at least 4 other areas where tight clusters of overburden drill holes, some drilled in successive years, might indicate that gold-bearing overburden was discovered. These areas are St. Joe Minerals Corporation (*see* Figure 1: location 11) and Cominco Ltd. (*see* Figure 1: locations 12, 13 and 15). A fifth cluster of overburden drill holes were drilled by Brightwest Resource Explorations Inc. (*see* Figure 1: location 14), but these only sampled the bedrock.

Table 1. Overburden gold anomalies in the eastern Porcupine Mining Camp.

Location No. (*see* Figure 1)	Anomaly Name	Highest Gold Value ppb Au (in concentrate)
1	Pamorex North	616 017
2	Pamorex South	64 972
3	BHP West	36 900
4	Asarco–Falconbridge	120 000
5	Falconbridge	15 000
6, 7	Kangeld	3 663
8	BHP East	31 700
9	Falconbridge North	100 000
10	Falconbridge East	220 000

Gold: Timmins Area, *continued*

Bedrock Topography

A bedrock topography map constructed using overburden and diamond-drill assessment data, has elevations that range from 185 to 315 m above sea level (Figure 2). A prominent, 50 m deep, north-northwest-trending bedrock valley with a floor that drops from an elevation of about 240 m at the north end to about 210 m at the south end, cuts the map area. The 30 m increase in depth of the valley over its 25 km length results in an overall south gradient of 1.2 m per kilometre (m/km).

A number of other bedrock valleys are present in the map area (*see* Figure 2), including

- a 6 km long north-trending valley that extends northward from the Pamorex North overburden anomaly (500000E 5381000N) to a topographic high (500000E 5387000N);
- a 20 km long east-trending valley that extends eastward from the projected Hoyle Pond fault (495000E 5381000N) to the western edge of the 50 m deep bedrock valley (507000E 5379000N);

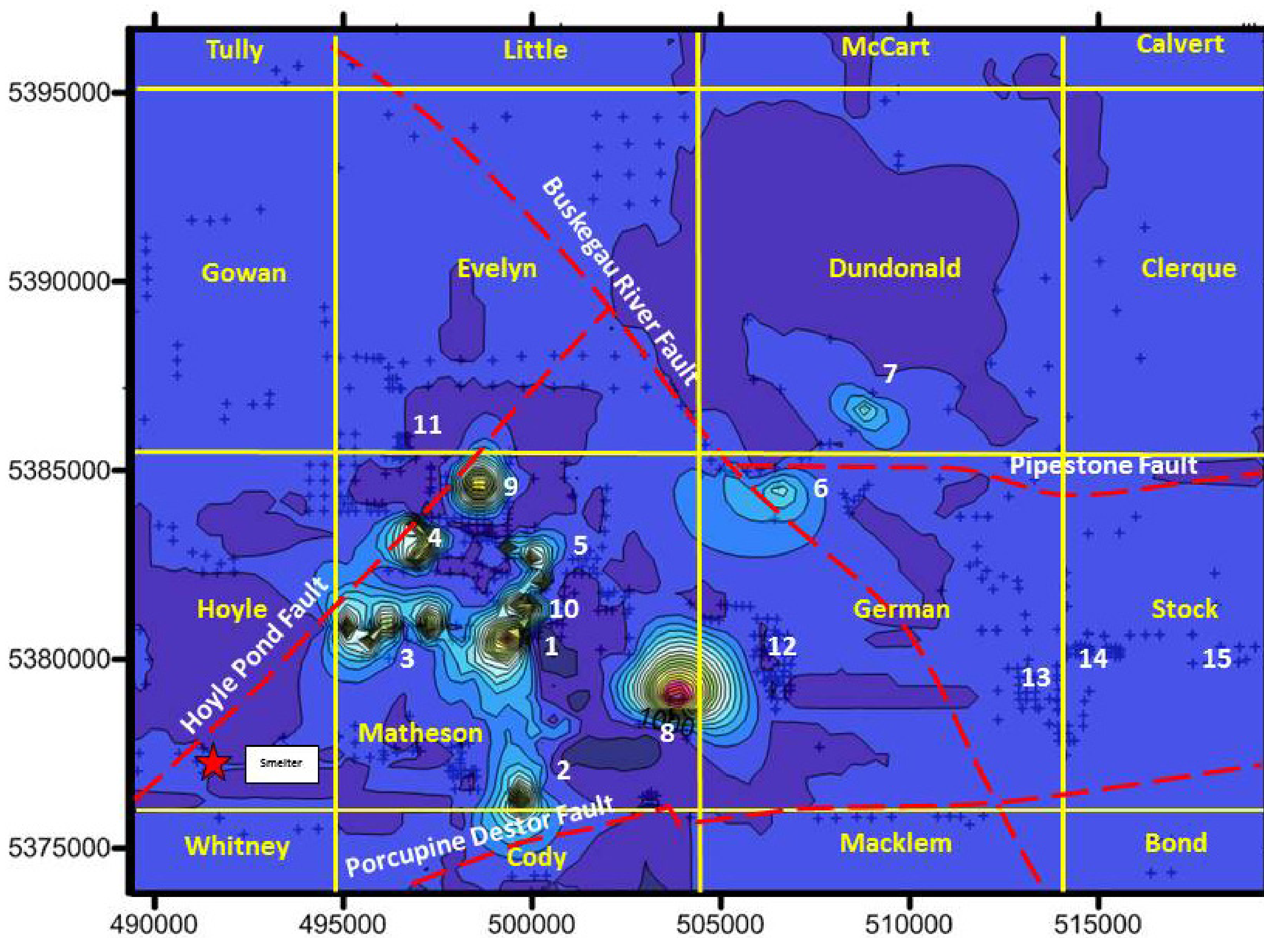

Figure 1. Contoured gold content of heavy mineral concentrates (in parts per billion (ppb)) separated from overburden samples recovered by reverse circulation drilling. All high gold values were cut to 10 000 ppb. Drill holes without reported assays were assigned a value of 5 ppb to permit contouring of the results. The contour interval is 500 ppb Au. Numbers on the map indicate anomalies discussed in the text. "Smelter" is the location of the Kidd Creek Metallurgical Complex. The red star is the location of the Hoyle Pond Mine. Universal Transverse Mercator (UTM) co-ordinates provided using North American Datum 1983 (NAD83) in Zone 17.

Gold: Timmins Area, *continued*

- a 5 km long west-trending valley that extends westward from the centre of Matheson Township (499000E 5383000N) to just inside Hoyle Township (494000E 5383500N) near the projected Hoyle Pond fault;
- a broad east-northeast-trending valley that extends from the centre of Dundonald Township (510000E 5390000N) through the northwest corner of Clergue Township (519000E 5394000N);
- a northeast-trending valley that extends from central Gowan Township (490000E 5390000N) into the northwest corner of Evelyn Township (497000E 5395000N) to near the Buskegau River fault;
- a valley that appears to follow the northern end of the Buskegau River fault into Evelyn Township (498000E 5393000N) from the Deep Valley (505000E 5389000N).

The northeast-trending Hoyle Pond fault, closely associated with gold mineralization in the Hoyle Pond Mine (Dinel et al. 2008), appears to continue to the Buskegau River fault, based on the termination of bedrock topographic highs and rapid changes in elevation.

