Current Research (2018) Newfoundland and Labrador Department of Natural Resources
Geological Survey, Report 18-1, pages 1-13

QUATERNARY MAPPING AND TILL SAMPLING IN CORMACK (NTS 12H/06) AND SILVER MOUNTAIN (NTS 12H/11) MAP AREAS, WESTERN NEWFOUNDLAND

S. Hashmi
Terrain Sciences and Geoscience Data Management Section

ABSTRACT

Quaternary mapping and till sampling in NTS map areas 12H/06 (Cormack) and 12H/11 (Silver Mountain) were completed between June and August, 2017. This region is prospective for Au, bitumen/shale oil, Cu, Ni, PGEs and U; however, most of the bedrock is covered by glacial sediments deposited during the Late Wisconsinan, thus hindering mineral exploration.

The three main objectives of this project are to: 1) update the surficial geology maps for the two map areas, 2) reconstruct the glacial history of the region, and 3) carry out a regional till-sampling program to characterize the regional till geochemistry and mineralogy. A total of 208 till samples were collected for minor- and trace-element geochemistry, and 44 samples for indicator mineral separation. Preliminary ice-flow mapping (in conjunction with previous striation mapping) has identified two dominant ice-flow movements, an earlier east-northeastward movement and a subsequent southeast to southwestward movement. Surficial geology mapping has identified four distinct till units, derived from sedimentary rocks of the Deer Lake Basin, and felsic to intermediate and mafic rocks of the Long Range Inlier, all deposited during the same glacial event.

INTRODUCTION

A regional surficial geology mapping and till-sampling survey of NTS 12H/06 (Cormack) and 12H/11 (Silver Mountain) map areas was completed between June and August, 2017. The surficial geology for these two map areas has been mapped previously (*see* Batterson, 1994a, b; Vanderveer, 2011); however, more detailed mapping is now possible as there is better road and trail access. This region is prospective for Au, bitumen/shale oil, Cu, Ni, PGE and U (Geological Survey of Newfoundland and Labrador, 2016a); however, most of the bedrock is covered by surficial sediments associated with the last glaciation, thus hindering mineral exploration.

The three main objectives of this multi-year project are to:

1) Update the surficial geology maps for the Cormack and Silver Mountain map areas,

2) Reconstruct the glacial history of the region, and

3) Continue the regional till-sampling program for Newfoundland, thereby characterizing the regional till geochemical, mineralogical and lithological compositions and identify geochemical anomalies in till, potentially associated with unknown (and known) mineral occurrences.

LOCATION, ACCESS AND PHYSIOGRAPHY

The study area is located in western Newfoundland, in NTS 1:50 000-scale map areas 12H/06 (Cormack) and 12H/11 (Silver Mountain). It covers approximately 2000 km^2 and is located between latitudes 49°15′ and 49°45′N and longitudes 57°00′ and 57°30′W (Figure 1). This region is easily accessible by the Trans-Canada Highway (TCH), which passes through both map areas, as well as by several resource-access roads.

REGIONAL GEOLOGICAL SETTING

PHYSIOGRAPHY

The highest elevation in the study area is 636 m above sea level (asl), in the central part of the Cormack map area, immediately west of Adies Pond, and the lowest elevation is 25 m asl, where the Upper Humber River leaves the Cormack map area. The average elevation in the study area is approximately 275 m asl. Relief within the two map areas varies from low to high; although, local relief may exceed

