Current Research (2019) Newfoundland and Labrador Department of Natural Resources
Geological Survey, Report 19-1, pages 187-210

2017 RECONNAISSANCE TILL-INDICATOR MINERAL AND GLACIAL MAPPING STUDY, HOPEDALE BLOCK, NTS MAP AREAS 13N AND 13M, LABRADOR

H.E. Campbell, M.B. McClenaghan[1], H.A.I. Sandeman[2] and A. Hinchey[3]
Terrain Sciences and Geoscience Data Management Section
[1]Geochemistry Section, Geological Survey of Canada, 601 Booth Street, Ottawa, K1A 0E8
[2]Mineral Deposits Section
[3]Regional Mapping Section

ABSTRACT

In July 2017, a reconnaissance till-indicator mineral, till-geochemistry and glacial mapping study was initiated in the Hopedale Block, Labrador, to test the application of indicator minerals (IM) for tracing mineralization sources. This study is part of a larger collaborative project between the Geological Survey of Canada (GSC) under its Geomapping for Energy and Minerals (GEM) Program, the Geological Survey of Newfoundland and Labrador (GSNL) and the Nunatsiavut Government, to better understand the geology and mineral potential of the Hopedale Block.

*The surficial geology north and west of the Hunt and Adlatok rivers consists of thin (less than 2 m) but continuous till veneer on hilltops, with ridged moraine and ice-contact sediments in valleys. South of the Hunt River, there is discontinuous till distribution on hilltops, and postglacial marine and fluvial sedimentation in the Adlatok River valley. Preliminary results from striations and other ice-flow indicators suggest an east-northeast ice-flow, with a (more localized?) east-southeast flow. Preliminary surficial mapping conducted in the in the Sarah Lake area (eastern portion of NTS map area 13M), revealed crescentic ribbed and disintegration moraine, and ice-proximal glaciofluvial deposits bounded by west–east-oriented streamlined landforms (*e.g., *crag-and-tails). The orientation of the streamlined landforms and moraines suggest that a west–east-flowing ice mass was blocked, with east-northeast and east-southeast deflection, and* in-situ *melting of the remnant ice. In this area, early deposited till has been re-entrained and eroded, and results of till-geochemical sampling programs may reflect this.*

Eight 15–21 kg till samples representing different bedrock types were sent for processing by tabling and heavy-liquid separation to recover the heavy-mineral fraction for gold and indicator mineral grain counts, including kimberlite (KIM) and metamorphic and massive sulphide indicator (MMSIM) minerals. The results of the indicator mineral examinations have already been presented in Open File LAB/1743; the current contribution explains these results as they relate to the bedrock and mineral occurrences proximal to sample sites.

*Grain counts revealed gold, and the metamorphic and massive sulphide indicator minerals galena, chalcopyrite, molybdenite and scheelite in till concentrates. Non-ore bearing MMSIM's (*e.g., *apatite, red rutile) were also found. No KIM's were observed. Gold grains were recovered from four of the IM samples, including two samples taken in till overlying or dispersed from known occurrences. The source of the gold in the other two samples is unknown; however, IM assemblages suggest that there may be unrecognized sources of Aucoin-type (orogenic) and porphyry or skarn Cu–Au–Mo mineralization up-ice of, or underlying, the locations of the till samples.*

These results demonstrate the potential of using IM in tills to characterize bedrock mineral assemblages and detect the responses to known and unknown mineralization. In addition, the till IM results, coupled with the newly acquired airborne magnetic data, assisted in identifying prospective localities for the 2018 sampling program. Till IM sampling, in conjunction with traditional till geochemistry and pebble-lithology indicator studies, is suggested for future work in map area 13M.

INTRODUCTION

This surficial study was initiated in July 2017 under the Geological Survey of Canada's Geomapping for Energy and Minerals (GEM) Program in collaboration with the Geological Survey of Newfoundland and Labrador (GSNL) and the Nunatsiavut Government. The objectives of the GEM project in Labrador are outlined by Corrigan *et al.* (2018). The goals of this reconnaissance surficial study are to test the efficacy of indicator mineral (IM) methods to identify mineral assemblages that are characteristic of mineralization and bedrock in the region.

Fieldwork for this study was conducted, concurrently with a bedrock-geological mapping, sampling and geochronology program. Sample sites were chosen for their bedrock geological significance. Till samples were collected from till veneer and mudboils, proximal to bedrock outcrop. Eight bulk till samples (15–21 kg) were collected for IM analysis, along with smaller 3–5 kg till samples for matrix geochemical analysis, and pebbles for coarse clast analysis. The samples were collected using GEM Program procedures (*see* Spirito *et al.*, 2011 and McClenaghan *et al.*, 2013). The IM results are published in Department of Natural Resources, Geological Survey of Newfoundland and Labrador, Open File LAB/1743 (Campbell and McClenaghan, 2019).

LOCATION

The study area is remote, accessible only by helicopter, and located west of the coastal community of Hopedale. Vale Canada Inc.'s Voisey's Bay Ni–Cu–Co mine is located 110 km north of the study area, west of the community of Nain. The area of study encompasses Big Bay in the northeast (Figure 1), to Ugjoktok Bay to the southeast and extends to the Harp Lake Complex in the southwest and Pants Lake in the northwest.

PHYSIOGRAPHY

The northern part of the study area is characterized by bedrock ridges with moderate till cover, and broad, glacially sculpted valleys that drain toward the coast from a high plain west of Sarah Lake and Harp Lake (Figure 1). The highlands east of Sarah Lake and north of Hunt Lake are underlain by resistant plutonic bedrock of the Nain Plutonic Suite and the Flowers River intrusive suite. Southwest of Sarah Lake, the uplands of the Harp Lake Complex are characterized by sparse glacial cover and vegetation, and incised by deep valleys, with Harp Lake itself occupying the most prominent of these (Lopoukhine *et al.*, 1977). South and west of Hunt Lake, forested ridges and lowlands have been burned over, exposing boulders, sand and till. Toward the coast, ridges have commonly been scoured by glacial erosion and washed by marine inundation and thus are only sparsely covered by drift. Valleys, particularly those that drain into Big Bay and Flowers Bay to the northeast of the study area, are filled with glaciofluvial and glaciomarine sediment. Modern fluvial systems, including the Hunt and Adlatok rivers, are incised through glacial fluvial and marine sediments, and drain into Big Bay and Ugjoktok Bay, respectively.

REGIONAL BEDROCK GEOLOGY AND MINERALIZATION

The following is a brief summary of the regional bedrock geology of the study area. For a more detailed overview of the regional geology, the reader is referred to: Kranck (1953); Christie *et al.* (1953); Douglas (1953); Jesseau (1976); Taylor (1971, 1977); Ermanovics (1979, 1980, 1981a, 1993); Ermanovics and Korstgard (1981); Ermanovics and Raudsepp (1979); Grant *et al.* (1983); Thomas and Morrison (1991); Hill (1982a, b, c); Bertrand *et al.* (1993); Miller (1994); Wasteneys *et al.* (1996); Connelly and Ryan (1996); James (1997a, b); James *et al.* (1996, 2002) and Ermanovics and van Kranendonk (1998). In addition, a more detailed account of the objectives and preliminary results of the bedrock part of the GEM II 2018 Hopedale study can be found in Corrigan *et al.* (2018). Figure 2 illustrates the simplified bedrock geology of the region (Wardle *et al.*, 1997).

The Hopedale Block is part of the southwestern North Atlantic craton (James *et al.*, 2002), and is located in the southern part of the Nain Province (Stockwell, 1963; Taylor, 1971). It is bounded by Paleoproterozoic orogens on three sides; Makkovik to the southeast, Torngat to the west and Nagssugtoqidian to the northeast (James *et al.*, 2002). The western part of the study area straddles the inferred boundary between the Saglek and Hopedale blocks of the Nain craton and the Nain–Churchill boundary, as marked by the Torngat orogeny (Connelly and Ryan, 1996; James *et al.*, 2002). These boundaries are obscured by abundant Paleoproterozoic intrusions.

Bedrock geology from west to east across the Nain–Churchill boundary is summarized as follows. Paleoproterozoic gneisses of the southeastern Churchill Province (*i.e.*, Tassiuyak gneiss: Wardle, 1983) outcrop to the west and are structurally interleaved along the western boundary of the study area with a sequence of presumed Paleoproterozoic mafic volcanic, volcaniclastic and clastic sedimentary rocks of the Ingrid group (Ermanovics, 1993). East of the Ingrid group, at Ingrid Lake and extending to the coast, Mesoarchean tonalitic to granodioritic, migmatitic orthogneiss of the Hopedale Block (Maggo gneiss) contains

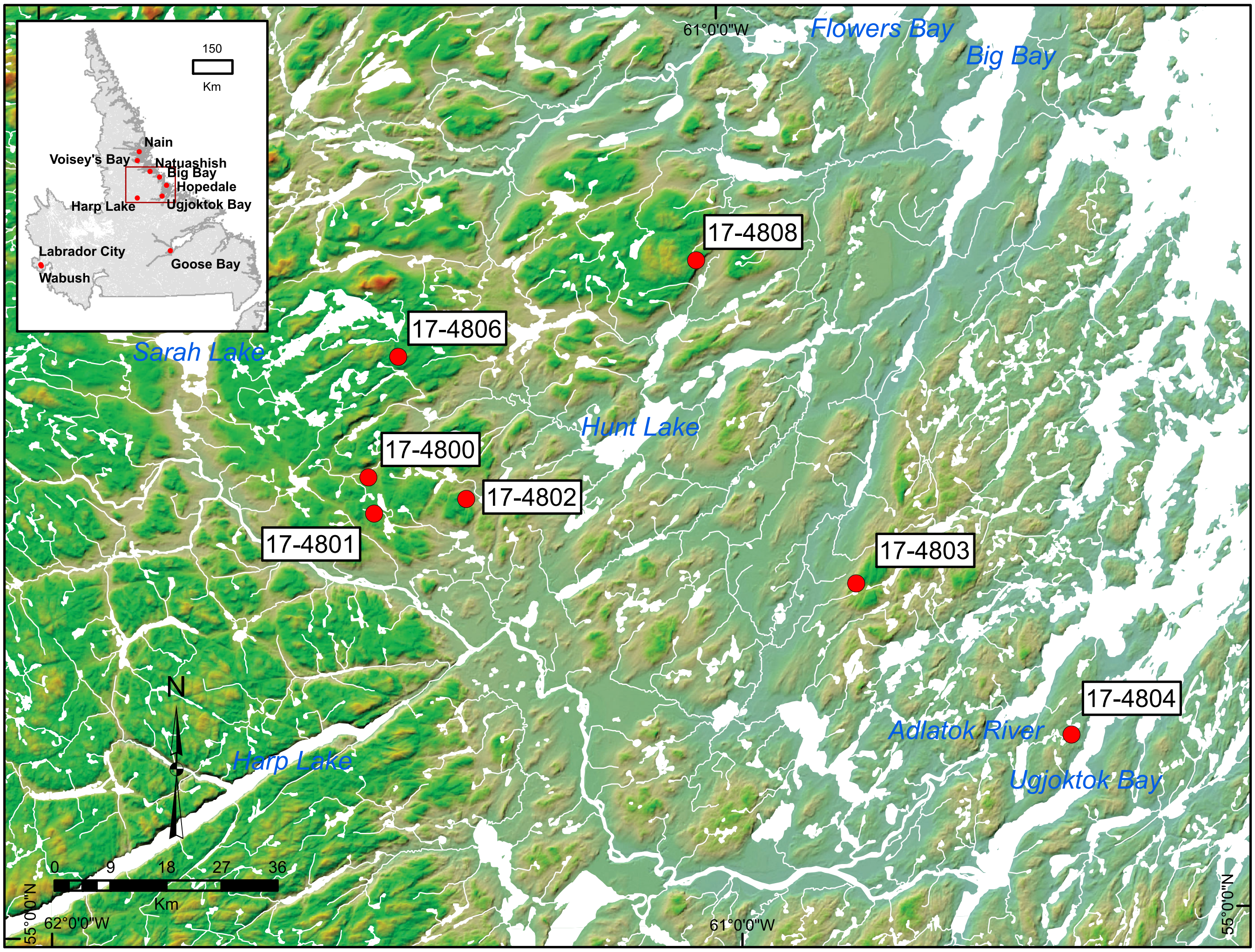

Figure 1. *Shaded-elevation map of the study area. Lighter coloured areas indicate highlands, darker indicate lowlands. Large lakes in the west (Harp and Sarah lakes) drain into the Ugjoktok River, which drains into Ugjoktok Bay. Hunt Lake drains into Hunt River, which drains into Big Bay. Red dots mark the locations of 2017 sample sites.*

widespread supracrustal remnants of the *ca.* 3.0 Ga Hunt River (volcanic) belt and Weekes amphibolite (Ermanovics, 1981b, 1993; James *et al.*, 2002). Remnants of the Hunt River (volcanic belt) and Weekes amphibolite are collectively intruded by the Mesoarchean granodioritic Kanariktok intrusive suite. An unusual assemblage of late Neoarchean syenite, monzodiorite and monzogabbro is also recognized in the western part of the study area, immediately east of the Ingrid group and around the Aucoin Au–Ag–Pb–Te prospect (Sandeman and Rafuse, 2011; Sandeman and McNicoll, 2015).