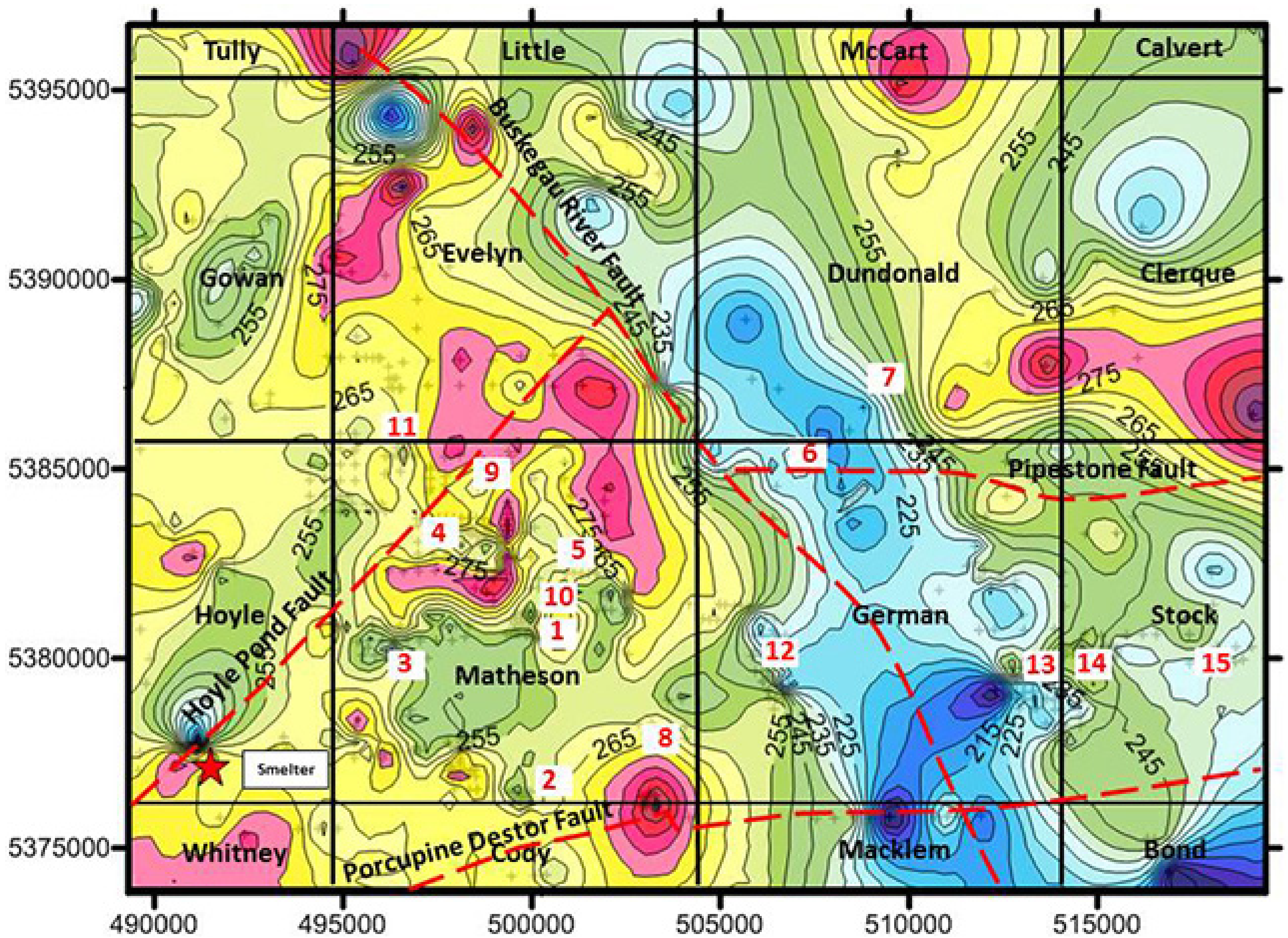

Figure 2. Bedrock topography map constructed by subtracting overburden thickness, obtained from drill-hole data submitted for assessment credit ("+" indicates hole location), *from* land surface elevation, obtained *from* Google Earth™ mapping service. The bedrock surface was generated using the Krigging method and contoured at 5 m intervals. The numbers on the map correspond with the overburden anomalies discussed in the text. "Smelter" is the location of the Kidd Creek Metallurgical Complex. The red star is the location of the Hoyle Pond Mine. The UTM co-ordinates provided using NAD83 in Zone 17.

Gold: Timmins Area, *continued*

The 6 km long valley that hosts the Pamorex North gold anomaly (*see* Figure 2: location 1) drops 25 m from a topographic high of about 275 m to less than 250 m at its southern end and has a gradient of 4.0 m/km. This gold anomaly occurs just upstream of the junction where the 6 km long valley meets the 20 km long east-trending valley and is 5 to 10 m higher than the floor of the east-trending valley. The Falconbridge gold overburden anomaly (*see* Figure 2: location 5) occurs about 2.5 km north and upstream of the Pamorex North anomaly.

The 20 km long east-trending bedrock valley hosts a) the BHP Canada Limited Ltd. BHP West gold anomaly at its western end (*see* Figure 2: location 3), b) the BHP East gold anomaly about 4 km from the eastern end (*see* Figure 2: location 8) and c) a cluster of Cominco Ltd. drill holes that suggest the presence of another overburden gold anomaly at the eastern end (*see* Figure 2: location 12). The 4 km long BHP West anomaly occurs along the northern edge of the valley where the elevation drops from 280 to 250 m. The western end of this gold anomaly occurs in close proximity to the proposed projection of the Hoyle Pond fault. The BHP East anomaly occurs on the south side of the valley, about 2 km north of the Porcupine–Destor fault, in a northeast-trending valley that slopes downhill the same direction. A large cluster of overburden drill holes located at the east end of the 20 km long valley, where it drops 25 m over 0.5 km into the deep north-northwest-trending valley (*see* Figure 2: location 12), suggests that the Cominco exploration program encountered a gold anomaly. The lack of drill hole data along the length of east-trending valley results in it being poorly defined and not having an obvious drop in elevation.

The 5 km long valley, associated with the Asarco–Falconbridge gold anomaly (*see* Figure 2: location 4), extends west from central Matheson Township and drops 15 m from a topographic high of about 275 m to 260 m at its western end, with a resulting gradient of 3.0 m/km. The Asarco–Falconbridge anomaly occurs along the northern edge of the valley where the elevation drops more than 5 m from a 270 m high terrace to the valley floor at less than 265 m. The west end of this anomaly is located close to the projected extension of the northeast-trending Hoyle Pond fault.

The broad valley that extends east-northeast from Dundonald Township into Clergue Township is similar in depth to the prominent 50 m deep north-northwest-trending valley. The broad valley is oriented parallel to the direction of the earliest glaciation event in the Timmins area (Veillette 1986; Bird and Coker 1987; McClenaghan et al. 1987). The weak Kangeld gold anomaly (~3600 ppb Au) occurs where the 2 deep valleys meet (*see* Figure 2: location 7). The second Kangeld gold anomaly occurs on the west side of the northwest-trending valley (*see* Figure 2: location 6).

There is an irregular-shaped northeast-trending valley defined by a string of bedrock lows that extends from Gowan Township into Evelyn Township and is up to 25 m deep. There are no known overburden gold anomalies or clusters of drill holes in this valley.

The northwest-trending valley that follows the Buskegau River fault is about 35 m deep and drops from 260 m at the northwest end to 220 m at the southeast end. This 40 m drop over 8 km results in the valley having a gradient of 5 m/km. This valley might be a finger extending off, or a bifurcation in, the prominent north-northwest-trending valley. There are no known overburden gold anomalies or clusters of drill holes in this valley.

Character of Overburden Gold

Heavy mineral separates prepared from the Pamorex North overburden samples (*see* Figure 1: location 1) contained a total of 156 gold grains. The grain-size distribution of this gold is comparable to that found in gold-bearing veins at the Dome and Pamour mines and is coarser than gold grains found in wall-rock–hosted mineralization at these same deposits (Figure 3) (van Hees 2000). These gold grains are predominantly irregular in shape and are commonly accompanied by 10 to 50% pyrite (in concentrate), as well as hematite and ilmenite. Only a trace amount of arsenopyrite was found in some mineral separates.

Heavy mineral separates prepared from overburden samples recovered from the BHP overburden anomalies contained 897 gold grains of which 793 occurred in the West anomaly and 104 in the East anomaly (*see* Figure 1:

Gold: Timmins Area, *continued*

locations 3 and 8). The gold grains are predominantly reshaped (56%) or modified (32%), and are accompanied by pyrite and cobaltite 92% and 50% of the time, respectively. Of the gold grains recovered from drill-hole MA-96-2 at the east end of the BHP West anomaly, 96% are pristine (MacNeil and Averill 1996).

Other than the assay values, there is no information available about the shape of the gold grains or gangue minerals collected in the heavy mineral concentrate for both the Asarco–Falconbridge and Falconbridge overburden anomalies (*see* Figure 1: locations 4 and 5) (van Hees 1991; MacRae 2008).

Gold grains in the Kangeld overburden anomalies (*see* Figure 1: locations 6 and 7) are primarily reshaped or modified with only a few being pristine or delicate. These gold grains are almost always accompanied by arsenopyrite (Hutteri 1988).

Overburden drilling conducted by Brightwest Resource Explorations Inc. (*see* Figure 1: location 14) differs from all other programs in the area because it sampled only bedrock and not the overburden (Karvinen 1989).