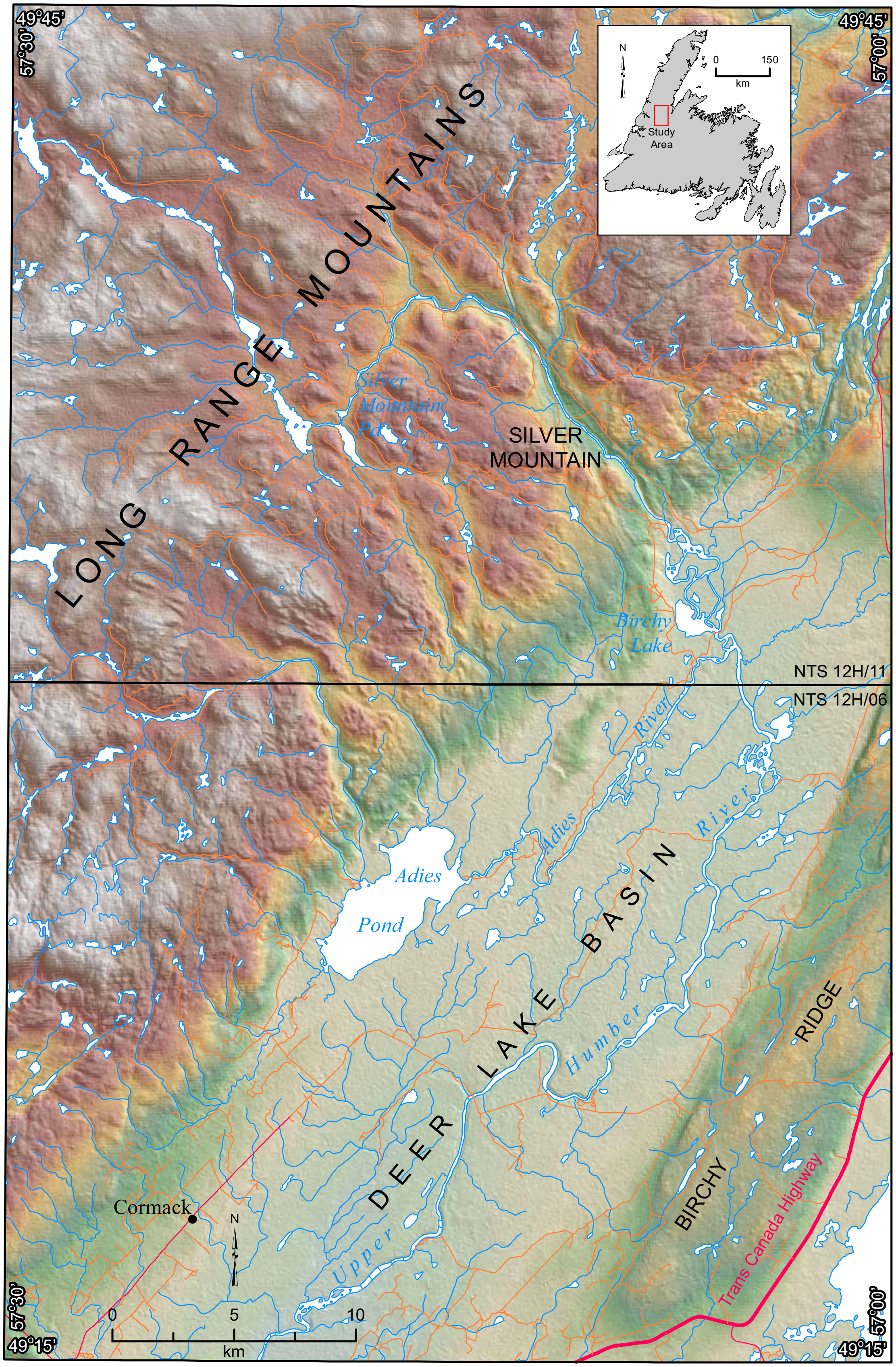

Figure 1. *Location, access and physiography of the study area.*

100 m. This region is poorly drained with numerous swamps in low-lying areas. The southeastern part of the Long Range Mountains is located in the northwest corner of the Cormack, and west-central Silver Mountain map areas. Birchy Ridge, which forms a topographic high (280 m asl), is located in the southeastern part of the Cormack map area (Batterson, 2003). Amongst the major drainages, Whites River flows in the west-central Cormack map area and drains into Adies Pond. Adies River and the Upper Humber River flow through the east-central Cormack map area, and the Upper Humber River flows through the west-central portion of the Silver Mountain map area.

The topography is strongly influenced by the underlying bedrock (*see* below). Highly resistive intrusive rocks (*i.e.*, granitoid and gneissic rocks of the Long Range Inlier) in the northwest and west-central study area form moderately to steeply sloping, sparsely vegetated topographic highs, whereas sedimentary rocks (of the Deer Lake Basin) form flat to undulating topography at lower elevations in the central and east-central parts of the Cormack map area, as well as the southeastern part of the Silver Mountain map area. Vegetation is dominated by spruce, fir, birch, aspen and alder.

BEDROCK GEOLOGY

The bedrock geology of the study area is summarized after earlier works by Colman-Sadd *et al.* (1990); Hinchey (2010); Minnett *et al.* (2010); Ivany (2011) and Sparkes (2011) (Figure 2). The study area lies within the Humber (tectonostratigraphic) Zone, consisting of Paleo- to Mesoproterozoic basement rocks, intruded by later, granitoid rocks and mafic dykes. These basement rocks are overlain by Neoproterozoic to Middle Ordovician sedimentary rocks and Carboniferous, shallow-marine and non-marine sedimentary rocks deposited within the Deer Lake Basin.