In the northwest and north, the Archean rocks are cut by the Mesoproterozoic Nain Plutonic Suite (NPS; Ryan and James, 2004) and the Flowers River igneous suite (Hill, 1982a, b, c; Krogh, 1993). The Flowers River igneous suite occurs as a series of nested calderas in the north of the study area. Mesoproterozoic anorthositic rocks of the Harp Lake Complex (Emslie, 1980) outcrop to the south and southwest. The Paleoproterozoic Kikkertavik dykes and Mesoproterozoic Harp Lake and Kokkorvik dykes (Ermanovics, 1993; Cadman *et al.*, 1993; Sparkes *et al.*, 2010) are found throughout the study area.

Significant mineralization in the area includes (from west to east):

- magmatic Ni–Cu–Co sulphide mineralization related to the Mesoproterozoic Pants Lake intrusions (Kerr, 2012);
- Paleoproterozoic orogenic-style, quartz-vein-related gold mineralization hosted by Neoarchean alkaline rocks at the Aucoin prospect (Sandeman and Rafuse, 2011; Sandeman and McNicoll, 2015);

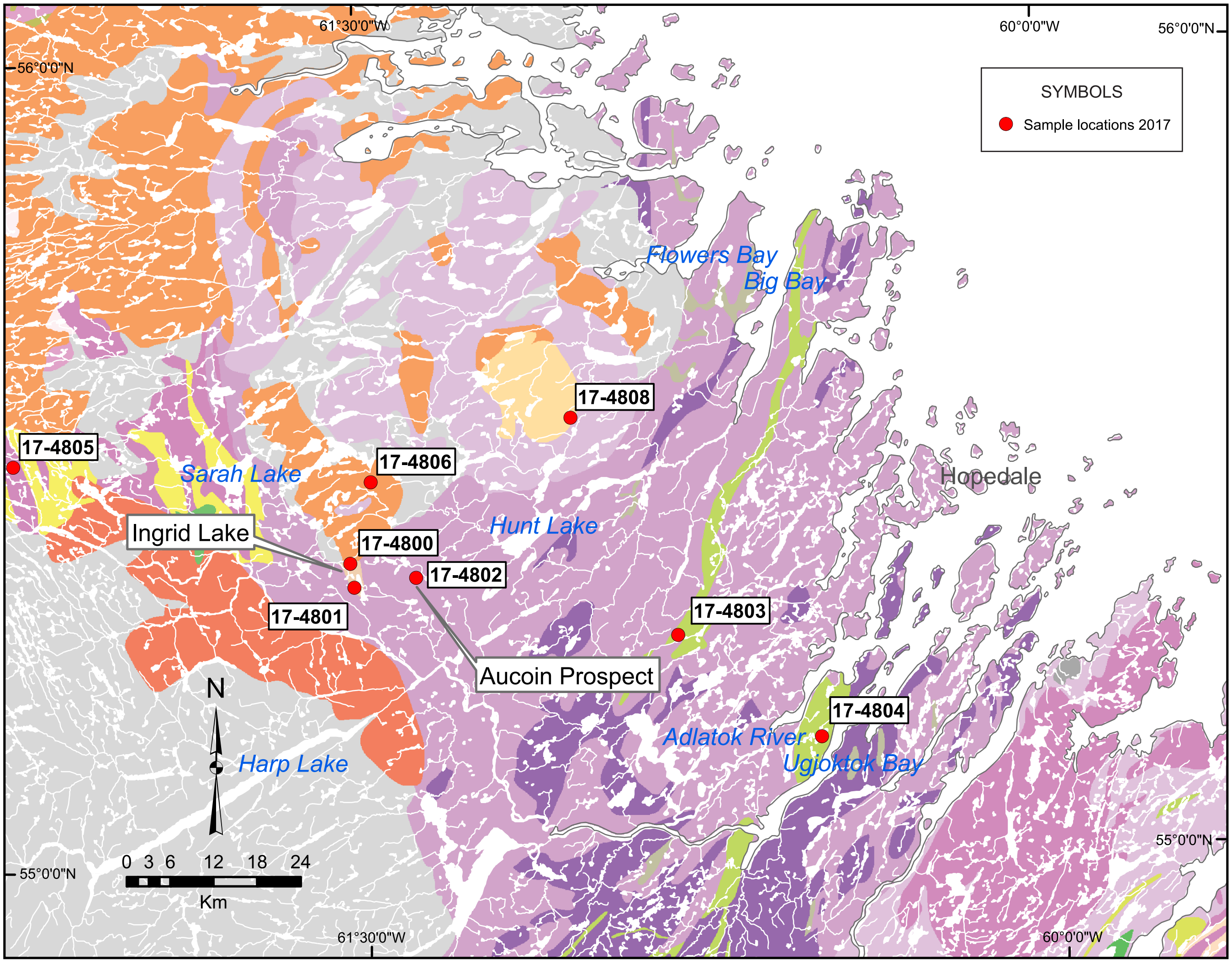

Figure 2. *Geology of the Hopedale Block (from Wardle* et al.*, 1997) showing the locations of 2017 samples collected for this study and the location of the Aucoin prospect.*

- rare-metal and rare-earth-element (RM-REE) mineralization in the Mesoproterozoic volcanic rocks of the Flowers River igneous suite (Kerr, 2011); and
- Ni–Cu and Au mineralization in the Hunt River and Florence Lake greenstone belts (James *et al.*, 1996).

GLACIAL GEOLOGY

Glacial sediments and landforms of the Hopedale area were mapped as part of the Geological Survey of Canada's 1:250 000 series maps, from airphotos and helicopter mapping traverses (Fulton *et al.*, 1974); these data were later compiled and assimilated into GSC Map 1814A (Klassen *et al.*, 1992). This map indicates areas of marine incursion in the Adlatok River valley, with terraces in Big Bay and Flowers Bay. Aggregate mapping by Ricketts (1984, 1988, 2011a, b) confirms the presence of marine terraces in the Big Bay area (Figure 2). Abundant glaciofluvial material was noted from Sarah Lake, toward Ugjoktok Bay (*ibid.*) with almost 100% rock outcrop nearer the coast.

Glacial-flow indicator mapping and till sampling (Klassen and Bolduc, 1986), illustrate ice-flow trends of 055° over the Hunt River belt, changing to 085° west of the Flowers River igneous suite and generally eastward in the western part of the study area. Till samples from that study were collected at a density of 1 per 5 km^2 to 1 per 10 km^2, with sample density greatest in tills overlying the Flowers River Igneous Suite, the results of which are discussed by Klassen and Knight (1995).

More detailed mapping (1:50 000), based on aerial photographs with ground-checking, was undertaken by Batterson (1995, 1996, 1999, 2000a–d) of NTS map areas 13N/01/02/03 and 06/07 (Figure 3) as part of a till-geochemistry, boulder tracing and surficial mapping program in

LEGEND

MESOPROTEROZOIC

Grenville Province

M3a Anorthosite and other, locally layered, mafic rocks

MIDDLE MESOPROTEROZOIC

Grenville, Southeastern Churchill and Nain provinces

M2pg Peralkaline granite and syenite intrusions locally with ring structure
M2pv Peralkaline felsic volcanic rocks
M2g Granitoid rocks, including rapakivi varieties
M2a Anorthositic rocks
M2mga Intermediate rocks, chiefly ferrodiorite

EARLY MESOPROTEROZOIC

Grenville and Southeastern Churchill provinces

M1g Granitoid rocks
M1a Anorthosite and other, locally layered, mafic rocks

MIDDLE PALEOPROTEROZOIC

Southeastern Churchill, Makkovik, Nain and Grenville provinces

P2mfv Basalt, andesite, dacite and conglomerate
P2fv Rhyolite, ash-flow tuff, breccia and hypabyssal rhyolite intrusions; volcaniclastic siltstone and sandstone; minor basalt
P2g Granite and granodiorite
P2mva Schistose amphibolite derived from mafic volcanic rocks
P2ga Gabbro and leucogabbro sills
P2sgn Pelitic metasedimentary gneiss, minor marble and calc-silicate rock

ARCHEAN AND/OR PALEOPROTEROZOIC

Southeastern Churchill province

A-Pggn Granitic gneiss
A-Ptgn Tonalitic to granodioritic migmatitic gneisses containing abundant mafic to ultramafic inclusions and relict mafic dykes
A-Psgn Pelitic gneiss, minor marble and calc-silicate rock

ARCHEAN

Southeast Churchill and Makkovik provinces

Aa Anorthosite and leucogabbro rocks

Meso-Archean Southern Nain (Hopedale block) and Makkovik Provinces

AMrgn Tonalitic and other gneisses reworked and retrograded during Makkovikian orogenesis
AMgd Granodiorite, tonalite and minor granite
AMmv Mafic volcanic and volcaniclastic rocks, lesser sedimentary and felsic volcanic rocks, and mafic-ultramafic sills; at greenschist to amphibolite facies
AMtgn Tonalitic to granodioritic migmatitic orthogneiss containing abundant mafic to ultramafic inclusions and relict mafic dykes
AMmgn Mafic gneisses including rocks of intrusive and extrusive origin

Legend for Figure 2.

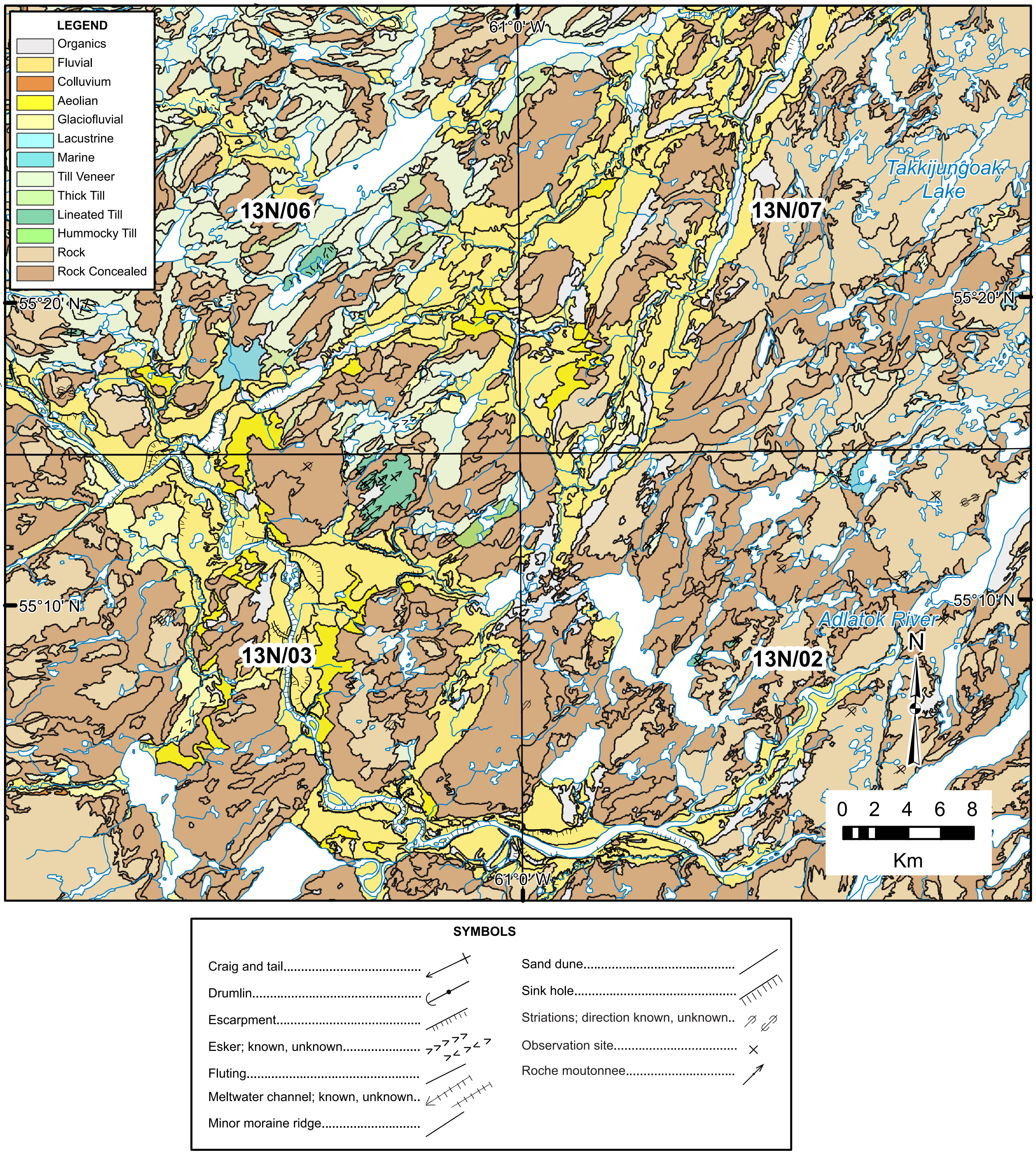

Figure 3. *1:50 000 surficial maps (Batterson, 1999, 2000a–d) of part of NTS map areas 13N/02, 03 and 13N/06, 07. The marine terrace referred to in the text is represented by a blue polygon in the south-central part of NTS 13N/06. Remnants of glaciofluvial material (tan) are noted west of the Adlatok River valley in NTS 13N/03, with major fluvial (mustard yellow) and minor aeolian (bright yellow) deposits noted in present-day river valleys. Bedrock (dark brown) and organically concealed bedrock (light brown) units comprise most of the map, with isolated till ridges (dark green) and till hummocks (lime green) and till veneer (light green) located in the northwestern corner of NTS 13N/06. Isostatic depression resulting from glaciation, and the subsequent melting of glaciers, resulted in marine incursion, and subsequent deposition of the marine terrace, 125 m asl and 50 km from the present-day coast.*

the Florence Lake belt. The conclusions from the above studies include: 1) the southern Hopedale Block, south of the Adlatok River, was ice-covered through the late Wisconsinan, with ice-flow direction to the northeast to east-northeast (035–075°), and minor ice-flow deflection into valleys; 2) isostatically depressed areas underwent marine transgression and were covered by marine sediments up to a maximum of 125 m asl immediately following deglaciation (~8000 Ka), as observed in a marine delta 50 km west of the current coastline in the Adlatok River valley; and, 3) sediments were modified by fluvial processes during rapid relative sea-level fall, as observed by terraced sediments in the Adlatok River valley. This suggests that elevations below 125 m, with the exception of areas that remained ice-covered (*i.e.*, Florence Lake, in the current study area), are unsuitable for geochemical and indicator mineral sampling, as any glacial material below this elevation would have been modified by marine processes (*ibid.*).