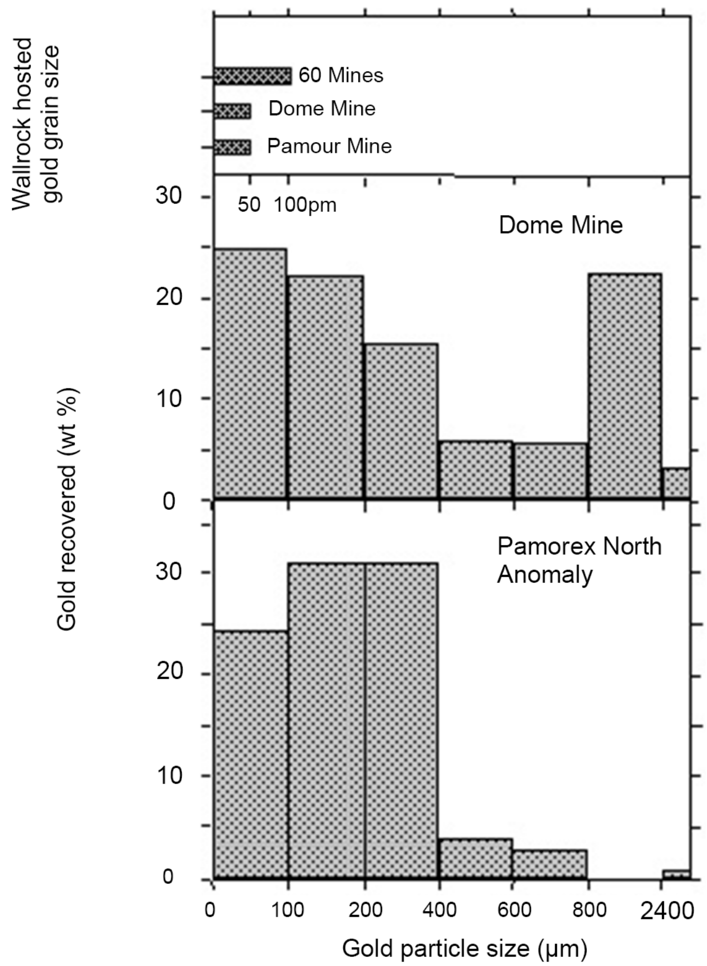

Figure 3. Grain sizes of gold recovered by the gravity circuit at the Dome Mine (middle chart) compared to that of gold in wall-rock–hosted deposits (upper chart). Gold observed in polished sections of wall-rock–hosted mineralization is smaller than most free gold recovered in the gravity mill circuits at the Dome and Pamour (not shown) mines. This difference indicates that the bulk of the gold recovered by gravity circuits cannot be derived from wall-rock–hosted mineralization and must originate from vein-hosted deposits. The grain size of the 156 gold grains recovered from Pamorex North overburden anomaly (lower chart) is comparable to that found in Dome Mine and Pamour Mine veins (*modified from* van Hees 2000).

Gold: Timmins Area, *continued*

Known Bedrock Gold Sources

There are 2 known bedrock sources of gold near the Pamorex North overburden anomaly (*see* Figure 1: location 1). The first, intersected in diamond-drill hole DMA2, is a 1 m wide vein that contains 2.5 g/t Au. Asarco Exploration Company of Canada Limited spotted this hole about 1 km north of the overburden anomaly (499855E 5382349N) (van Hees 1991). The Porcupine Joint Venture (51% Goldcorp Inc. and 49% Kinross Gold Corporation) discovered the second bedrock source when they drilled hole MT04-22 (498948E 5383654N) in 2004 and encountered a 0.45 m wide vein containing 2.16 g/t Au about 2.5 km north-northwest of the overburden anomaly (Waychison 2005).

Origin of Gold Anomalies

The Pamorex North and other overburden gold anomalies might have been formed by a number of different processes that affected the area, including 1) concentration by a stream into a placer deposit, before or after glaciation; 2) weathering of bedrock to form a regolith; or 3) erosion of a bedrock by a glacier to form a till. Knowing the process that formed the gold anomalies has implications for finding their bedrock source(s).

Seven gold values between 100 000 ppb Au and 600 000 ppb Au in the Pamorex North heavy mineral fraction are equivalent to gold values of between 0.08 and 1.8 ppm Au (1:350 concentrate) in the original overburden and appear to support the anomaly being formed by a gold concentrating process. A fast-flowing river could readily form a placer gold deposit and would account for the abundance of sand and/or gravel in many of the gold-bearing samples (Pamour Inc. 1986). A fluvial process is also consistent with the close proximity of the anomaly to extensive gravel deposits and a longer than 100 km esker (Lee 1979a, 1979b). The location of the Pamorex North anomaly in the north-trending valley and topographically above the flat-dipping east-trending valley (*see* Figure 2: location 1) is also consistent with the formation of a gold placer. Additionally, the 2 known gold-bearing veins, located in bedrock about 1 km and 2.5 km north and topographically upstream from the Pamorex North anomaly, indicate that gold-bearing bedrock sources occur nearby.

Formation of a regolith by weathering could concentrate gold to form the Pamorex North anomaly, but follow up diamond drilling (9 holes) did not encounter weathered bedrock or gold-bearing mineralization underlying the anomaly (Pamour Inc. 1986). Consequently, it is unlikely that the Pamorex North anomaly was formed by weathering.

Erosion of bedrock by glaciers causes gold mineralization to disperse down ice and is inconsistent with high gold values, such as those found in the Pamorex North anomaly or gold-bearing sediment depths of 20 m (Pamour Inc. 1986; MacNeil and Averill 1996). Additionally, sediment transported by a glacier originating from the northeast (e.g., valley in Dundonald and Clergue townships) is likely to further disperse entrained gold when it passed through the 50 m deep north-northwest-trending bedrock valley.

The location of the BHP gold anomalies (*see* Figure 2: locations 3 and 8) in the 20 km long east-trending valley supports placer deposit formation. Gold required to form the BHP anomalies might have been derived from 1) a topographic high north of the BHP West anomaly; 2) bedrock near the projected Hoyle Pond fault; 3) sediment that washed past the Pamorex North anomaly to form the BHP East anomaly; or 4) a topographic high located south of the BHP East anomaly.

The pristine shape of gold grains found at the eastern end of the BHP West anomaly (*see* Figure 1: location 3) supports that they were derived from a nearby bedrock source area, located just north of the valley. The dominantly abraded to irregular shaped gold grains found in the rest of the anomaly indicate that the gold was derived from a bedrock source located more than 1 km away (MacNeil and Averill 1996). The abundant cobaltite accompanying this gold suggests both minerals originated near the ultramafic rocks. The west end of the anomaly lies near the projected Hoyle Pond fault and is underlain by mafic and ultramafic rocks (Berger 1994) similar to

Gold: Timmins Area, *continued*

those found in the Hoyle Pond and Owl Creek mines. The area near the projected Hoyle Pond fault meets all the criteria as a possible source for the gold.

The Asarco–Falconbridge gold anomaly (*see* Figure 2: location 4) extends from 1 to 4 km downslope, to the south and west, of the second known bedrock gold source (498948E 5383654N; Waychison 2005), as well as close to the projected Hoyle Pond fault. The close proximity of the Asarco–Falconbridge overburden anomaly to a known bedrock source suggests that the gold might be derived from the general area. The west end of the anomaly occurs close to both the projected Hoyle Pond fault and to mafic and ultramafic bedrock (Berger 1994). The presence of both favourable structure and host rock support the possibility that gold in the overburden anomaly might have originated from that general area. The lack of gold grain or heavy mineral descriptions precludes making any comments about transport distance or rock type in the source area.

The Falconbridge anomaly (*see* Figure 2: location 5) might also originate from a bedrock source located to the north or northwest and be related to the second known bedrock gold source.

The Kangeld gold anomalies (*see* Figure 2: locations 6 and 7) have lower gold values that are only 5 to 10% of those reported for most other gold anomalies and are generally associated with arsenopyrite. The close association of gold with arsenopyrite indicates that it likely originated from a sediment-hosted vein(s) (van Hees et al. 1999).

The Falconbridge North anomaly (*see* Figure 2: location 9) is defined by a single analytical result and no detailed sample descriptions (MacRae 2008). All that can be said about this anomaly is that it is located close to the projected Hoyle Pond fault and to underlying mafic and ultramafic bedrock (Berger 1994).