The oldest rocks within the study area consist of pre-Grenvillian granitoid, orthogneiss (including mafic varieties), and paragneiss and associated granitoid rocks of the Long Range Inlier, mapped in the west-central Silver Mountain and northwestern part of the Cormack map areas. These rocks are intruded by Meso- to Neoproterozoic granitoids, comprising the Main River and Potato Hill plutons, all of which are crosscut by later (600 Ma) Long Range dykes and are overthrust by a klippe of Neoproterozoic to Middle Ordovician siliciclastic and carbonate rocks in the north-central part of the Cormack map area. Early to Late Silurian volcanic and siliciclastic non-marine rocks of the Sops Arm Group are present in the northeastern part of the Silver Mountain map area and include ash-flows, unwelded tuff, rhyolite flows, volcanic breccia and sandstones. The youngest rocks in the study area are Devonian to Carboniferous marine and non-marine sedimentary rocks mapped in the Deer Lake Basin. Within the Cormack map area, these consist of the North Brook, Rocky Brook and Humber Falls formations. Of these, the North Brook Formation comprises red to grey arkosic sandstone and conglomerate, and red siltstone and pink to grey micritic limestone. The Rocky Brook Formation consists of red and grey siltstone, green, grey and black mudstone, red sandstone and minor shale oil. The Humber Falls Formation comprises light-grey, pink, red, orange and light-green sandstone and mudstone.

MINERALIZATION

Mineral occurrences present within the study area include U, bitumen/shale oil and Au–Cu–Ni. All mineral occurrences discussed below have been sourced from the Mineral Occurrence Database System (MODS) at the Geological Survey of Newfoundland and Labrador.

Uranium

Active exploration for U began in the mid-1970s, following the discovery of U-bearing float (containing up to 11.5% U_3O_8 and up to 859 oz/ton Ag) by Westfield Minerals Ltd. (Ivany, 2011; Sparkes, 2011). Uranium occurrences located within the Cormack map area are associated with sedimentary rocks of the Deer Lake Basin, as well as the Long Range inlier granitoids and gneiss (*ibid*).

The Deer Lake Basin sedimentary rocks are highly prospective for U mineralization and host several U and Th occurrences. Uranium mineralization associated with sedimentary rocks of the Deer Lake Basin falls into three styles, hosted by:

1) The unconformity between the North Brook Formation and the underlying carbonate and metasedimentary rocks along the western edge of Deer Lake Basin,
2) Sandstone, siltstone and mudstone of the Rocky Brook Formation, and
3) Sandstone of the Humber Falls Formation.

The most notable U occurrences comprise the following: Wigwam Brook, a stratabound sandstone-hosted U prospect (Geological Survey of Newfoundland and Labrador, 2016a); Reid Lot 218, an undivided stratabound prospect in clastic sedimentary rocks; and, Mistaken Point, an undivided, epigenetic stratabound deposit in carbonate rocks.

Uranium-bearing minerals include coffinite, uraninite and brannerite (Ivany, 2011). Silver has been noted as a secondary commodity in mineralization hosted in the Humber Falls Formation (*ibid*).