INDICATOR MINERALS

Indicator minerals (IM) are defined, in the current study, as those minerals that are specific to a certain mineral deposit type, alteration style, or bedrock lithology. They are ideal in identifying dispersion from mineralization, as mineral grain identification is independent of the bulk sample concentration, and is not diluted by non-IM material (Averill, 2001). In contrast, traditional geochemical methods, involving the digestion of mineralized and non-mineralized components of the silt and clay fraction of the surficial material, may cause the signature of minute particles of mineralized material to be diluted. Also, certain indicator mineral grains (*e.g.*, gahnite) are deposit-type characteristic and therefore, can assist in detecting dispersal patterns from the inferred bedrock source (*ibid.*).

Indicator mineral sampling has been shown to be effective across Canada in different terrains, including the mountains of the western Cordillera (*e.g.*, Hashmi *et al.*, 2015; Plouffe *et al.*, 2016), the plains of the Western Canada Sedimentary Basin (Paulen *et al.*, 2011; Oviatt *et al.*, 2015), Arctic regions underlain by the Canadian Shield (*e.g.*, McClenaghan *et al.*, 2015), the boreal forest of the central Canadian Shield (*e.g.*, Barnett and Averill, 2010) and the eastern Canadian Shield (*e.g.*, McClenaghan *et al.*, 2014, 2017a). Earlier IM work in Labrador includes a KIM study (Ryan and McConnell, 1995; McConnell and Ryan, 1996) focusing on assessing the potential for diamonds in the Saglek, Hopedale and Makkovik blocks. Two recent studies have been conducted in Newfoundland and Labrador by the GSNL, including a KIM study of eskers in western Labrador (Brushett and Amor, 2013) and a study in tills over and down-ice of the Pipestone Pond Complex in central Newfoundland (Brushett and Amor, 2016). The results of these studies demonstrate that IM sampling can detect dispersed bedrock and mineralization signatures in a variety of different glacial materials.

Common sulphide IM include base-metal-bearing minerals such as pyrite, chalcopyrite, galena and sphalerite, native precious metals and alloys, and more exotic, radioactive or rare earth element-bearing phases. Non-sulphide indicators include KIM such as Cr-diopside, Cr-pyrope, eclogitic garnet, Mg-ilmenite, Cr-spinel (chromite) and diamond itself, whereas other non-ore-bearing KIM include rutile, apatite, enstatite, and olivine (*see* McClenaghan and Paulen, 2017 and references therein for a more complete list of indicator minerals). Many of the non-sulphide indicator minerals listed above (*e.g.*, apatite and rutile) can occur in a variety of geological environments and are not diagnostic of a specific deposit type. However, trace-element analysis of apatite, and subsequent discriminant analysis can indicate whether the source is barren or potentially represented by porphyry, skarn, or iron-ore–copper–gold-related mineralization (Mao *et al.*, 2016). Similarly, rutile forms in a number of geological environments, but is a common alteration mineral in gold-mineralized rocks, and trace-element analysis can assist in identifying specific mineral sources (Clark and Williams-Jones, 2004).

METHODS

MAPPING

Preliminary mapping was conducted using helicopter traverses and satellite imagery. Twenty-two striation measurements were recorded from bedrock outcrops, to determine ice-flow directions. The results of these investigations, along with airphoto interpretation, detailed and targeted IM, till sampling and surficial materials, and bedrock observations will be integrated into a comprehensive contribution at a later date.

INDICATOR MINERAL SAMPLING

The sample sites were chosen to reflect the varied bedrock environments within the Hopedale Block. Eight bulk till samples were collected, along with smaller samples for till-geochemistry and pebble-lithology identification (Figure 2). Results of the till-geochemistry and pebble-lithology study are not yet available. Indicator mineral results of bulk till samples have been released in Open File LAB 1743 (Campbell and McClenaghan, 2019).

The till samples were collected from till veneer and mudboils, and placed in large (15–21 kg) bags, using GEM Program protocols (Spirito *et al.*, 2011 and McClenaghan *et al.*, 2013). The bags were taped, bagged again and re-taped to prevent tearing and spillage during transport, and put into buckets for shipment to St. John's and subsequently to Overburden Drilling Management Limited (ODM) in Ottawa, Ontario, for indicator mineral processing. Two GSC in-house heavy mineral "Bathurst blanks" (samples 17-4809 and 17-4810) were inserted in the analytical batch to monitor contamination. These blanks were collected from a weathered Silurian–Devonian granite "grus" from the South Nepisiguit River Plutonic Suite 66 km west of Bathurst, New Brunswick (Wilson, 2007), and consist of little to no indicator mineral or gold content (Plouffe *et al.*, 2013). At ODM, the samples were processed using a combination of tabling, panning and heavy liquid separation in methylene iodide (SG 3.2). All samples were panned for gold, platinum-group minerals and fine-grained indicator minerals. The samples were processed following procedures described McClenaghan *et al.* (2017b) and Plouffe *et al.* (2013).

RESULTS

MAPPING

General glacial ice-flow patterns can be discerned from satellite imagery (Figure 4). The west–east orientation of streamlined land forms west of Sarah Lake changes to ~070° northeast of and ~120° southeast of Sarah Lake. A series of ridges (rogen moraine?) are discernible in satellite imagery, south of Sarah Lake (Figure 4).

Striation directions measured in 2017 range from 054–094°, and indicate similar trends of those reported by

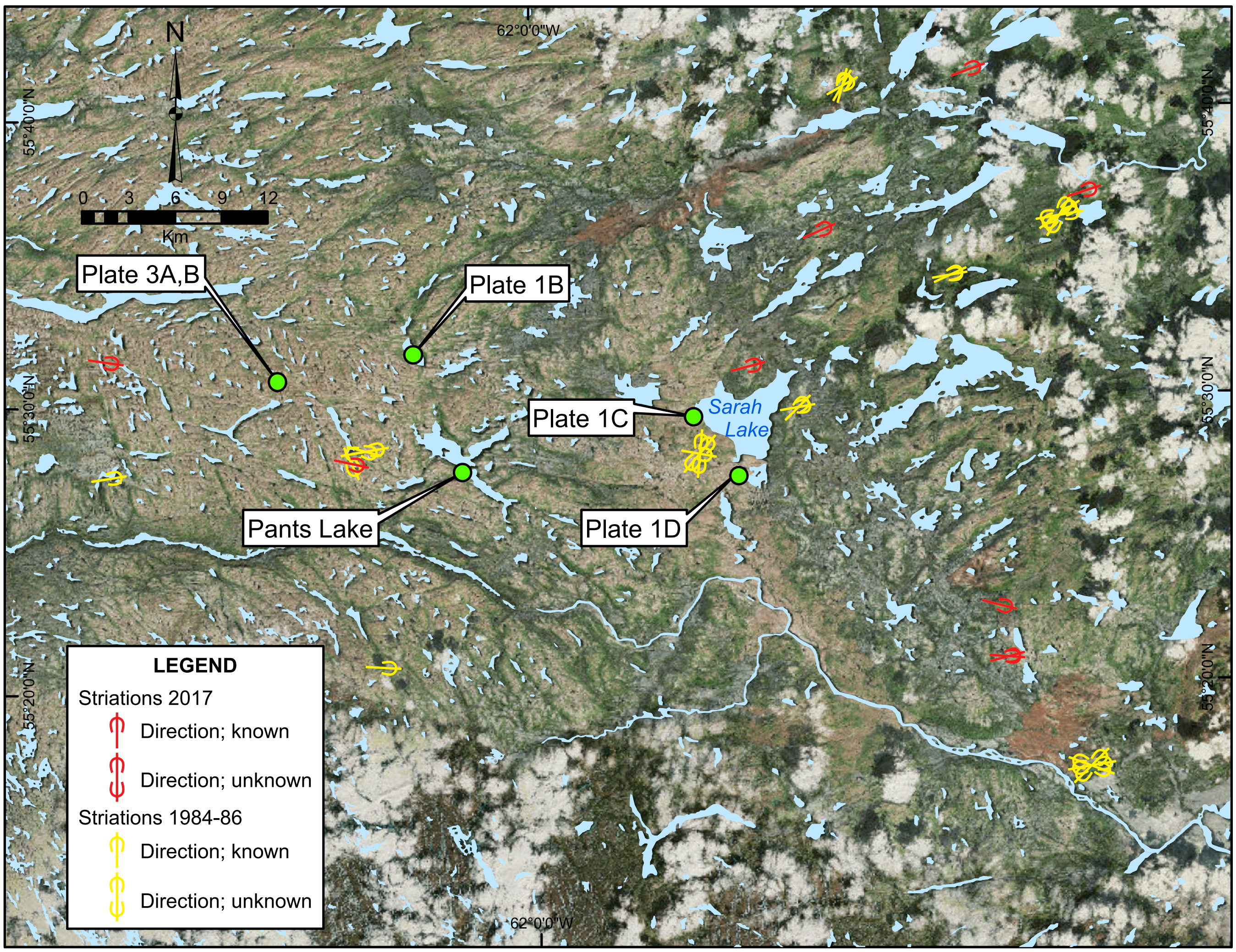

Figure 4. *Satellite image (Source: ESRI, Digital Globe, GeoEye, Earthstar Geocgraphics, CNES Airbus DS, USDA, USGS, AeroGRID) of the Sarah Lake region. Red striation indicators show measurements taken in 2017; yellow striation indicators show measurements taken in 1984–1986 by Klassen and Bolduc (1986). Ridged moraines are visible south of Sarah Lake, with glaciofluvial and fluvial sediments observed along the Adlatok river valley.*

Klassen and Bolduc (1986). A striation measurement of 154° was recorded in a valley at the extreme west of the study area, and may reflect local deflection of ice toward lower elevations (*see* Batterson *et al.*, 1987).

To the west, near the Québec–Labrador border and south of Mistastin Lake (Plate 1A), disintegration moraines, eskers and glaciofluvial material are abundant. Large-scale landforms northwest of Pants Lake indicate eastward flow (Figure 4; Plate 1B), whereas streamlined landforms and striation measurement west of Sarah Lake demonstrate that west- to east-flowing ice was redirected to the east-northeast and to the east-southeast.

Massive, hummocky boulder-strewn terrane (interpreted as moraine), boulder ridges, ribbed moraine, streamlined landforms, and minor glaciofluvial material are variably distributed in a ~200 km^2 area west of, and at, Sarah Lake, and to the south, toward the Adlatok River valley. Channels and boulders, and round potholes mark the surface of the boulder fields. South of Sarah Lake, two different sets of ridges (crescentic (flow till?) ridges overprinting southeast-oriented ribbed (Rogen moraine) are preserved (Plate 1C). Small (less than 1 km^2) ice-contact glaciofluvial deposits and eskers occur between bedrock ridges to the north and east of Sarah Lake (not shown), with a larger, braided esker plain on the northwest shore of Sarah Lake (Plate 2). West-northwest to east-southeast and west–east flowing ice appears to have transposed ribbed till ridges (*see* Dunlop and Clark, 2006), into east-southeast and eastward-oriented streamlined landforms west of Sarah Lake (Figure 4, Plate 1D). Sinuous ridges, similar to those shown in Plate 1C, are present in the northwest and southwest corners of the lake, and overprint the streamlined ridges.