The Falconbridge East anomaly (*see* Figure 2: location 10) is also defined by a single analytical result and no detailed sample descriptions (MacRae 2008). All that can be said is that it is located close to and northeast of the Pamorex North anomaly and the first known bedrock gold source.

Summary

In summary, the Pamorex North anomaly appears to have been produced in a fluvial environment by a stream that flowed south from a topographic high. The source of the anomaly is likely more than 1 km from the anomaly. There are 2 other overburden anomalies located to the north and east, as well as 2 known bedrock gold sources to the north. Further exploration to the north of the anomaly is warranted.

Three different overburden anomalies (*see* Figure 2: locations 3, 4 and 9) are all closely associated with the northeast projection of the Hoyle Pond fault where it cuts mafic and ultramafic bedrock units. The importance of the projected Hoyle Pond fault as proposed and other, as yet, unrecognized northeast-trending faults that coincide with bedrock valleys having a northeast orientation (e.g., McGowan Township to Evelyn Township) should be taken into account when exploring the area.

Gold grains found in 1 overburden hole at the east end of the BHP West anomaly (*see* Figure 2: location 3) are predominantly pristine (92%) suggesting that the vein system source is located in bedrock just north of the hole.

Arsenopyrite found with gold in the Kangeld anomalies (*see* Figure 2: locations 6 and 7) indicates the bedrock source to be vein(s) hosted in metasedimentary rocks.

There are large parts of Dundonald, Evelyn, German, Gowan, Little and Tully townships that warrant additional exploration because they have comparable geology and a limited exploration history.

Gold: Timmins Area, *continued*

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Gold in the Round Lake Batholith

HIGHLIGHTS

- **Alluvium samples taken within the Round Lake batholith returned numerous highly anomalous gold grain values including "pristine" gold grains. Many of the sample sites that yielded anomalous values were from sites on or adjacent to significant topographic lineaments and intersections of those lineaments.**
- **Gold-bearing quartz veins in shear zones that transect similar plutons have been mined elsewhere in the Abitibi and Wawa subprovinces.**

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The Round Lake batholith in the southern Abitibi Subprovince is a Neoarchean multiphase pluton with a high-aluminum tonalite-trondhjemite-granodiorite (TTG) petrogenetic affinity (Beakhouse 2011). The exposed area of the batholith is greater than 1000 km^2 and it intrudes Archean greenstones. To the west and south, the Round Lake batholith is overlain by Proterozoic Huronian Supergroup sedimentary rocks, which, in turn, are intruded by Nipissing diabase intrusions.

Sampling of alluvium in streams underlain by the Round Lake batholith yielded highly anomalous gold grain counts (Guindon and Reid 2005; Figure 1). Eight of the 60 samples collected in the area of the Round Lake batholith contained 6 grains or more of alluvial gold. This number of gold grains corresponds to the 90th percentile or greater in the data set of 357 samples (Guindon and Reid 2005). Thirty other sites within the batholith yielded gold grains. Such high values warrant a deeper investigation into the potential gold sources for these samples. Of particular note is the presence of pristine gold grains as a component of these samples (Figure 2). Pristine alluvial gold grains are a strong indication that the source of the gold is close to the sample location. Figure 2 illustrates that pristine gold grains were identified from sample sites both near the batholith margins, but also well within the batholith. This begs the question: where did this gold come from?

Limited mineral exploration has been conducted within the Round Lake batholith. According to Ontario's Mineral Deposit Inventory, 15 mineral exploration targets have been identified in the batholith, 4 for peat as a fuel source, 1 for copper, 2 for diamonds in kimberlite and 8 gold exploration targets. All but 2 of the gold occurrences are along the margins of the batholith (*see* Figure 2).

The Round Lake batholith has a geochemical and petrologic affinity to the trondhjemite-tonalite gneisses that host the Renabie Mine in the Michipicoten greenstone belt of the Wawa Subprovince (Callan 1991). Hosted within the metamorphosed intrusive rocks, gold mineralization at the Renabie Mine occurs at or near the contact between the gneissic intrusive rocks and metavolcanic rocks. Ore is characterized by gold-pyrite–bearing quartz veins within a shear zone (Ontario Geological Survey 2015).

Another possible analogue for the Round Lake batholith within the Abitibi Subprovince is the Bourlamaque batholith near Val d'Or, Quebec. The Bourlamaque batholith is a polyphase intermediate pluton of a similar age and size to the Round Lake batholith. This pluton hosts multiple past-producing gold mines (Belkabir et al. 1993). The Balmoral and Beacon mines occur well inside the pluton and are associated with shearing. The Sullivan, Perron and Courvan mines are located near the margins of the Bourlamaque batholith and are associated with diorite dikes.

Topographic lineaments from digital elevation model data clearly indicate a strong correlation between the presence of pristine gold grains in alluvium samples, as well as the 2 known gold occurrences within the middle of the Round Lake batholith (*see* Figure 2). Such topographic

Gold Potential: Round Lake Batholith, *continued*

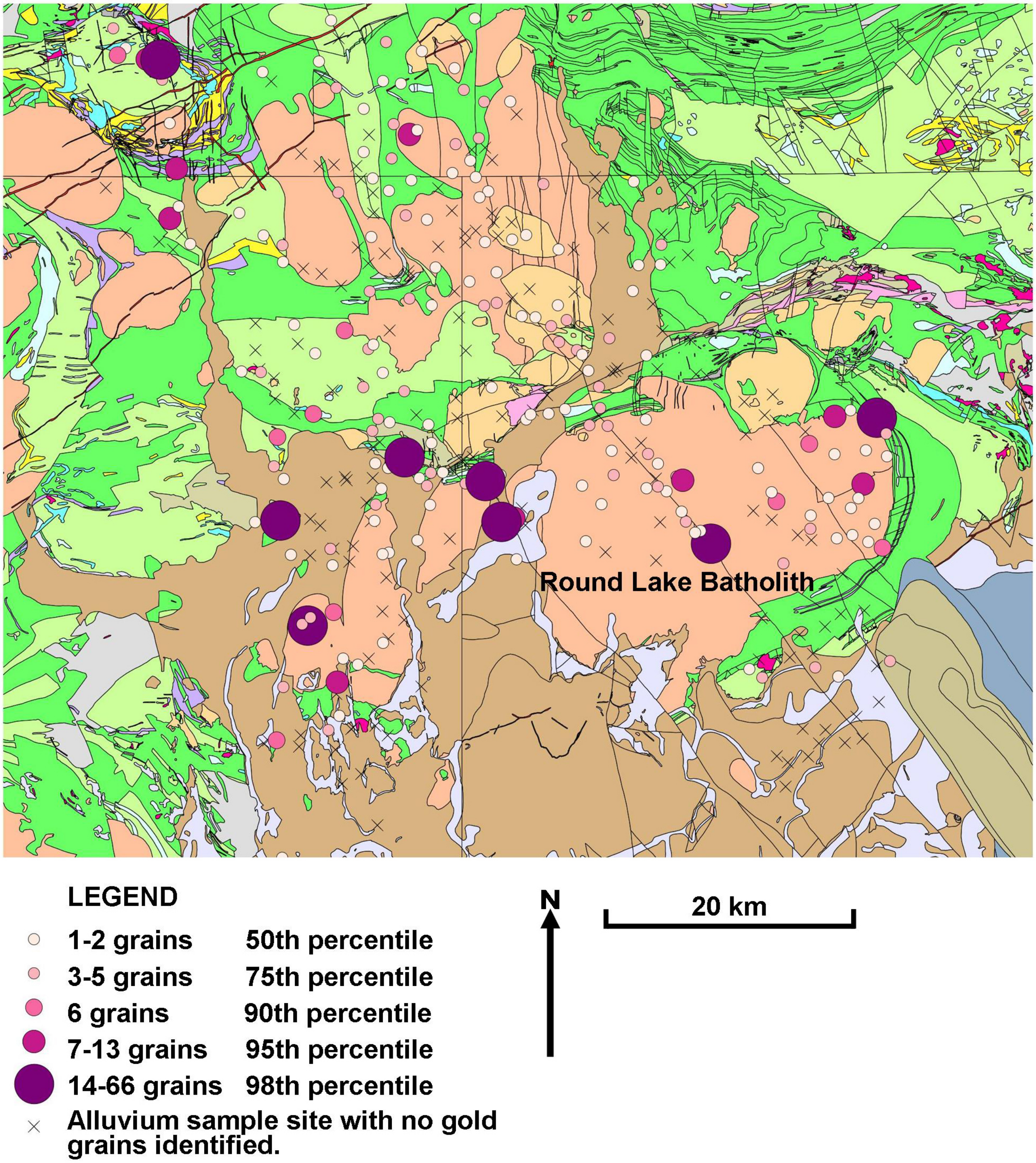

Figure 1. Bedrock geology of the study area with the gold grain counts plotted for all alluvial sample sites (Guindon and Reid 2005). Pink and peach areas on the map represent Archean felsic to intermediate plutons; green and yellow areas represent Archean metavolcanic rocks; brown areas represent Proterozoic sedimentary rocks; blue areas represent Proterozoic mafic intrusions; pale grey areas represents Paleozoic sedimentary rocks. Geology *from* Ayer, Trowell and Josey (2004).