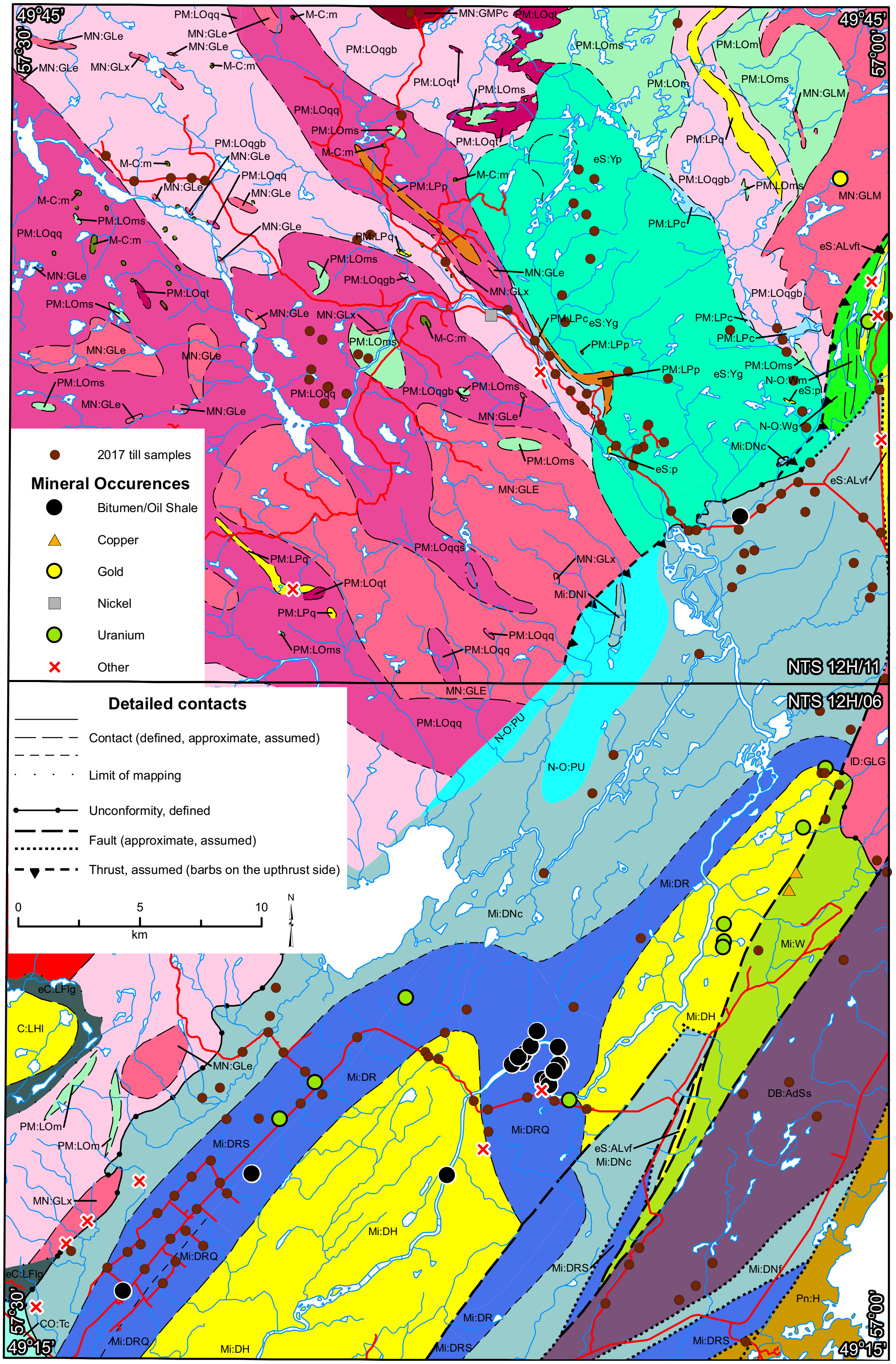

Figure 2. *Detailed bedrock geology of the study area. Modified after Colman-Sadd* et al. *(1990).*

Post-Ordivician Units

Overlap Sequences

Pennsylvanian

Howley Formation

Pn:H — Grey to red sandstone, pebble–cobble conglomerate and siltstone, black carbonaceous shale, minor bituminous coal

Mississippian

Deer Lake Group

Humber Fall Formation

Mi:DH — Very light grey, light orange and red sandstone, pink to grey, pebble to cobble conglomerate, and mostly red, but also grey siltstone

Rocky Brook Formation

Mi:DRQ — Squires Park Member: Grey to green siltsone, grey to green and black mudstone, grey dolomitic limestone and calcareous dolostone, dark brown oil shale, very rare gypsum in drill core

Mi:DRS — Spillway Member: Grey to red and brown, calcareous siltstone, grey to green mudstone, grey to cream and orange-weathering calacareous dolostone and dolomitic limestone, rare grey to red sandstone, and dark brown oil shale

Mi:DR — Red calcareous siltstone and fine-grained sandstone, grey to green, siltstone and mudstone, black mudstone, grey calcareous dolostone, dolomitic limestone and dolomitic oil shale

North Brook Formation

Mi:DNl — Grey limestone breccia and limestone

Mi:DNf — Red to grey sandstone and interbedded red siltstone; lithologies arranged in a fining-upward sequence

Mi:DNc — Mainly red to grey, pebble to boulder conglomerate and interbedded red to grey sandstone

Wigwam Brook Formation

Mi:W — Red, brown and grey sandstone; grey to red, pebble to boulder conglomerate; grey limestone