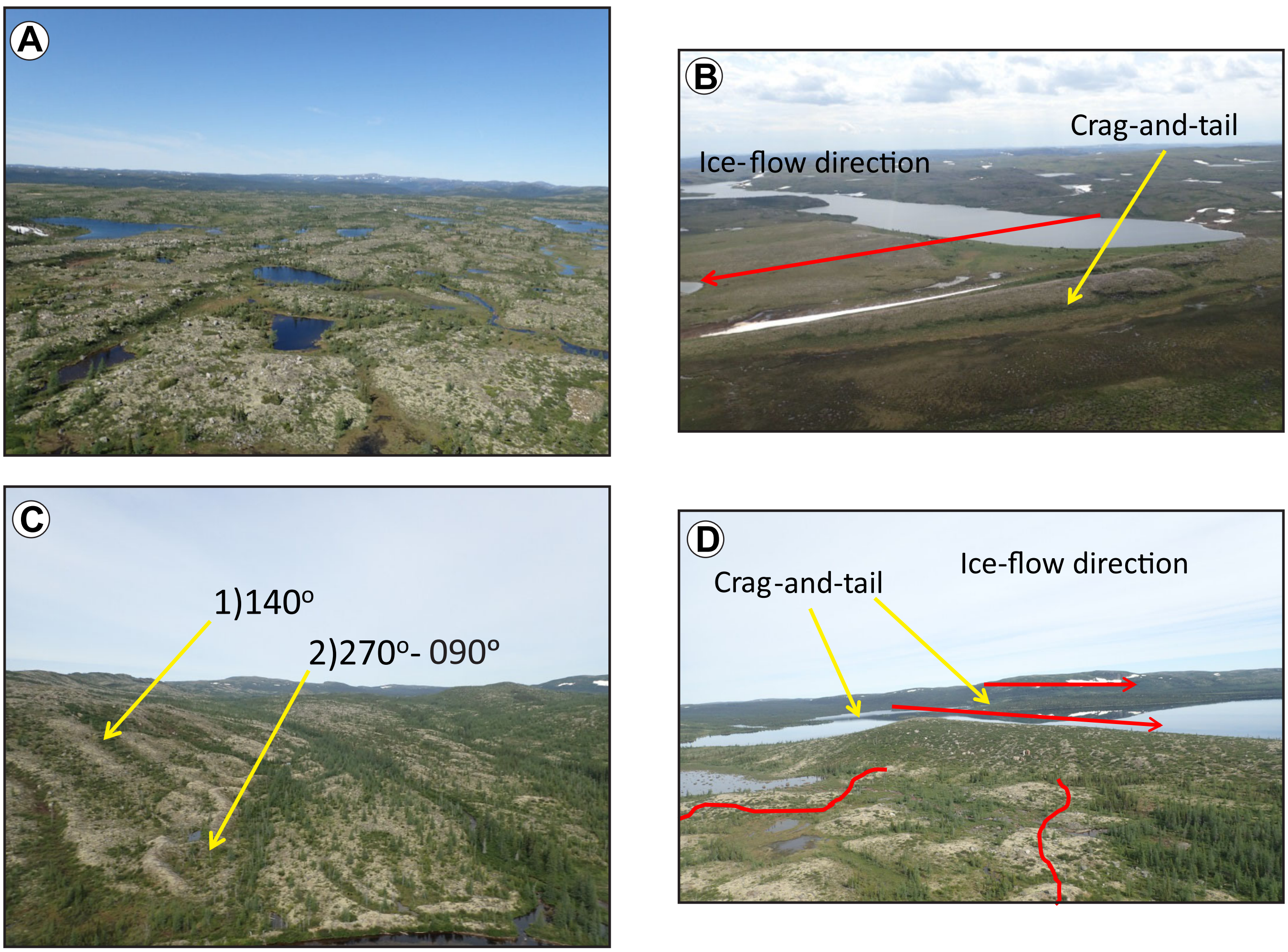

Plate 1. *A) Disintegration moraine west of the study area, 60 km east of the Québec border; B) Looking southwest over a west–east-trending crag-and-tail landform north of Pants Lake; C) sinuous linear ridges (Rogen moraine) oriented 140° overprinted by crescentic ridges on the northwest shore of Sarah Lake; D) Crag-and-tail landform overprinting? ribbed moraine (red sinuous lines) 4 km west of Sarah Lake.*

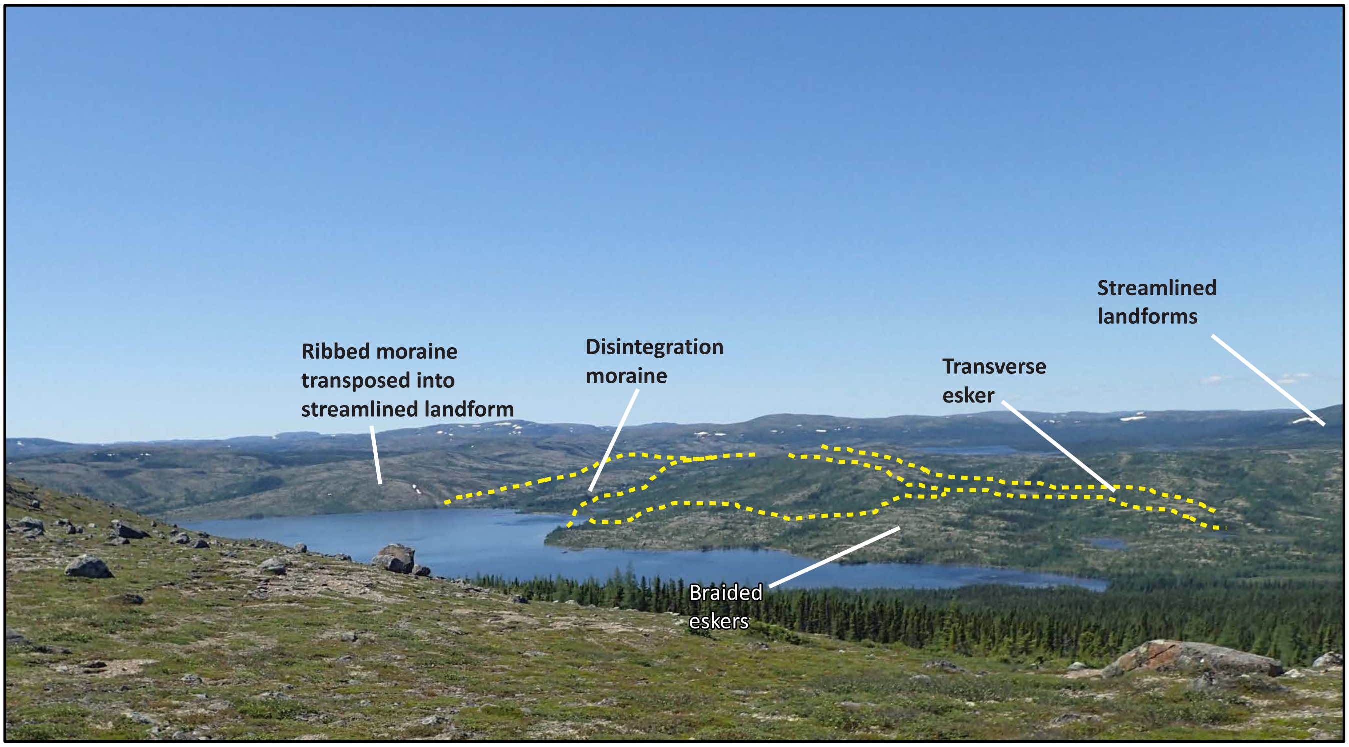

Plate 2. *Looking west over Sarah Lake at a glaciofluvial plain with braided eskers (foreground), ice-contact deposits, including ridges, and massive hummocky moraine (area between the dotted yellow lines), that overprint ribbed moraine (ridges in background).*

Glacially eroded valleys, interpreted to result from the onset of topographically confined glacial flow, begin at a plateau north of Ugjoktok River (Figure 4; Plate 3A), and continue eastward toward the coast (Plate 3B). These valleys have been locally covered by thick (>90 m) glaciofluvial, glaciomarine and fluvial deposits (Plate 3C). Glaciomarine deposits are also located at lower elevations (80 m asl) near the coast, 7 km east of Big Bay (Plate 3D).

In general, till is more abundant in the west of the study area, on hilltops and in valleys surrounding the Aucoin prospect and over the Ingrid Lake area, as well as near the Pants Lake Intrusive Suite (Figure 4). Local pockets of preserved till are located on hilltops south of Hunt Lake and southeast of Big Bay. Tills overlying the Hunt River belt consist of thin veneer (<2 m), giving way to exposed rock to the southeast.

INDICATOR MINERAL QA

In order to evaluate the quality of the data, the mineral grain counts for the two Bathurst blanks were examined and compared to published values (Plouffe, 2013; McClenaghan *et al.*, 2017b). The samples contained the same mineral assemblage as their underlying source (South River Plutonic Suite; *see* Plouffe *et al.*, 2007, page 308), containing no gold or indicator minerals, satisfactorily demonstrating that no cross-contamination occurred during the processing of the minerals.

SITE RESULTS

Site observations, from northwest of the study area to the southeast, with details of the local glacial environment and the IM summaries for the individual sites are described and tabulated below. Figures 1 and 2 show the location for each of the described sites.

Sample 17-4805: 10 km West of Pants Lake: 62°15’37”W, 55°30’17” (NAD27), Elevation = 539 m (Table 1)

Sample 17-4805 was collected from a light, brownish-grey till veneer (<2 m) on the edge of a cirque basin (Plates 3A and 4E). Till is thick (>2 m) in places, and is cut by east–west-trending glacially scoured valleys. Small (<500 m long, 2–3 m wide) glaciofluvial channels are locally observed, cutting through bedrock and till. Striation measurements of 102 and 155° were recorded on the side and top respectively of an outcrop of coarse-grained garnetiferous gneiss, in a valley 6.3 km east-southeast of the sample site at an elevation of 517 m.

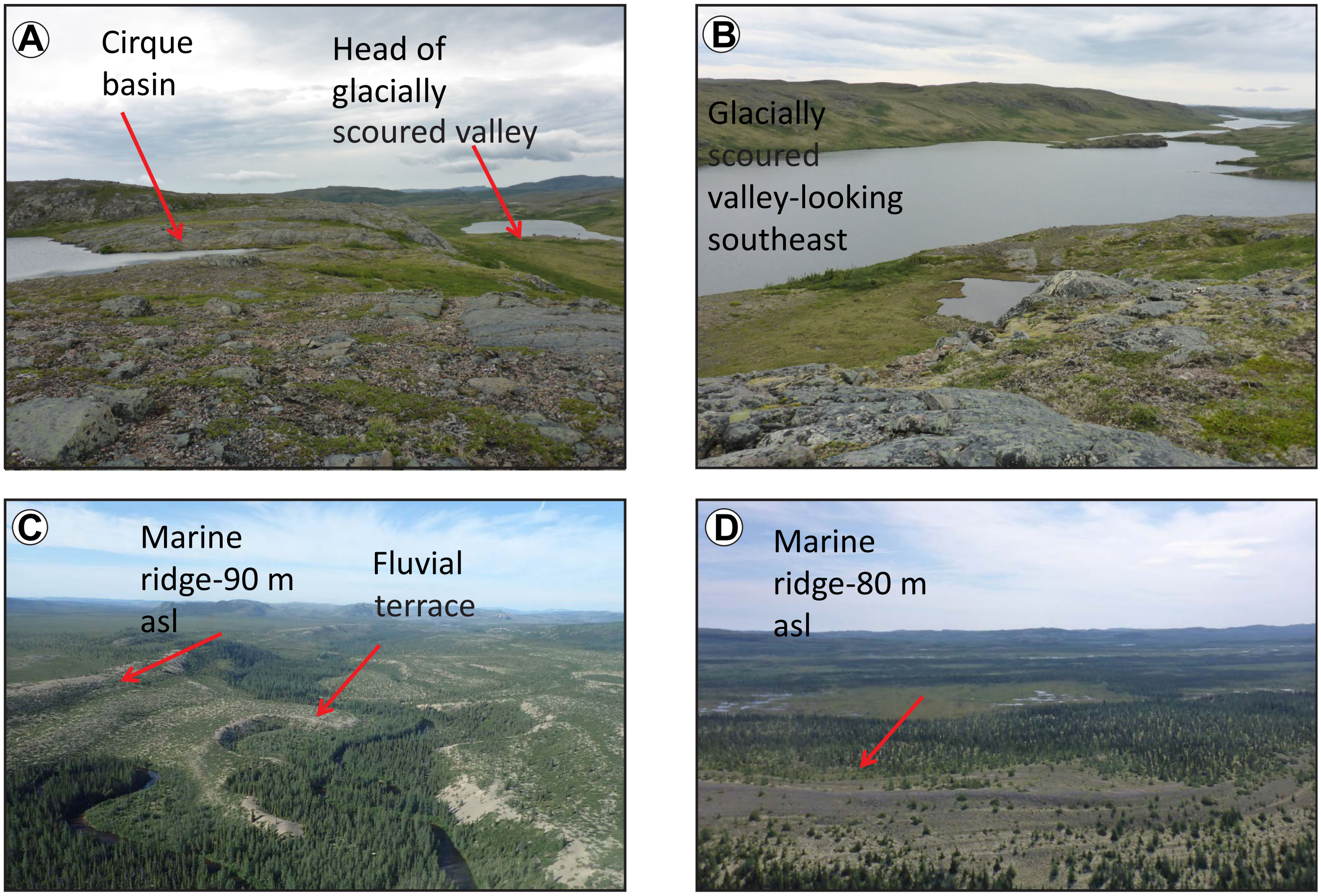

Plate 3. *A) Looking west-northwest over a minor cirque basin (left) perched above a west–east trending glacially scoured valley (right) that leads to the coast; B) The valley begins in the Harp Lake uplands, continuing east; C) A relict marine ridge (90 m asl) and an incised fluvial terrace, in a valley south of Hunt River; D) Marine ridges (uppermost ridge is 80 m asl) 7 km west of Big Bay.*