Gold Potential: Round Lake Batholith, *continued*

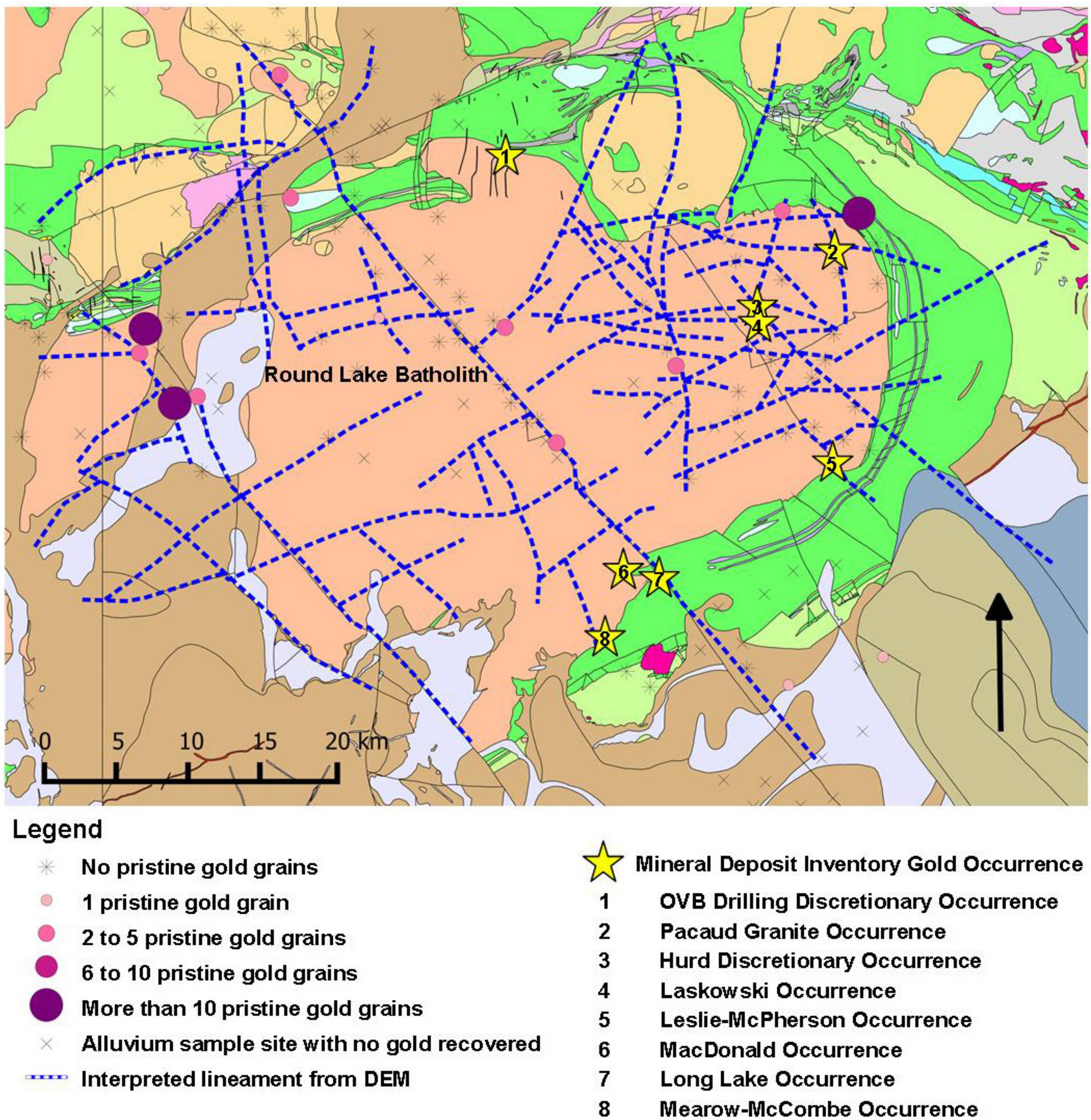

Figure 2. Geologic setting of the Round Lake batholith with locations of pristine gold grain abundances, gold occurrences and topographic lineaments plotted. Pink and peach areas on the map represent Archean felsic to intermediate plutons; green and yellow areas represent Archean metavolcanic rocks; brown areas represent Proterozoic sedimentary rocks; blue areas represent Proterozoic mafic intrusions; pale grey areas represents Paleozoic sedimentary rocks. Geology *from* Ayer, Trowell and Josey (2004); Mineral Deposit Inventory occurrences *from* Ontario Geological Survey (2015).

Gold Potential: Round Lake Batholith, *continued*

lineaments may reflect the presence of structures, which transect the batholith, holding potential for gold-bearing quartz veins akin to those hosting the gold mineralization at the Renabie and Belmoral mines.

It is recommended that prospecting in the vicinity, particularly up stream, of the alluvium anomalies be undertaken in an effort to locate gold-bearing quartz veining within structural zones.

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Sodium Metasomatic-Hosted Gold

HIGHLIGHTS

- **Gold mineralization hosted in brecciated, chloritized albite.**
- **Six (6) gold deposits were developed and produced gold. Numerous prospects require further exploration.**
- **U/Pb geochronology indicates alkalic magmatism at 1700±2 Ma.**

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Regionally albitized sedimentary rocks of the Paleoproterozoic upper Huronian Supergroup of the Southern Province of the Canadian Shield host several small gold deposits. A conservative production estimate is 40 000 ounces of gold with grades ranging between 0.1 and 0.3 ounce gold per ton. Copper from chalcopyrite and bornite was also recovered. Historical data are unreliable (Gordon et al. 1979).

Sodium metasomatism occurs from near Bruce Mines in the west, to the Temagami area in the east, a distance of about 340 kilometres. A belt of gold deposits extends from northeast of the Sudbury basin to south of Espanola (Figure 1), where the former McMillan gold mine is located, a distance of about 120 kilometres. Moreover, the McMillan gold mine lies in an east-trending linear belt of gold deposits stretching approximately 18 km through McKinnon, Mongowin and Curtin townships. Work by the Ontario Geological Survey (Gates 1991) established a common alteration signature and style of mineralization for these deposits. The most prominent zones of alteration occur south and east of Wanapitei Lake and in the Espanola–Whitefish Falls area (Gates 1991).

The first phase of hydrothermal alteration was albitization of the host sediments at 1700±2 Ma (Schandl, Gorton and Davis 1994). Albitized zones, several hundred metres long, were subject to silica flooding and the development of carbonate veins, stockwork and breccia, followed by a gold-rich episode that filled fissures with chlorite, carbonate, pyrite, arsenopyrite and gold. Movre intense chlorite alteration is associated with higher gold values.

Elevated levels of rare earth elements (REE) have been identified in some of the host rocks. This may suggest carbonatitic or alkalic intrusions at depth as an aid in mineralization (Schandl, Gorton and Davis 1994).

Sodium metasomatism within the Sudbury area involves replacement by albite that can range from incipient to complete. The albite is most commonly tan to pink, with colour variations resulting from size, frequency and distribution of very fine-grained inclusions, which most commonly include a hematite dust. The alteration is easily recognized in most rocks by the strong colour difference.

Based on discoveries to date, an appropriate gold exploration model for this "gold belt" in the Huronian Supergroup would take into consideration the following characteristics.

- Brittle-fractured quartzites and conglomerates have the best potential to be sulphidized.
- The best gold targets will be within sulphidized zones (arsenical and/or pyritic sulphides that return elevated copper, cobalt and possibly nickel values).
- The sulphidized zones along with envelopes of chlorite + quartz + carbonate alteration may occur within or along the boundary of wide zones of albitization and silica flooding. Both may be highly sheared. Harder sulphide species, such as pyrite and arsenopyrite, will be recrystallized in a chlorite-rich host.

Gold Potential: Huronian Supergroup, *continued*

- An envelope of chlorite + quartz + carbonate alteration ± chalcopyrite ± pyrite ± arsenopyrite. The chloritic envelope will likely be gold bearing.
- The envelopes of chlorite + quartz + carbonate alteration can be weakly magnetic inside a flat magnetic background, and will often form a weak traceable magnetic anomaly. For a magnetic survey to find targets and fully cover the normal strike length of these envelopes, a grid with a spacing of 25 m and readings every 6.25 m would give the best coverage.
- Humus sampling for gold, arsenic and copper might help find further significant targets in areas covered by ephemeral swamp or deeper till and clay.

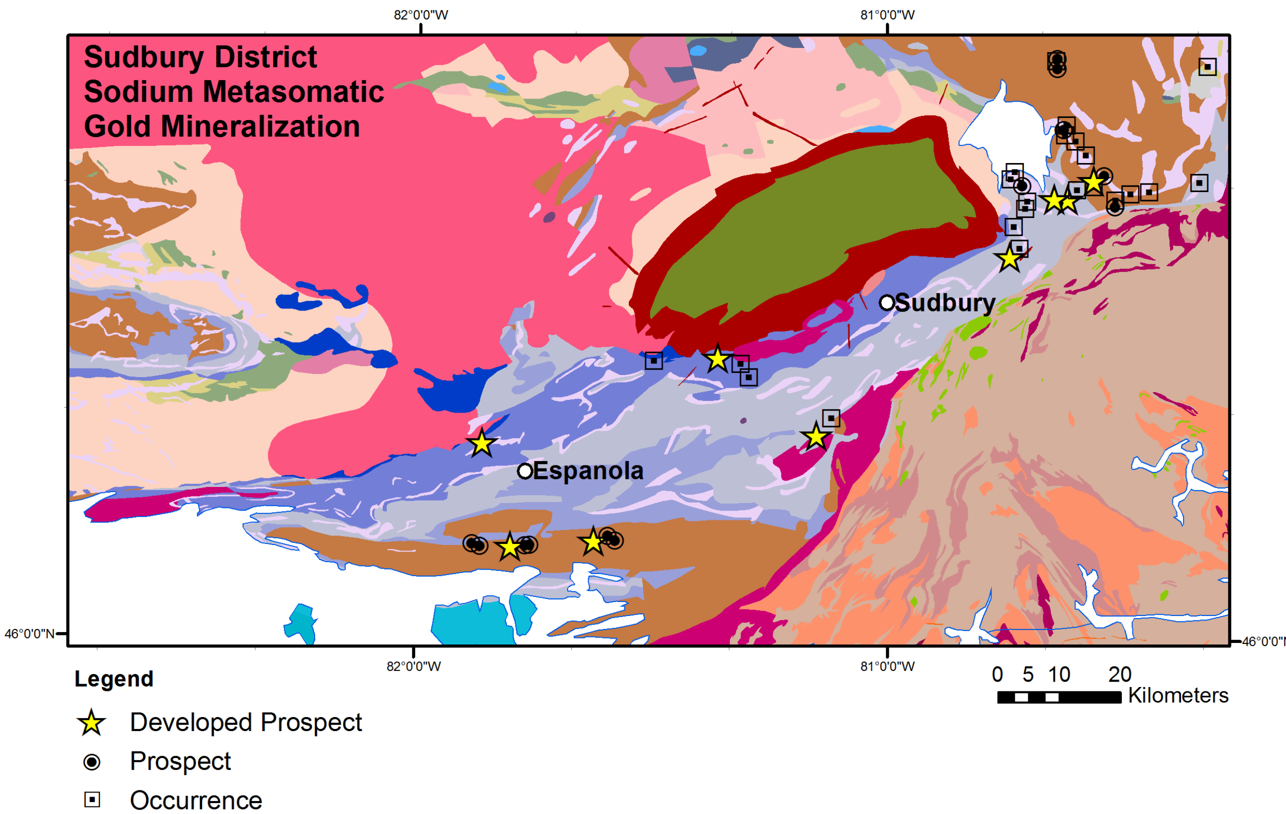

Figure 1. Sodium metasomatic gold mineralization within the Sudbury District. Mineral Deposit Inventory data *from* Ontario Geological Survey (2015). Geology *from* Ontario Geological Survey (2011).

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HIGHLIGHTS

- **Ontario's first documented occurrence of nephrite jade.**
- **Potential for nephrite in areas of siliceous, dolomitic marble adjacent to intrusions in low-grade metamorphic terrane.**

Nephrite Jade in Southeastern Ontario

In 2014, staff of the Resident Geologist Program in Tweed identified a sample of waste rock from the Canada Talc Mine in Madoc as nephrite jade. The Canada Talc Mine closed in 2010. X-ray diffraction analysis of sample Cantal-14-1 determined the rock to consist entirely of tremolite (Fernandes 2014). Nephrite located farther from the mine workings, identified in dumped diamond-drill core, remains relatively unfractured (Photo 1).

There are 2 forms of jade: nephrite and jadeite. Nephrite consists of massive, micro- to cryptocrystalline intergrowth of grains of the tremolite-actinolite series of the amphibole group, $Ca_2(Mg,Fe)_5(OH)_2[Si_8O_{22}]$; jadeite is a clinopyroxene with composition $Na_2(Al,Fe)_2[Si_4O_{12}]$. Although jadeite can be slightly harder than nephrite (hardness of 7.0 and 6.5, respectively), nephrite is the tougher variety as a result of interlocking fibrous tremolite-actinolite crystals. Nephrite jade can range in colour from nearly white when composed of magnesium-rich tremolite, to dark green when actinolite is the predominant component. British Columbia is Canada's only producer of jade, with prices ranging from $200 to $2000 per kg (Hsu 2015).

Nephrite jade can be produced by 1) the metamorphism of dolomite and silica to form tremolite or 2) the alteration of serpentinite by calcium metasomatism at contacts with more silicic rock (Harlow, Sorensen and Sisson 2007). Talc is the first mineral to form during progressive metamorphism of siliceous dolomitic limestone. With increasing temperature, tremolite is formed. The Canada Talc deposit occurs within marble of the Belmont domain, in an area of middle to upper greenschist facies metamorphism, approximately 800 m northwest of the Moira granite. Stromatolitic marble, consisting of alternating quartz and dolomite laminae, are present in the host rock sequence. Talc and tremolite alteration can form within thermal aureoles of intrusions in areas of siliceous dolomitic marble of low regional metamorphic grade and with structures present to allow circulation of magmatic or meteoric fluids and escape of CO_2.

Also in the Madoc–Marmora area, green marble deposits have been quarried as decorative stone since the 1930s. Samples of green marble from the Huntingdon quarry (TW-14-01) and from a rock cut on Highway 7 near the Elzevir–Kaladar township line (TW-14-03) contain 88% and 94% tremolite, respectively (Wilson 2014). Green marble also occurs adjacent to wollastonite-bearing marble zones in Marmora Township (Figure 1).

The presence of nephrite jade at Madoc and zones of green marble with high tremolite content within a belt of marble containing quartz and dolomite (locally stromatolitic), extending from Belmont Township to Kaladar Township (*see* Figure 1) indicate favourable conditions for alteration of quartz-dolomite to tremolite-actinolite and the potential for additional nephrite jade mineralization. Marble-hosted occurrences of talc and wollastonite associated with thermal metamorphic aureoles of intrusive bodies should also be considered as target areas for nephrite, with the potential for tremolite occurrence in adjacent higher and lower temperature metamorphic zones, respectively.