Table 1. Table summarizing the results for sample 17-4805

Gneissic Bedrock (SECP) (Thomas and Morrison, 1988; Hill 1982a, c; Wardle *et al.*, 1997)	**Summary-Indicator Mineral Sample 17-4805 Matrix: Very Coarse Silty Very Fine Sand. Munsell Colour: 10YR 6/2**	**Clasts >2 mm Total: 22%**	**%**
Nearest bedrock outcrop: granitic gneiss intermixed with tonalite gneiss and quartz syenite (*7*: Thomas and Morrison, 1988; ***10b***: Hill, 1982a and c) Also mapped as ***P2g*** (Wardle *et al.*, 1997)	Indicator minerals present: native gold (1 grain, pristine, 25 µm long, calculated ppb=1), pyrite (1 grain), molybdenite, 50 µm long (1 grain), red rutile (1 grain), spinel (3 grains), low-Cr diopside (1), apatite (8 grains), chondrodite (Mg–Fe fluorosilicate-1 grain), sillimanite (5 grains)	Volcanic rocks/ sediments	10
Constituent bedrock mineral assemblage: orthopyroxene, clinopyroxene, amphibole, garnet, sillimenite, chlorite	Mineral assemblage: hornblende–almandine/ diopside–epidote	Granites	90
Mineralization: pyrite, pyrrhotite			

Sample 17-4806: Southwest Flowers River, 19 km East of Sarah Lake: 61°28'47"W, 55°28'46"N (NAD27), Elevation = 573 m (Table 2)

Sample 17-4806 was collected from a light, brownish-grey till veneer proximal to an outcrop of gabbro. The local area to the sample site is characterized by ridges of till veneer, with exposed bedrock at high elevations, interspersed with spruce and moss-covered rock ridges, minor east-northeast streamlined ridges 800–900 m long, and bogs at lower elevations. Small glaciofluvial channels (<500 m long, 2–3 m wide) were noted. Striation orientations recorded on coarse-grained granitoid outcrop west and north of the sample site range from 66–75°. Striation measurements 11 km to the south of this site are mentioned in the description of sites at Ingrid Lake.

Samples 17-4800: 61°31'40"W, 55°22'45"N (NAD27), Elevation= 472 m, and 4801: 61°31'14"W, 55°20'56"N (NAD27), Elevation = 387 m (Tables 3 and 4)

Sample 17-4800 was collected from a light yellowish-brown till veneer overlying green basalt. Locally, till veneer and rock outcrop dominate the hilltops with minor (ice-contact?) glaciofluvial material in valleys. Exposed bedrock is locally polished, particularly over fine-grained rock units, and stossed to the east. A single striation measurement of 104° was recorded on fine-grained basaltic rock at this site.

Sample 17-4801 was collected in a light yellowish-brown mudboil overlying interbedded polymictic conglomerate and greywacke, with isolated felsic rocks. Two ice-flow directions were observed at the site, at a lower elevation, in polymictic conglomerate (Plate 4A): an east-south-eastward (094°) striation cut by what appears to be a later east-northeastward striation (075°). Similar orientations (080–110°) were also noted by Klassen and Bolduc (1986), but with opposite relative ages (*i.e.*, a 080° striation crosscut by a 110°) and, at a location 9 km to the south, closer to the Adlatok River valley (*see* striation database, Taylor, 2001).

Sample 17-4802 Aucoin Prospect Area: 61°23'07"W, 55°21'34"N (NAD27), Elevation = 334 m (Table 5)

Sample 17-4802 was collected from a pale-brown mudboil overlying a fine-grained monzodiorite outcrop, 300 m south-southeast of MODS 013N/06/Au001. Ridgetops and valleys proximal to the Aucoin prospect are covered by a thin (<2 m) till veneer, with commonly scoured and polished bedrock exposures outcropping throughout. To the north-east, small eskers (<2 km-long) and sporadically preserved glaciofluvial deposits were noted, along with minor ridges and drumlinoid landforms. Thick (>2 m) till is abundant south of Aucoin (Plate 4B). No striation measurements were made at this site.

Sample 17-4808: Flowers River Intrusive Suite: 61°02'21"W, 55°33'13"N (NAD27), Elevation = 511 m (Table 6)

Sample 17-4808 was collected from a light brownish-grey till veneer overlying disintegrated bedrock (grus). Till in this region is thin (<1 m) but extensive, leaving moderate bedrock exposure on the hilltops (Plate 4F). Striation measurements on the up-ice side (stoss) of a quartz–feldspar-porphyry unit in outcrop include a set oriented at 060°, and another set at 076° on the down-ice (lee) side of the outcrop.

Sample 17-4803: Hunt River Belt: 60°49'08"W, 55°16'48"N (NAD27), Elevation = 372 m (Table 7)

Sample 17-4803 was collected from a light yellowish-brown mudboil overlying amphibolite. Locally, till overlying rocks of the Hunt River belt is thin (<1 m), and preserved in shallow pockets between rock outcrops. Directly north of the sample site, terraced moss and tree-covered rock outcrops lead to a broad, flat (glacially scoured) valley devoid of glacial deposits. Polished surfaces are not common in the immediate sample area, possibly owing to the strongly foliated nature of the bedrock (Plate 4D). A striation measurement of 054°, taken at an elevation of 295 m, was noted 3 km north of the sample site, on an outcrop of pelitic metasedimentary rock.

Sample 17-4804: Florence Lake Belt: 60°30'48"W, 55°08'55"N (NAD27), Elevation = 173 m (Table 8)

Sample 17-4804 was collected in a light olive-brown mudboil, 4 km northeast and in the inferred down-ice direction of MODS 13N/02/Au001. Much like the Hunt River belt, till in the vicinity of the sample site in the central Florence Lake belt, is thin (<1 m), large bedrock ridges and

Plate 4. *(Plate on page 199). A) Striated (075/094°) polymictic conglomerate with minor mafic dyke (photo facing northeast; B) Looking north over a small (<1 km) esker (foreground), ridged till (on bedrock knob in background) and streamlined landforms (background, behind bedrock knob), 3.3 km north of the sample 17-4802; C) Epidote alteration in monzogabbro bedrock outcrop (top picture) in the same location as plate 4B, and medium-grained hornblende ± clinopyroxene syenite with hornblende ± clinopyroxene ± magnetite rich lenses (bottom picture – Sandeman and Rafuse, 2011), 1.4 km southwest of the Aucoin prospect; D) Looking northwest across the Hunt River Belt, toward a glacially scoured valley; E) Site of westernmost sample (17-4805) taken on the edge of a cirque basin over gneissic bedrock west of Pants Lake; F) Looking northwest over the innermost caldera complex of the Flowers River igneous suite.*

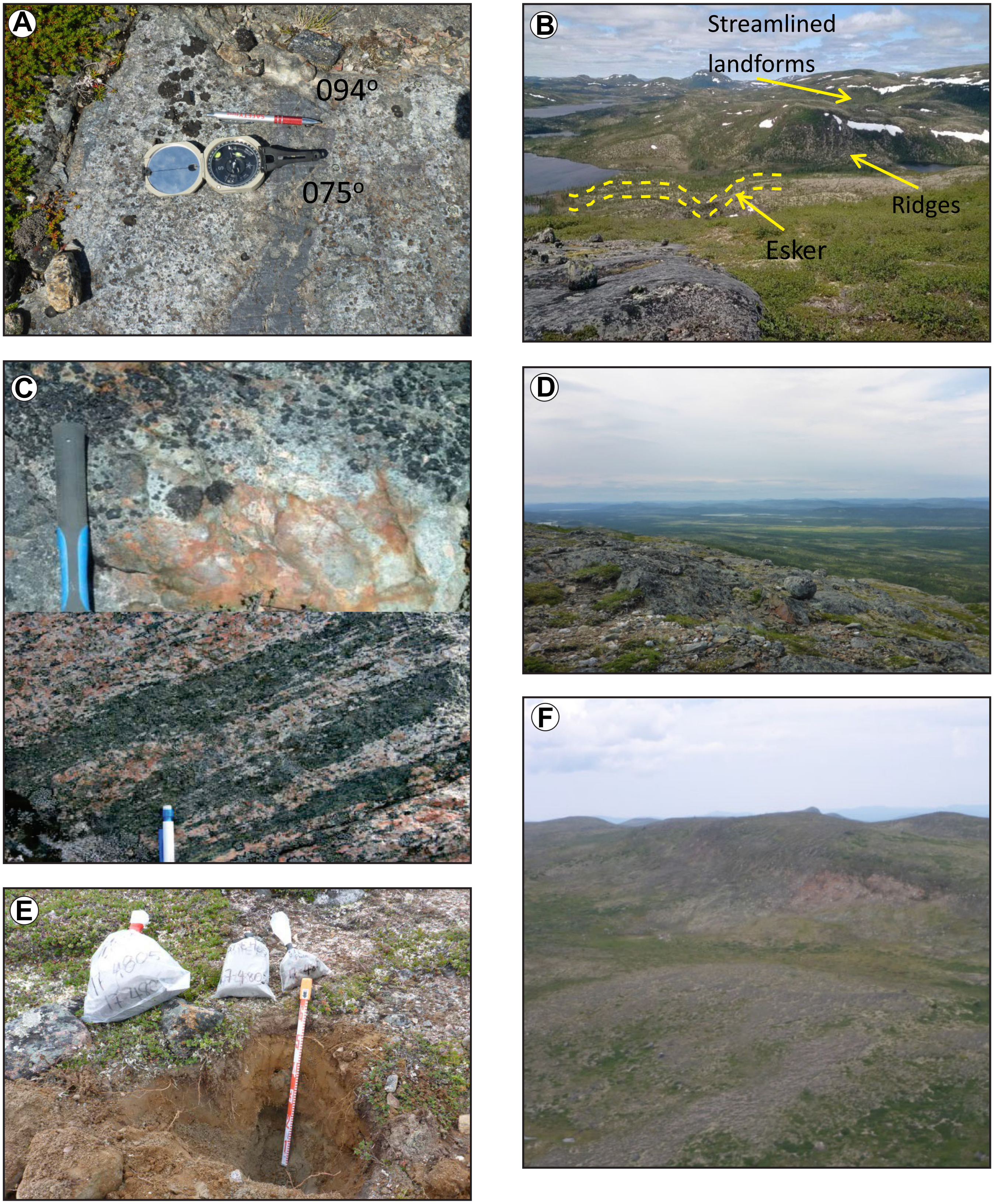

Plate 4. *Caption on page 198.*

Table 2. Table summarizing the results for sample 17-4806

Flowers River Igneous Suite/Nain Plutonic Suite Bedrock (Thomas and Morrison, 1991; Hill, 1982a, c; Wardle *et al.*, 1997)	Summary-Indicator Mineral Sample 17-4806 Matrix: Coarse Silty Very Fine Sand. Munsell Colour: 2.5Y 6/2	Clasts >2 mm Total: 23%	%
Nearest bedrock outcrop: contact of peralkaline granite and gabbro of the Nain Plutonic Suite (***21***:Thomas and Morrison, 1991). Mapped in other areas as medium grained quartz-syenite, quartz monzonite (***16b***: Hill, 1982a, c) and peralkaline coarse-grained granite (***19a,b***: Hill, *ibid.*) and plagioclase-phyric olivine gabbro, gabbronorite and monzogabbro (***14a***: Hill, *ibid.*). Also mapped as granite, monzanite and charnockite (***M2g***: Wardle *et al.*, 1997)	Indicator minerals present: chalcopyrite (1 grain), red rutile (2 grains) , apatite (20 grains)	Volcanic rocks/ sediments	5
Constituent bedrock mineral assemblage: peralkaline granite: quartz, perthite, plagioclase, aegerine, arfvedsonite and reibekite; gabbro: pyroxene, amphibole, epidote, amphiboles, clinopyroxene, olivine	Mineral assemblage: augite–hornblende–fayalite/diopside–apatite	Granites	95
Mineralization: pyrite, pyrrhotite (Wares and Leriche, 1996)			

Table 3. Table summarizing the results for sample 17-4800

Ingrid Lake Bedrock (Ermanovics, 1993; Wardle *et al.*, 1997)	Summary-Indicator Mineral Sample 17-4800 Matrix: Coarse-Silty Very Fine Sand. Munsell Colour: 10YR 6/4	Clasts >2 mm Total: 20%	%
Nearest bedrock outcrop: intermediate lavas with minor porphyritic basalt (***Almv***). Also mapped as mafic and felsic volcanics (***P2mfv***: Wardle *et al.*, 1997)	Indicator minerals present: native gold (1 grain modified, 25 µm, 1 reshaped 50 µm, calculated ppb = 1), red rutile, apatite (2 grains), Cr-grossular (1 grain), leucoxene (1 grain)	Volcanic rocks/ sediments	30
Constituent bedrock mineral assemblage: actinolite, chlorite, epidote, carbonate, hornblende, diopside	Mineral assemblage: augite–almandine/epidote–diopside–leucoxene	Granites	70
Mineralization: pyrite			

Table 4. Table summarizing the results for sample 17-4801

Ingrid Lake Bedrock (Ermanovics, 1993; Wardle *et al.*, 1997)	Summary-Indicator Mineral Sample 17-4801 Matrix: Very Coarse-Silty Very Fine Sand. Munsell Colour: 2.5Y 6/3	Clasts >2 mm Total: 9%	%
Nearest bedrock outcrop: polymictic conglomerates and greywackes (***Als***: Ermanovics, 1993). Also mapped as mafic and felsic volcanics (***P2mfv***: Wardle *et al.*, 1997)	Indicator minerals present: apatite, leucoxene	Volcanic rocks/ sediments	10
Constituent bedrock mineral assemblage: microcline, plagioclase, quartz, chlorite, clinozoisite, biotite	Mineral assemblage: orthopyroxene–hornblende–ilmenite/epidote–diopside–apatite, leucoxene	Granites	90
Mineralization: 5–8% pyrite			

Table 5. Table summarizing the results for sample 17-4802

Aucoin Bedrock (Sandeman and Rafuse, 2011, 2015; Thomas and Morrison, 1991; Wardle *et al.*, 1997)	**Summary-Indicator Mineral Sample 17-4802 Matrix: Very Coarse-Silty Very Fine Sand. Munsell Colour: 10YR 6/3**	**Clasts >2 mm Total: 29%**	**%**
Nearest bedrock outcrop: pink-, to buff-coloured, generally medium-grained, massive to weakly-foliated or lineated, hornblende, clinopyroxene syenite (mapped as a relect granulite facies rock (***A'Mgl***: Ermanovics, 1993), fine-grained monzodiorite and pegmatite dykes, and medium-grained hornblende porphyritic monzogabbro. Also mapped as foliated, hornblende, biotite granite (***2***: Thomas and Morrison, 1991) and as tonalitic to granodioritic migmatitic orthogneiss (***AMTgn***: Wardle *et al.*, 1997)	Indicator minerals present: native gold (1 grain modified, 100 µm long, 1 grain pristine, 100 µm long, calculated ppb = 11, galena (2 grains, 75-100 µm long) , pyrite (10 grains, 25-100 µm) red rutile, apatite, low-Cr diopside	Volcanic rocks/ sediments	20
Constituent bedrock mineral assemblage: perthitic potassium feldspar, green hornblende, clinopyroxene, magnetite–ilmenite, apatite, titanite, rutile	Mineral assemblage: orthopyroxene–hornblende/ apatite–epidote–diopside	Granites	80
Mineralization: gold (electrum), pyrite, chalcopyrite (Sandeman and Rafuse, 2011; Sandeman and McNicoll, 2015; Hussey and Moore, 2005, 2006a, b)			

Table 6. Table summarizing the results for sample 17-4808

Flowers River Intrusive Suite-Bedrock (Hill, 1982b; Wardle *et al.*, 1997)	**Summary-Indicator Mineral Sample 17-4808 Matrix: Coarse Silty Very Coarse Sand. Munsell Colour: 10YR 6/2**	**Clasts >2 mm Total: 23%**	**%**
Nearest bedrock outcrop: diorite, monzonite, quartz monzonite ***15b***: Hill, 1982b). Also mapped as peralkiline rhyolite (***M2pv***: Wardle *et al.*, 1997)	Indicator minerals present: apatite	Volcanic rocks/ sediments	10
Constituent bedrock mineral assemblage: augite, olivine, clinopyroxene, orthopyroxene, amphibole, apatite, titanite, allanite	Mineral assemblage: hornblende–orthopyroxene–augite/zircon–apatite	Granites	90
Mineralization: fluorite, rare earth metals, pyrite			

shrub and spruce-covered low ground. The bedrock is locally polished, outcropping on ridges, between shrubs and trees. Till is preserved in shallow (30–40 cm) pockets between rock outcrops.

DISCUSSION

GLACIAL ENVIRONMENT

The glacial sediment varies from the northwest to the southeast of the study area. Ice-contact glaciofluvial material in valleys, streamlined rock outcrops, ridged-moraines and continuous till units characterize the higher elevation, northwestern and northern parts of the study area, whereas fluvial material, discontinuous till veneer and organic material characterize the lower elevation, southern and southeastern areas. Striation measurements obtained during the 2017 field season indicate eastward and northeastward flow; however, they are limited to a few places, and not sufficiently widespread to conclusively determine individual and crosscutting flow sets.

Striation sets recorded on the west side of Sarah Lake, south of Ingrid Lake and north of the Adlatok River valley (Klassen and Bolduc, 1986), appear to indicate multidirectional flow. The northwest–southeast-oriented striations

Table 7. Table summarizing the results for sample 17-4803

Hunt River Bedrock (Ermanovics, 1993; Wardle *et al.*, 1997)	Summary-Indicator Mineral Sample 17-4803 Matrix: Very Fine-Sandy Coarse Silt. Munsell Colour 2.5Y 6/3	Clasts >2 mm Total: 13%	%
Nearest bedrock outcrop: near the contact between fine- to medium-grained, homogeneous to laminate (millimetre scale), black to dark grey and green smooth-weathering amphibolite (***A'Hv***) and pale-dark green hornblende schists, tremolite, serpentine schists (*A'Hum*). Also mapped as metabasalt, amphibolite, ultramafite (***AMMv***: Wardle *et al.*, 1997)	Indicator minerals present: pyrite (5 grains, 25–10 µm), scheelite (1 grain)	Volcanic rocks/ sediments	5
Constituent bedrock mineral assemblage: hornblende, actinolite, epidote, chlorite, calcite, olivine, orthopyroxene, clinopyroxene, phlogopite	Mineral assemblage: augite–hornblende/epidote–diopside	Granites	95
Mineralization: pyrite, chalcopyrite			

Table 8. Table summarizing the results for sample 17-4804

Florence Lake Bedrock (Ermanovics, 1993; Wardle *et al.*, 1997)	Summary-Indicator Mineral Sample 17-4804 Matrix: Coarse Silty Very Fine Sand. Munsell Colour: 2.5Y 5/3	Clasts >2 mm Total: 29%	%
Nearest bedrock outcrop: near contact of greywacke and conglomeratic units with blue quartz clasts of the Lise Lake Formation (***AFLq***) and layered flows and sills of the Schist Lakes Formation (***AFSv***). Also mapped as (metabasalt, amphibolite and ultramafite ***AMMv***: Wardle *et al.*, 1997)	Indicator minerals present: gold (1 pristine grain, 75 µm long), pyrite (10 grains, 25–100 µm long)	Volcanic rocks/ sediments	0
Constituent bedrock mineral assemblage: hornblende, chlorite, muscovite, epidote, amphibole, clinopyroxene	Mineral assemblage: augite–ilmenite/ epidote–diopside	Granites	100
Mineralization: pyrite, gold, chalcopyrite			

(100–110°) of these sets may indicate a later shift in ice flow, related to ice drawdown resulting from the melting of glacial ice initiated by marine incursion into this region (Batterson, 1996). The crosscutting striation set, measured at Ingrid Lake (*this study*), indicates east-southeast flow (094°) crosscutting east-northeast flow (075°). This relative age relationship is opposite to those noted by Klassen and Bolduc (1986), and may represent: 1) locally deflected, topographically controlled ice flow at lower elevations unrelated to the larger regional trends, 2) localized east-southeast flow related to the glacial dynamics at Sarah Lake that were subsequently overprinted by east-northeast ice flow, or 3) a misinterpreted age relationship. Clearly, more data are needed to determine the ice-flow sequence in this and other localities, and to relate the local ice-flow events to regional ice-flow trends.

The glacial dynamics west of, and at, Sarah Lake are important to constrain, as there are a number of Ni–Cu ± Co mineral occurrences associated with the Pants Lake intrusions (Kerr, 2012), and these are located up-ice (west) of this region. The following sequence of events at Sarah Lake is proposed:

1) Cessation of west- to east-directed movement of an ice mass by a granite ridge, and deposition of ribbed moraine immediately west and south of Sarah Lake (Figure 4, Plates 1C and 2);

2) Melting of ice and deposition of glaciofluvial material, including braided esker plains to the northwest of Sarah Lake (Plate 2);

3) Onset of high-velocity, east-southeast-directed ice flow on the southern margin of the ice mass south of Sarah Lake and east-northeast-directed ice flow on the northern margin of the ice mass northeast of Sarah Lake, thereby producing streamlined landforms from previously deposited ribbed moraine and rocks to the north (Plate 1D), and forming drumlin fields to the southwest;

4) *In-situ* melting of an ice mass and deposition of massive, boulder-strewn melt-out tills and till ridges (flow till from down-wasting ice margins?) over ribbed moraine (Plates 1C and 2).

In order to solidify this preliminary interpretation of the dynamics of ice flow in the region, further mapping and examination of the surficial materials has to be undertaken. It is emphasized that care and caution must be applied when conducting drift prospecting or surficial materials geochemical sampling in this part of Labrador, as material from ribbed moraines has clearly been re-entrained and transported farther down ice from inferred sources by the later, high-velocity ice. In addition, *in-situ* melting of a remnant ice mass in the west to east valley leading to Sarah Lake, may have deposited material entrained and transported on the top of the glacier from a source farther west (englacial material). Meltwater will have eroded basally deposited material into a coarser grained, sorted glaciofluvial material making it harder to trace to the source. This glaciofluvial material is readily identified and should be avoided during sampling campaigns. Material sampled from these landforms must be sourced up-stream rather than up-ice, and paleo-stream directions are often difficult to determine.

Geochemical responses to mineralization in these areas may be diluted, either through the removal of the silt and clay fraction of till, where base-metal sulphides commonly reside (*see* McClenaghan and Paulen, 2017 and references therein), or by the addition of non-mineralized material.

Glacial deposits overlying the Hunt River and Florence Lake greenstone belts are scarce, and limited to shallow (<1 m) till pockets preserved between bedrock outcrops on ridges; with isolated glaciomarine deposits in valleys. In general, erosion of glacial material and deposition of marine sediments are expected at elevations below the marine limit of 125 m asl. The lack of marine sediments in the valley directly north of the Hunt River belt (Plate 4D) suggests that this area may have been ice covered during marine incursion, similar to Florence Lake (Batterson, 1996). In addition, the lack of till deposits on the ridgetops suggests a locally colder based, less-erosive ice environment (Benn and Evans, 2010).

INDICATOR MINERAL

The IM samples contain mineral assemblages that are found in the rock units from which they are presumably derived. Sulphides or gold are noted in five of the seven samples. Sample 17-4802, with a calculated value of 11 ppb and containing one pristine and one modified grain, and sample 17-4804, with a calculated value of 8 ppb and containing one pristine grain, were collected near or immediately down-ice of known gold occurrences. The occurrence of gold in these samples lends support to the veracity of the IM sampling process, although the overall grain count is low. The paucity of gold grains in sample 17-4802, may reflect that the sample was taken 300 m south-southeast of the Aucoin prospect, not in the inferred down-ice direction. In addition, the gold in the Aucoin prospect is hosted in anastomosing and discontinuous <60-cm-wide quartz veins (Sandeman and McNicoll, 2015), the distribution and erosion of which may contribute to variable amounts of gold grains in tills. The pristine grain collected from Sample 17-4804 is suspected to be from a source less than 100 m southwest of the sample site, and not from the Thurber Dog Lake #1 showing, which is 4 km in the inferred up-ice direction.

Galena and pyrite were also noted in sample 17-4802; again, these minerals are constituents of the mineralized zones at the Aucoin prospect (Sandeman and McNicoll, 2015). There are no known gold occurrences in the Ingrid group or in the gneisses west of Pants Lake. Thus, the two gold grains (reshaped and modified) from till overlying the Ingrid group, and one pristine grain from the till sample west of Pants Lake (samples 17-4800 and 17-4805) either suggest the unrealized presence of auriferous mineralization, or alternatively they may simply represent background levels of gold-in-tills in these areas. Molybdenite was noted in till sample 17-4805. Scheelite is noted in the sample from the Hunt River belt (17-4803) and chalcopyrite is noted in the southwest Flowers River region (17-4806). The significance of the abundance (or lack thereof) of these minerals in till is not clear, as the sample density is not sufficient to establish a background grain content.

Apatite is noted in all samples with the exception of the two samples obtained from tills overlying the Archean Hunt River and Florence Lake greenstone belts. As discussed previously, apatite can be formed in a number of different geological environments, so the presence of the mineral alone in till is not diagnostic. Leucoxene, a common alteration phase derived from primary titanium-bearing minerals (*e.g.*, ilmenite or titanite: Deer *et al.*, 1978), is present in samples 17-4800 and 17-4801 obtained from till overlying the Ingrid group. Sillimanite, a high-temperature metamorphic mineral (*ibid.*) is found in samples 17-4805 and 17-4806 and chondrodite, a mineral normally associated with calc-silicate skarns and hydrothermal alteration of carbonate and ultramafic rocks (*e.g.*, Zhao *et al.*, 1999), was recovered from sample 17-4805. Almandine garnet, another high-temperature metamorphic mineral (Deer *et al.*, 1978), occurs in sample 17-4800, overlying the Ingrid group and in sample 17-4805, overlying the gneisses complex; zircon, a mineral associated with alkaline plutonic rocks (*ibid.*), occurs in sample 17-4808. Epidote, hornblende and diopside grains are found in all of the samples.