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Nephrite Jade: Southeastern Ontario, *continued*

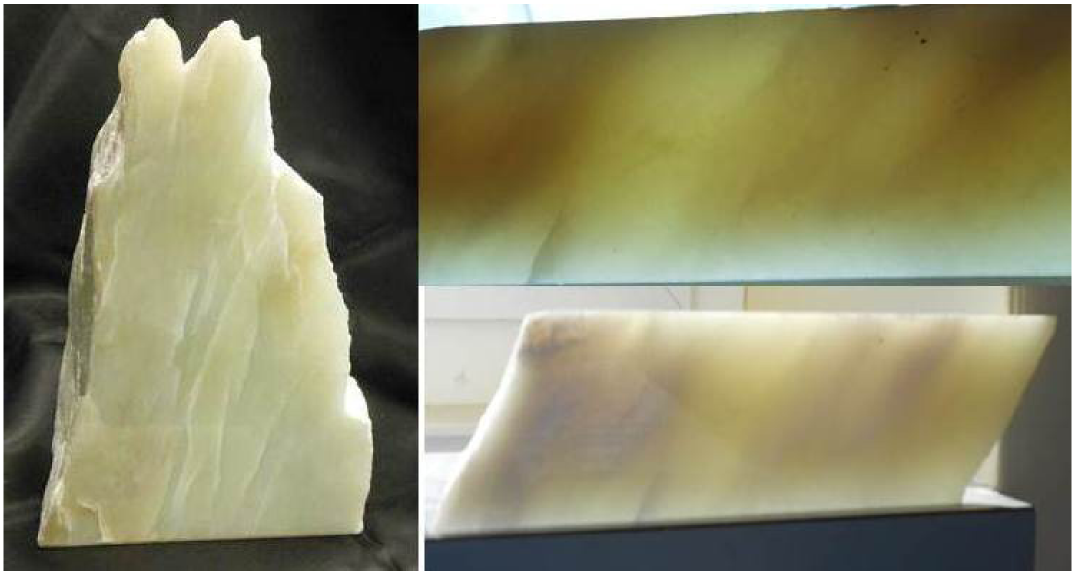

Photo 1. Left) Polished piece of sample Cantal-14-1, nephrite jade, approximately 15 by 9 cm, from Canada Talc mine waste rock pile, Madoc, Ontario. **Lower right**) Polished diamond-drill core of pale green nephrite and white calcitic marble; 4.6 cm high. **Upper right**) Same sample as shown in lower right, showing translucence of nephrite in back lighting; sample thickness at centre is 2.0 cm.

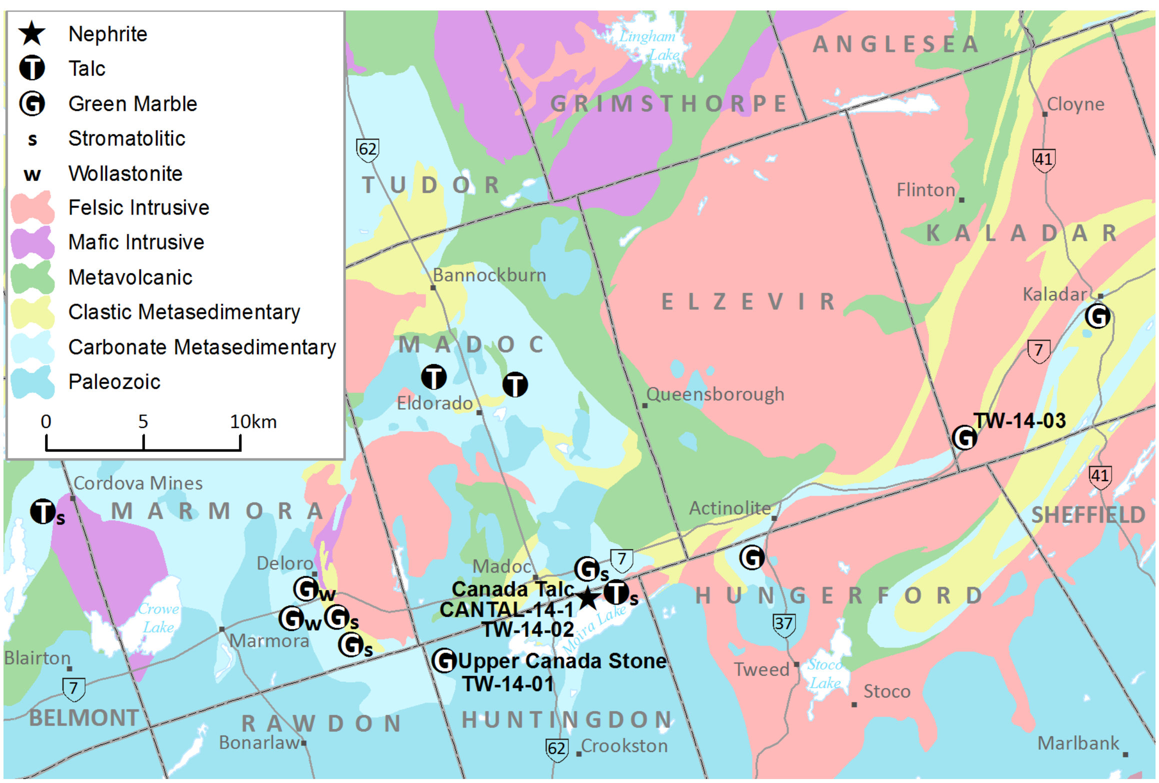

Figure 1. Geology of the Belmont–Kaladar area, showing the locations of the Canada Talc Mine nephrite occurrence, and occurrences of green marble and marble-hosted talc. Geology *from* Ontario Geological Survey (2011).

Nephrite Jade: Southeastern Ontario, *continued*

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HIGHLIGHTS

- **High-quality, crushed aggregate demand is increasing, particularly in southern Ontario.**
- **Use of trap rock for manufacturing mineral wool and continuous fiber is increasing. Southern Ontario has transportation and manufacturing infrastructure in place.**

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Trap Rock: Aggregate and Industrial Use in Southern Ontario

Trap rock is any dark, fine-grained, non-granitic intrusive or extrusive igneous rock, including basalt, peridotite, diabase and gabbro. Trap rock in southeastern Ontario has been quarried for 100 years. Historical use of trap rock was as construction aggregate and roofing material (mixed with pitch). More recent use of trap rock is for top-coat asphalt, roofing shingles, railway ballast, filter stone and rock wool production.

The projection for Ontario's consumption of aggregates is to average about 186 million tonnes per year over the next 20 years, 13% higher than in the past 20 years. Although crushed stone currently accounts for less than half of the primary aggregate consumed, the expectation is for demand to continue to increase over the next 20 years as new construction standards specify higher quality stone (Altus Group Economic Consulting 2010). For example, specifications for highways with speeds in excess of 80 km per hour, are for premium surface course mixes which provide adequate frictional resistance and resist rutting. These require 100% premium coarse and fine aggregates, such as crushed trap rock.

Projections for the mineral wool market are 7.0% per year growth to 2019. There is increasing demand for mineral wool–based thermal and acoustic insulation in the residential and commercial buildings and demand for heat insulation for the industrial applications (Markets and Markets 2015). The primary ingredient in mineral wool is trap rock, generally basalt, diabase or gabbro, which is blended with other materials such as anorthosite, limestone, dolostone and slag. In some cases, higher magnesium content of the trap rock may eliminate the need for some of the additional ingredients. A high magnesium gabbro quarried in Elzevir Township, southern Ontario, has been successfully tested in the production of rock wool and the quarry (Danford Granite Ltd., Bridgewater Quarry) is expected to begin full production in 2016 (A. Danford, Danford Granite Ltd., personal communication, 2015). Other uses of mineral wool are resin-bonded panels; as filler in compounds for gaskets, brake pads and plastics in the automotive industry; as an additive to asphalt; as a filtering medium, and as a growth medium in hydroponics.

Continuous basalt fiber is also produced by melting trap rock, but, unlike mineral wool, the extruded material forms continuous strands that can be woven or compressedvv into various products, such as cloth, reinforcing mesh, chopped fiber and reinforcing bars. About 80% of the total basalt fiber demand in 2014 was from building construction, automobile and wind energy industries, generally in applications requiring high-temperature resistance, chemical resistance, durability, mechanical strength and low water absorption. The global basalt fiber market has experienced significant growth in the past few years and is expected to continue to grow at 13.1% annually between 2015 and 2020 (Research and Markets 2015).

Trap Rock: Southern Ontario, *continued*

Figure 1 illustrates the locations of the current trap rock producers in southern Ontario:

- MRT Aggregates Inc. quarries gabbro for use as highway construction aggregate and railway ballast;
- I.K.O. Industries Ltd. produces granules for production of roofing shingles from andesitic rock;
- Drain Bros. Excavating Inc. quarries basalt for use as roofing granules, highway construction aggregate, railway ballast and rock wool production;
- Danford Granite Ltd. quarries both a high-iron gabbro for road aggregate and railway ballast and high-magnesium gabbro for rock wool production.