The combination of molybdenite, gold and rutile in sample 17-4805, obtained from till overlying granitic and tonalite gneiss, 10 km west of Pants Lake, may suggest a Cu–Au–Mo porphyry or skarn association (*e.g.*, McClenaghan and Paulen, 2017) for their source. The inferred source is expected to be less than 100 m to the west of the sample site, as the gold grain is pristine (Averill, 2001). The chondrodite grain may be derived from tonalitic gneiss of Unit 8b of Hill (1982c), which was reported to contain a number of metre-scale lenses of coarse-grained marble associated with garnetiferous granitic migmatite.

Scheelite, of which one grain was extracted from sample 17-4803, is commonly associated with greenstone belt-hosted gold, and is typical of skarns, hydrothermal veins, greisens and pegmatites. It is not understood whether this mineral reflects possible mineralization in the Hunt River belt or whether it is related to a granitic pegmatite (Unit H'pe, Ermanovics, 1993) 840 m in the inferred up-ice direction (southwest) of the sample site, or from a local, unknown pegmatitic source.

The source for the gold in sample 17-4800 is unknown, but the combination of the rutile, gold and leucoxene may indicate a prospective mineralized system. Gold, leucoxene and pyrite occur in gold deposits elsewhere (*e.g.*, Hemlo deposit; Corfu and Muir, 1989; Stog'r Tight deposit; Ramezani *et al.*, 2002). These deposits were interpreted to have formed *via* the interaction of hydrothermal, gold- and sulphur-bearing fluids with primary Fe–Ti oxides; the oxidation of this fluid causing the co-precipitation of gold and pyrite (Pochon *et al.*, 2017). Rutile replacing ilmenite is associated with gold mineralization at the Aucoin prospect (Sandman and McNicoll, 2015). The mineral assemblages observed in sample 17-4800 may be derived from as yet unrecognized Aucoin-like mineralization, east (up-ice) of the sample site.

CONCLUSIONS AND FUTURE WORK

Preliminary glacial mapping has identified two flow-set directions, as evidenced by striation measurements and in landforms. The formation of ribbed moraine in close proximity to a glaciofluvial system at Sarah Lake, with marginal streamlined ice-forms, and the subsequent deposition of massive, poorly sorted, sandy till (interpreted as disintegration moraine), suggest that an ice mass was initially blocked, with flow on the north and south margins of the ice mass redirected to the east-northeast and east-southeast, and that the remaining ice mass melted *in situ*. However, the mapping and striation data are limited, and not yet conclusive. Further measurements are needed to understand ice flow, and the paleo-glacial environment within the study area and these will be obtained during future field seasons.

Till is continuous on ridges in the northwestern part of the study area, with moraine ridges and minor ice-contact glaciofluvial material in valleys. Discontinuous till cover, with bedrock and organic materials, dominate the southern part of the study area, along with evidence of glaciofluvial, glaciomarine and fluvial deposition in valleys. Further mapping will clarify the nature of the paleo-ice environment, particularly in the Sarah Lake area, and allow for more conclusive insights into glacial erosion and deposition.

Indicator mineral results demonstrate that many minerals derived from local bedrock have been entrained in till. Two of the till samples (17-4802 and 17-4804), proximal to and perhaps dispersed from known mineralization, contained gold, galena and pyrite. In addition, gold, rutile and leucoxene were noted in sample 17-4800 and gold, molybdenite and rutile in sample 17-4805. The presence of sulphide minerals and gold in these two samples is promising. Furthermore, the mineral assemblages noted in sample 17-4800 may be indicative of unrecognized Aucoin-type orogenic gold, immediately up-ice of that locality. Similarly, the mineral assemblage of molybdenite + gold + rutile in sample 17-4805 may suggest proximal, unrecognized Cu–Au–Mo porphyry or skarn mineralization. These preliminary results underscore the necessity for continued till indicator mineral studies, reconnaissance and locally focused geochemical studies, along with detailed geological and surficial materials mapping to further evaluate the potential for Hopedale Block bedrock sources to contain more extensive, Aucoin-type orogenic as well as Cu–Au–Mo porphyry or skarn mineralization.

ACKNOWLEDGMENTS

The authors are very grateful to David Corrigan for providing funds for the geochemical sampling component of the

GEM II Hopedale program. In addition, both he and Deanne Van Rooyen of Cape Breton University are thanked for their insights on the bedrock geology of the Hopedale Block. Wayne Tuttle is thanked for his logistical expertise and for making sure we returned safely to camp. Bruce Ryan provided much literature and discussions regarding the geology of the Nain Province. Much appreciation is given to Sarah Hashmi for her shared discussions and literature suggestions on indicator minerals. Discussions with Martin Batterson regarding the paleo-glacial environment of the Hopedale Block were very helpful. We are very grateful to Patty Pottle and the staff of the Amaguk Inn for their wonderful hospitality and excellent food. The authors are grateful to the crew at Overburden Drilling Management and Shaunna Madore at the GSC for their expertise with analytical protocols. A special thank you is given to Kim Morgan for her excellent work with the figures; and to Joanne Rooney, for her work finalizing this contribution. Lastly, Steve Amor is thanked for his detailed editorial work on the paper.

REFERENCES

Averill, S.
2001: The application of heavy indicator mineralogy in mineral exploration with emphasis on base metal indicators in glaciated metamorphic and plutonic terranes. *In* Drift Exploration in Glaciated Terrain. *Edited by* M.B. McClenaghan, P.T. Bobrowsky, G.E.M. Hall and S.J. Cook. Geological Society, London, Special Publications, Volume 185, pages 69-81.

Barnett, P.J. and Averill, S.
2010: Heavy mineral dispersal trains in till in the area of the Lac des Iles PGE deposit, northwestern Ontario, Canada. Geochemistry: Exploration, Environment, Analysis, Volume 10, pages 391-399.

Batterson, M.J.
1995: Quaternary geology of parts of the central and southern Hopedale Block, Labrador. *In* Report of Activities. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report of Activities, pages 3-4.

1996: Quaternary geology of parts of the central and southern Hopedale. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 96-1, pages 1-10.

1999: Landforms and surficial geology of NTS map sheet 13N/07 (untitled) Labrador. Map 99-018. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/07/0100.

2000a: Landforms and surficial geology of NTS map sheet 13N/06 (untitled) Labrador. Map 99-017. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/06/0099.

2000b: Landforms and surficial geology of the Shapio Lake map sheet [NTS 13N/03], Labrador. Map 2000-39. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/03/0112.

2000c: Landforms and surficial geology of the Ugjoktok Bay map sheet (NTS 13N/02), Labrador. Map 2000-38. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/02/0111.

2000d: Landforms and surficial geology of the Kanairiktok map sheet (NTS 13N/01), Labrador. Map 2000-37. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/01/0110.

Batterson, M., Scott, S. and Simpson, A.
1987: Quaternary mapping and drift exploration in the eastern part of the central mineral belt, Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 87-1, pages 1-9.

Benn, D.I. and Evans, D.J.A.
2010: Glaciers and Glaciation. Second edition. Hodder Education, 802 pages.

Bertrand, J.M., Roddick, J.C., van Kranendonk, M.J. and Ermanovics, I.
1993: U–Pb geochronology of deformation and metamorphism across a central transect of the Early Proterozoic Torngat Orogen, North River map area, Labrador. Canadian Journal of Earth Science, Volume 30, pages 1470-1489.

Brushett, D. and Amor, S.
2013: Kimberlite-indicator mineral analysis of esker samples, western Labrador. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File LAB/1620, 68 pages.

2016: Till geochemistry of Eastern Pond and Miguels Lake (NTS map areas 2D/11, 12), Jeddore Lake (NTS map areas 1M/13, 2D/04 and 12A/01) and surrounding areas. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File NFLD/3273, 107 pages.

Cadman, A.C., Heaman, L., Tarney, J., Wardle, R. and Krogh, T.E.
1993: U–Pb geochronology and geochemical variation within two Proterozoic mafic dyke swarms, Labrador. Canadian Journal of Earth Sciences, Volume 30, pages 1490-1504.

Campbell, H.E. and McClenaghan, M.B.
2019: Results of a 2017 heavy mineral indicator pilot study in the NTS 13N and 13M map areas, Hopedale Block, Labrador. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File Lab/1743, 10 pages.

Christie, A.M., Roscoe, S.M. and Fahrig, W.F.
1953: Preliminary Map. Central Labrador Coast, Newfoundland; Geological Survey of Canada, Paper 53-14, 3 pages.

Clark, J.R. and Williams-Jones, A.E.
2004. Rutile as a potential indicator mineral for metamorphosed metallic ore deposits. Montreal, Diversification de L'Exploration Minérale au Québec, Sous-projet SC2 Final Report, 17 pages.

Connelly, J.N. and Ryan, B.
1996: Late Archean evolution of the Nain Province, Nain, Labrador: imprint of a collision. Canadian Journal of Earth Sciences, Volume 33, pages 1325-1342.

Corfu, F. and Muir, T.L.
1989: The Hemlo-Heron Bay greenstone belt and Hemlo Au-Mo deposit, Superior Province, Ontario, Canada 2. Timing of metamorphism, alteration and Au mineralization from titanite, rutile, and monazite U–Pb geochronology. Chemical Geology, Volume 79, pages 201-223.

Corrigan, D., Rayner, N., Hinchey, A., Sandeman, H. and Girard, E.
2018: Report on field studies in the Hopedale Block of the North Atlantic Craton (Nain province), Newfoundland and Labrador. Geological Survey of Canada, Open File 8509, 11 pages.

Deer, W.A., Howie, R.A., Zussman, J.
1978: An introduction to the rock forming minerals. Eleventh Edition. Longman Group Limited, London. 528 pages.

Douglas, G.V.
1953: Notes on localities visited on the Labrador coast in 1946 and 1947. Geological Survey of Canada, Paper 53-1, 67 pages.

Dunlop, P. and Clark, C.D.
2006: The morphological characteristics of ribbed moraine. Quaternary Science Reviews, Volume 25, Issue 13-14, pages 1668-1691.

Emslie, R.F.
1980: Geology and petrology of the Harp Lake Complex, central Labrador: An example of elsonian magmatism. Geological Survey of Canada, Bulletin 293, 136 pages.

Ermanovics, I.F.
1979: Geology, Adlatok Bay–Florence Lake map-area, Labrador. Geological Survey of Canada, Open File 580.

1980: Geology of the Hopedale block of Nain Province Labrador: Report 2, Nain–Makkovik boundary zone. *In* Current Research, Part B. Geological Survey of Canada, Paper 80-1B, pages 11-15.

1981a: Geology, Ingrid Group map-area, Newfoundland (13N/5). Geological Survey of Canada, Open File 755.

1981b: Geology, Hunt River map-area, Labrador, Newfoundland (parts of 13N/7,9,10,15,16). Geological Survey of Canada, Open File 778.

1993: Geology of the Hopedale Block, Southern Nain Province, and the adjacent Proterozoic terranes, Labrador, Newfoundland. Geological Survey of Canada, Memoir 431.

Ermanovics, I. and Korstgard, J.A.
1981: Geology of the Hopedale Block and adjacent areas, Labrador: Report 3. *In* Current Research, Part B. Geological Survey of Canada, Paper 81-1A, pages 69-76.

Ermanovics, I. and Raudsepp, M.
1979: Geology of the Hopedale Block of eastern Nain Province, Labrador: Report 1. *In* Current Research, Part B. Geological Survey of Canada, Paper 79-1B, pages 341-348.

Ermanovics, I. and van Kranendonk, M.
1998: Geology of the Archean Nain Province and Paleoproterozoic Torngat Orogen in a transect of the

North River-Nutak map areas, Newfoundland (Labrador) and Quebec. Geological Survey of Canada, Bulletin 497, 156 pages.

Ermanovics, I. and van Kranendonk, M.
1998: Geology of the Archean Nain Province and Paleoproterozoic Torngat Orogen in a transect of the North River-Nutak map areas, Newfoundland (Labrador) and Quebec. Geological Survey of Canada, Bulletin 497, 1998, 156 pages.

Fulton, R.J., Hodgson, D.A., Minning, G.V. and Thomas, R.D.
1974: Surficial geology, Hopedale, Labrador, Geological Survey of Canada, Open File 216, scale 1:250 000.

Grant, N.K., Voner, F.R., Marzano, M.S., Hickman, M.H. and Ermanovics, I.F.
1983: A summary of Rb–Sr isotope studies in the Archean Hopedale Block and the adjacent Proterozoic Makkovik Subprovince, Labrador: Report 5. *In* Current Research, Part B. Geological Survey of Canada. Paper 83-1B, pages 127-134.

Hashmi, S., Ward, B.C., Plouffe, A., Leybourne, M.I. and Ferbey, T.
2015: Geochemical and mineralogical dispersal in till from the Mount Polley Cu–Au porphyry deposit, central British Columbia, Canada. Geochemistry, Exploration, Environment and Analysis, Volume 15, pages 234-249.

Hill, J.D.
1982a: Notakwanon River area, Labrador. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Map 81-137.

1982b: Flowers River area, Labrador. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Map 81-136.

1982c: Geology of the Flowers River–Notakwanon River area, Labrador. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 82-06, 148 pages.

Hussey, A.M. and Moore, P.J.
2005: Assessment report of geology and lithogeochemistry on Licences 8482M (3rd yr.) and 9692M & 9693M (1st yr. supplementary), Aucoin Property, NTS 13N/06, Labrador. NFLD 013N/06/0129.

2006a: Fourth year assessment report of geology and geochemistry on mineral licence 8482M, Aucoin Property, NTS 13N/06, Labrador. NFLD 013N/06/0130.

2006b: Fifth year assessment report of geology and geochemistry of Mineral License 8482M, Aucoin property, NTD13N/06, Labrador. Cornerstone Resources Incorporated, Turpin, A. and Hillier, L. Newfoundland and Labrador Geological Survey, Assessment File 13N/06/0131, 2006, 41 pages.

James, D.T.
1997a: Geology of the northern part of the Archean Hunt River Greeenstone belt, Hopedale Block [Nain Province] eastern Labrador (part of NTS map area 13N/10, 13N/15 and 13N/16). Map 97-06. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/07/004.

1997b: Geology of the southern part of the Archean Hunt River Greeenstone belt, Hopedale Block [Nain Province] eastern Labrador (part of NTS map area 13N/7). Map 97-05. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File 13N/07/0073.

James, D.T., Kamo, S. and Krogh, T.
2002: Evolution of 3.0 and 3.1 Ga volcanic belts and new thermotectonic model for the Hopedale Block, North Atlantic craton (Canada). Canadian Journal of Earth Sciences, Volume 39, pages 687-710.

James, D.T, Miller, R.R., Patey, R.P. Thibodeau, S. and Kilfoil, G.J.
1996: Geology and mineral potential of the Archean Florence Lake greenstone belt, Hopedale Block (Nain Province), eastern Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 96-1, pages 85-107.

Jesseau, C.W.
1976: A structural, metamorphic and geochemical study of the Hunt River supracrustal belt, Nain Province, Labrador. Unpublished M.Sc. thesis, Memorial University of Newfoundland, St. John's, 211 pages.

Kerr, A.
2011: Rare-earth-element [REE] mineralization in Labrador: a review of known environments and the geological context of current exploration activity. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Mines Branch Report 11-1, pages 109-143.

2012: The Pants Lake Intrusions, central Labrador: geology, geochemistry and magmatic Ni–Cu–Co sulphide mineralization (parts of NTS 13N/05, 13N/12, 13M/08 and 13M/09). Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 12-2, 153 pages.

Klassen, R. and Bolduc, A.
1986: Ice flow trends and drift composition, Flowers River area, Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 86-01, pages 317.

Klassen, R.A. and Knight, R.D.
1995: Till geochemistry of central Labrador. Geological Survey of Canada, Open File 3213, 250 pages.

Klassen, R.A., Paradis, S., Bolduc, A.M. and Thomas, R.D.
1992: Glacial landforms and deposits, Labrador, Newfoundland and eastern Québec. Geological Survey of Canada, Map 1814A, scale 1:1 000 000.

Kranck, E.H.
1953: Bedrock geology of the Seaboard of Labrador between Domino Run and Hopedale; Geological Survey of Canada, Bulletin 26, 45 pages.

Krogh, T.E.
1993: Report on Labrador geochronology 1992-93. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Labrador, 997. Newfoundland and Labrador Geological Survey. "Geochronology." Newfoundland and Labrador GeoScience Atlas OnLine. Last update: October 2018. http://geoatlas.gov.nl.ca [January 12, 2019].

Lopoukhine, N., Prout, N.A. and Hirvonen, H.E.
1977: Ecological land classification of Labrador. Ecological Land Classification Series 4. Lands Directorate (Atlantic region), Environmental Management Service, Fisheries and Environment Canada, Halifax, Nova Scotia, 85 pages.

Mao, M., Rukhlov, A.S., Rowins, S.M., Spence, J.S. and Coogan, L.A.
2016: Apatite trace element compositions: a robust new tool for mineral exploration. Economic Geology, Volume 111, Number 5, pages 1187-1222.

McClenaghan, M.B., Budulan, G., Averill, S.A., Layton-Matthews, D. and Parkhill, M.A.
2012: Indicator mineral abundance data for bedrock and till samples from the Halfmile Lake Zn-Pb-Cu Volcanogenic Massive Sulphide Deposit, Bathurst Mining Camp, New Brunswick. Geological Survey of Canada, Open File 7076.

McClenaghan, M.B., Plouffe, A., McMartin, I., Campbell, J.E., Spirito, W.A., Paulen, R.C., Garrett, R.G. and Hall, G.E.M.
2013: Till sampling and geochemical analytical protocols used by the Geological Survey of Canada. Geochemistry: Exploration, Environment, Analysis, Volume 13, pages 285-301.

McClenaghan, M.B. and Paulen, R.C.
2017: Chapter 20: Mineral exploration in glaciated terrain. *In* Past Glacial Environments (Sediments, Forms and Techniques). *Edited by* J. Menzies and J.J.M. van der Meer. Elsevier, pages 689-751.

McClenaghan, M.B., Paulen, R.C. and Layton-Matthews, D.
2015: Glacial dispersal of gahnite from the Izok Lake Zn–Cu–Pb–Ag VMS deposit, northern Canada. Geochemistry: Exploration, Environment, Analysis, Volume 15, Number 4, pages 333-349.

McClenaghan, M.B., Paulen, R.C., Rice, J.M., Campbell, H.E. and Pyne, M.D.
2017b: Gold grains in till samples from the southern Core Zone, Quebec and Newfoundland and Labrador (NTS 23-P and 23-I): Potential for undiscovered mineralization. Geological Survey of Canada, Open File 8222.

McClenaghan, M.B., Parkhill, M.A., Pronk, A.G. and Sinclair, W.D.
2017a: Indicator mineral signatures of Sn–W deposits: examples from the Mount Pleasant Sn–W–Mo–Bi–In deposit, New Brunswick, Canada. Journal of Geochemical Exploration, Volume 172, pages 151-166.

McClenaghan, M.B., Seaman, A.A., Parkhill, M.A. and Pronk, A.G.
2014: Till geochemical signatures associated with the Sisson W–Mo deposit, New Brunswick, Canada. Atlantic Geology, Volume 50, pages 116-137.

McConnell, J. and Ryan, B.
1996: The search for kimberlite and lamproite intrusions in northeastern Labrador: results of a surficial sediment survey and bedrock orientation study. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 96-1, pages 193-205.

Miller, R.R.
1994: Rare-metal metallogeny in Newfoundland and Labrador. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, NFLD/2727, 363 pages.

Oviatt, N.M., Gleeson, S.A., Paulen, R.C., McClenaghan, M.B. and Paradis, S.
2015: Characterization and dispersal of indicator minerals associated with the Pine Point Mississippi Valley-type (MVT) district, Northwest Territories, Canada. Canadian Journal of Earth Sciences, Volume 52, Number 9, pages 776-794.

Paulen, R., Plouffe, A., Smith, R. and Paradis, S.
2011: Pb and S isotopic composition of indicator minerals in glacial sediments from NW Alberta: Implications for Zn–Pb base metal exploration. Geochemistry: Exploration, Environment, Analysis, Volume 11, pages 309-320.

Plouffe, A., Ferbey, T., Hashmi, S. and Ward, B.C.
2016: Till geochemistry and mineralogy: vectoring towards Cu porphyry deposits in British Columbia, Canada. Geochemistry, Exploration, Environment and Analysis, Volume 16, pages 213-232.

Plouffe, A., McClenaghan, M.B., Paulen, R.C., McMartin, I., Campbell, J.E. and Spirito, W.A.
2013: Processing of unconsolidated glacial sediments for the recovery of indicator minerals protocols used at the Geological Survey of Canada. Geochemistry, Exploration, Environment and Analysis, Volume 13, pages 303-316.

Plouffe, A., Paulen, R.C., Smith, I.R. and Kjarsgaard, I.M.
2007: Chemistry of kimberlite indicator minerals and sphalerite derived from glacial sediments of northwest Alberta. Geological Survey of Canada, Open File 5545 (also Alberta Energy and Utilities Board, Alberta Geological Survey, Special Report 87)

Pochon, A., Beaudoin, G., Branquet, Y., Boulvais, P., Gloaguen, E. and Gapais, D.
2017: Metal mobility during hydrothermal breakdown of Fe–Ti oxides: insights from Sb–Au mineralizing event (Variscan Armorican Massif, France). Ore Geology Reviews, Volume 91, pages 66-99.

Ramezani, J., Dunning, G.R. and Wilson, M.R.
2002: Geologic setting, geochemistry of alteration, and U–Pb age of hydrothermal zircon from the Silurian Stog'er Tight Gold Propsect, Newfoundland Appalachians, Canada. Exploration and Mining Geology, Volume 9, Numbers 3 and 4, pages 171-188.

Ricketts, M.J.
1984: Coastal Labrador aggregate resources. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Open File LAB/0642, 174 pages.

1988: Aggregate review-1988. *In* Report of Activities. Government of Newfoundland and Labrador, Department of Mines, Geological Survey Branch, Report of Activities, page 112.

2011a: Granular-aggregate resources of the Davis Inlet map area (13N/15). Map 2011-33. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File 13N/15/0141.

2011b: Granular-aggregate resources of the Big Bay map area (13N/10). Map 2011-32. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File 13N/10/0140.

Ryan, B. and James, D.
2004: The Mesoproterozoic Nain Plutonic Suite and its country rocks in the Kingurutik Lake-Fraser River area, Labrador (NTS 14D/9 and 16). *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 04-1, pages 235-258.

Ryan, B. and McConnell, J.W.
1995: The search for kimberlite and lamproite intrusions in eastern Labrador: initial report of a bedrock and surficial-sediment sampling survey. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 95-1, pages 47-54.

Sandeman, H.A. and McNicoll, V.J.
2015: Age and petrochemistry of rocks from the Aucoin gold prospect (NTS map area 13N/6), Hopedale Block, Labrador. Late Archean, alkalai monzodiorite–syenite hosts Proterozoic orogenic Au–Ag–Te mineralization. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 15-1, pages 85-103.

Sandeman, H.A. and Rafuse, H.
2011: The geological setting of Au–Ag–Te mineralization at the Aucoin prospect, (NTS map area 13N/6) Hopedale Block, Labrador. *In* Current Research.

Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 11-1, pages 167-183.

Sparkes, G.W, Dunning, G.R. and McNicoll, V.J.
2010: New U–Pb age constraints and potential implications for the genesis of the Kitts uranium deposit, Central Mineral Belt, Labrador. *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 10-1, pages 93-109.

Spirito, W.A., McClenaghan, M.B., Plouffe, A., McMartin, I., Campbell, J.E., Paulen, R.C., Garrett, R.G. and Hall, G.E.M.
2011: Till sampling and analytical protocols for GEM Projects from field to archive. Geological Survey of Canada, Open File 6850.

Stockwell, C.H.
1963: Third report on structural provinces, orogenies and time-classification of the Canadian Shield. Geological Survey of Canada, Paper 63-17.

Sutton, J.S.
1971: Geological report on the area from English River to Iggiuk Bight in the Kaipokok Bay area, Labrador. British Newfoundland Exploration and Brinex Limited. Newfoundland and Labrador Geological Survey, Assessment File 13J/13/0086, pages 1-11.

Taylor, D.
2001: Newfoundland and Labrador striation database. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Open File NFLD/2195, version 4.

Taylor, F.C.
1971: A revision of Precambrian structural provinces in northeastern Quebec and northern Labrador. Canadian Journal of Earth Sciences, Volume 8, pages 579-584.

1977: Geology, Hopedale, Newfoundland. Geological Survey of Canada, 1443A, scale 1:250,000.

Thomas, A. and Morrison, R.S.
1991: Geological map of the central part of the Udjoktok River (NTS 13N/5 and parts of 13M/8 and 13N/6), Labrador (with accompanying notes). Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Map 91-160, scale 1:50 000.

Wares, R. and Leriche, P. D.
1996: Geological, geochemical and geophysical report on the Suture Property, central Labrador, Newfoundland, for work done September 5, 6, 7, and 9, 1995 on License # 3708M and 3709M, UTM 6151000 N and 600000 E. Labrador International Mining Company and The Labrador Nickel Syndicate: Pallaum Minerals Ltd., Swannell Minerals Corp. GSB# 013N/0101.

Wardle, R.J.
1983: Nain–Churchill Province cross-section, Nachvak Fiord, northern Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 68-90.

Wardle, R.J., Gower, C.F., Ryan, B., Nunn, G.A.G., James, D.T. and Kerr, A.
1997: Geological map of Labrador, Scale: 1:1 000 000. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Open File LAB/1226.

Wasteneys, H., Wardle, R., Krogh, T. and Ermanovics, I.
1996: U-Pb geochronological constraints on the deposition of the Ingrid Group and implications for the Saglek-Hopedale and Nain craton – Torngat orogeny boundaries. *In* Eastern Canadian Shield Onshore-Offshore Transect (ECSOOT). *Compiled by* R.J. Wardle and J. Hall. The University of British Columbia, Lithoprobe Secretariat, Report 57, pages 212-228.

Zhao, Y., Zhang, Y. and Bi, C.
1999: Geology of gold-bearing skarn deposits in the middle and lower Yangtze River Valley and adjacent regions. Ore Geology Reviews, Volume 14, Issues 3–4, pages 227-249.