The well-exposed mafic metavolcanic rocks in the south-central part of the Central Metasedimentary Belt, between Peterborough and Kaladar, as well as the mafic intrusive rocks found throughout the Central Metasedimentary Belt are worth further examination as potential trap rock sources. The extensive road network, as well as access to rail lines and deep-water ports, makes Southern Ontario attractive for additional trap rock extraction.

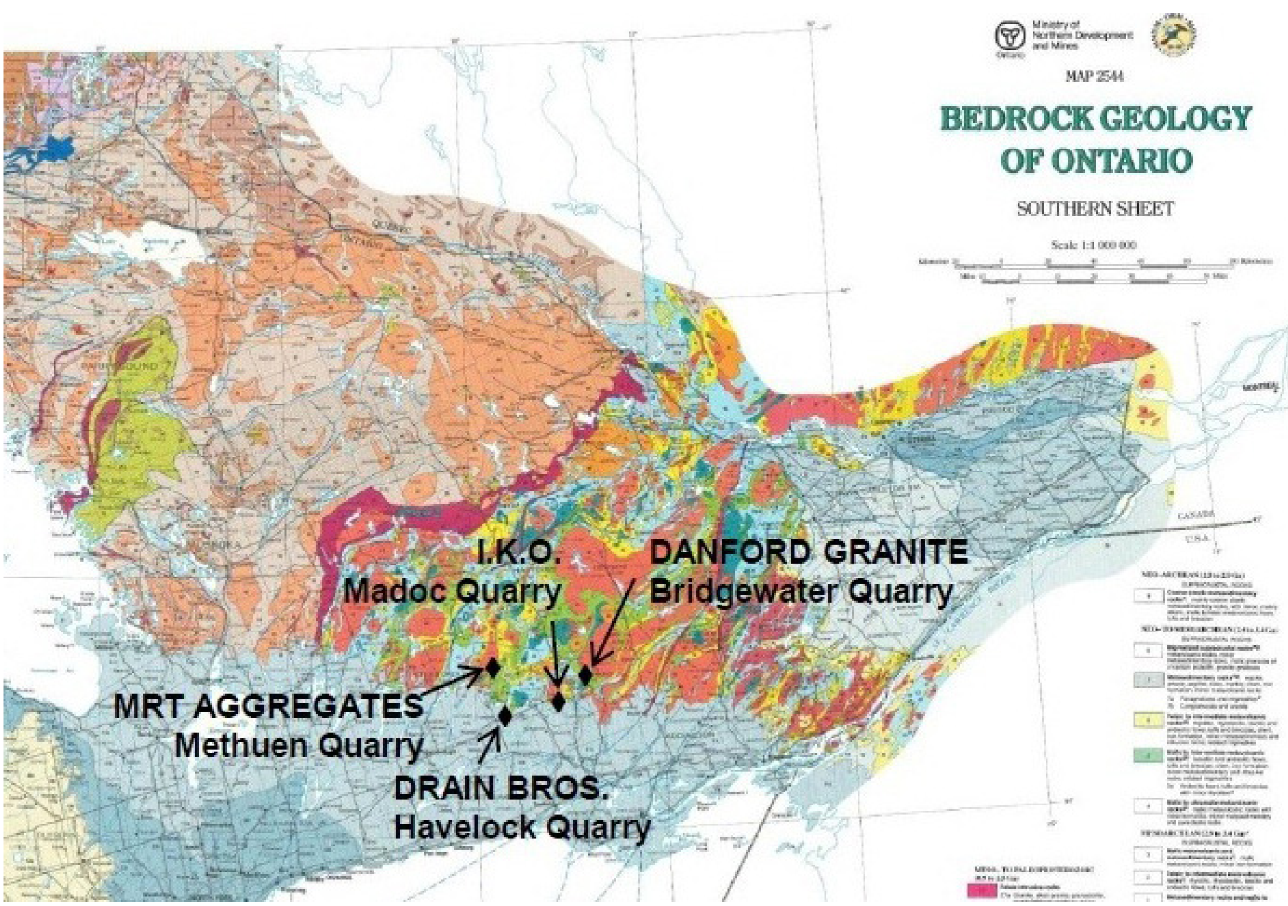

Figure 1. Locations of southern Ontario trap rock quarries (geology *from* Ontario Geological Survey 1991).

Trap Rock: Southern Ontario, *continued*

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Notes

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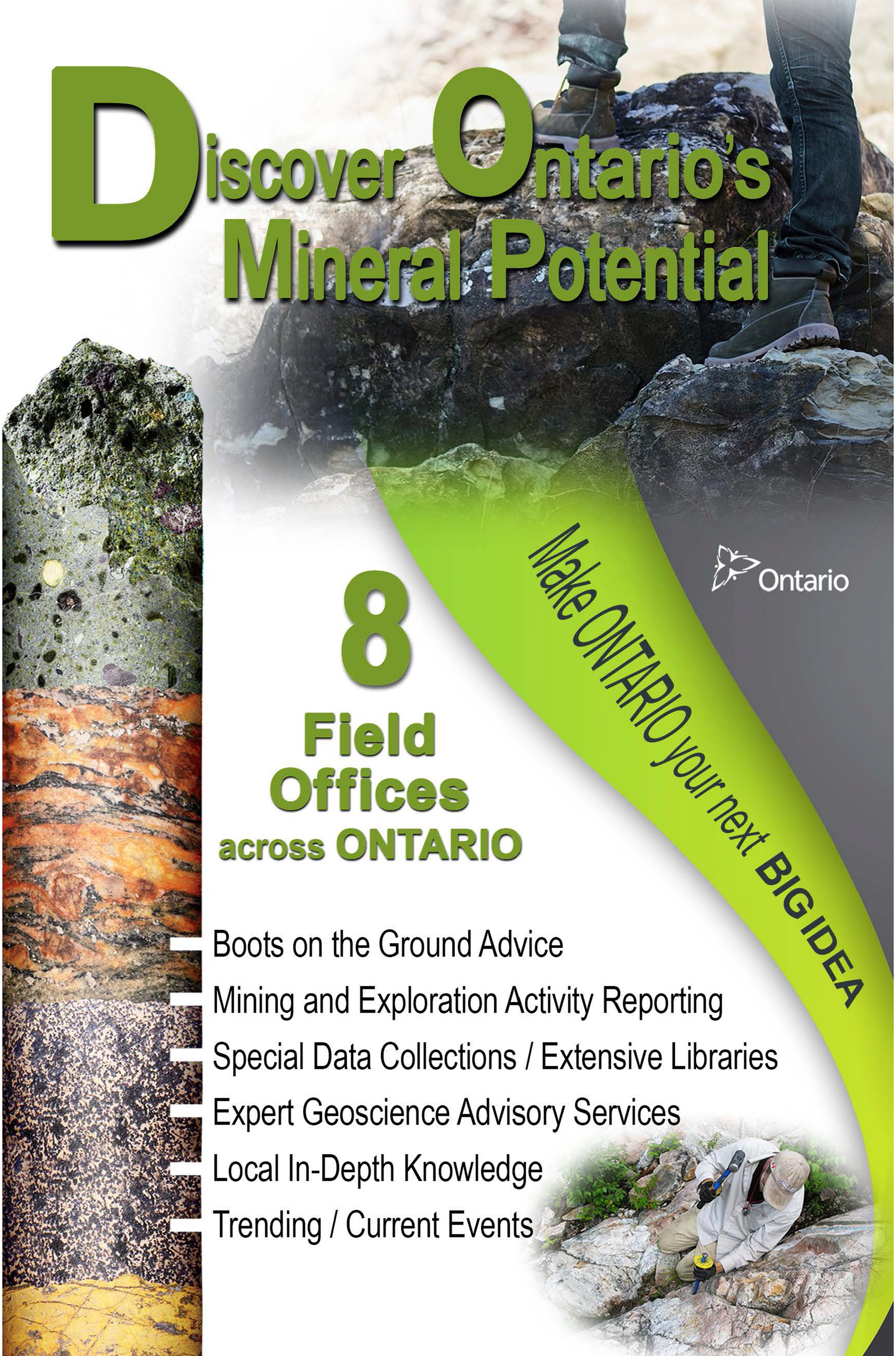
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