Late Devonian to Mississippian

Anguille Group (Deer Lake Basin)

Saltwater Cove Formation

DB:AdSs — Dark grey sandstone and siltstone (locally dolomitic), black carbonaceous shale and mudstone, interbedded with light grey sandstone, pebbly sandstone, and pebble to cobble conglomerate; rare limestone and dolostone

Early to Late Silurian

Sops Arm Group

Lower volcanic formation

eS:ALvf — Predominantly ash-flow tuffs and rhyolite flows, but also including unwelded tuff and volcanic breccia

eS:ALvft — Ash-flow tuff, welded and unwelded

Intrusive Rocks

Early Silurian to Late Devonian

Gull Lake intrusive suite

Gales Brook granite

lD:GLG — Megacrystic and fine-grained biotite granite, biotite granite porphyry, chlorite-altered granite, and biotite ± muscovite microgranite dykes

Early Silurian

Taylor Brook gabbro

eS:Yp — Stock and dykes of massive pegmatitic leucogabbro, cutting layering of main Taylor Brook gabbro intrusion

eS:Yg — Typically medium-grained, mesocratic, layered gabbro, containing calcic plagioclase and various combinations of olivine, augite and orthopyroxene; minor fine-grained pyroxene-bearing diorite

eS:p — Tan to rose, massive to schistose, very fine-grained felsic porphyry

Laurentian Margin

Humber Zone (Shelf and Related Rocks)

Middle Cambrian to Early Ordovician

Port au Port Group

CO:Tc — Recrystallized limestone and deformed grey to white marble, derived by metamorphism of Port au Port Group

Neoproterozoic to Middle Ordovician

Undivided sedimentary units of Humber Zone

N-O:PU — Marble, variably recrystallized dolostone, quartzite and schist, probably derived from the Labrador, Port au Port, St. George and/or Table Head groups

Neoproterozoic to Middle Cambrian

Labrador Group

Hawke Bay Formation

C:LHlm — Green to brown, quartz phyllite and schistose quartzite with minor chlorite–magnetite schist

C:LHl — Thick, massive to crossbedded, white and pink quartzite; thin- to medium-bedded, white, green and brown sandstone with minor conglomerate, shale and limestone

Forteau Formation

eC:LFlg — Medium- to thin-bedded, alternating grey and green shale and grey to buff-weathering, limy siltstone and limestone; limestone with archeocyathids at base where unit overlies Bradore Formation; locally includes thin unit of green quartz sandstone and arkosic sandstone at base (representing Bradore Formation); grey calcareous phyllite and schist adjacent to Long Range Inlier

Bradore Formation

eC:LBl — Medium to coarse, grey-green, arkosic sandstone, quartz–pebble conglomerate, and minor shale

Late Mesoproterozoic to Late Cambrian

M-C:m — Dark green, medium-grained, amphibole-bearing metagabbro, typically with subophitic texture

Late Mesoproterozoic to Neoproterozoic

Grenvillian granitoid rocks

Potato Hill pluton

MN:GMPc — Coronitic charnockite

MN:GLx — Potassium feldspar–megacrystic biotite ± hornblende granite

MN:GLe — Biotite ± hornblende granite

MN:GLP — Garnetiferous biotite ± hornblende granite

Main River pluton

MN:GLM — Pink, massive to foliated, potassium feldspar–megacrystic biotite ± hornblende granite

East Adies River pluton

MN:GLE — Medium-grained biotite–hornblende granite

Rex Lake pluton

MN:GLR — Pink, fine- to medium-grained, variably epidotized leucogranite

Lomond River pluton

M3:GGD — Coarse-grained to megacrystic biotite ± hornblende granodiorite

Late Paleoproterozoic to Mesoproterozoic

Long Range gneiss complex

PM:LOqqs — Grey, medium-grained, quartzofeldspathic biotite schist

PM:LOqq — Green-grey, medium-grained, flecky-textured, biotite ± hornblende ± hypersthene, quartz dioritic to locally granodioritic gneiss

PM:LOqgb — Granitic to granodioritic biotite gneiss; locally migmatitic

PM:LOqt — Orthopyroxene-bearing tonalitic and quartz dioritic gneiss

PM:LOms — Dark green, medium-grained, amphibole-bearing, dioritic gneiss and amphibolite

PM:LOm — Amphibolite, dioritic gneiss, and mesocratic to mafic gneiss; minor meta-ultramafite

PM:LPc — Buff, grey or white, medium-grained, forsterite ± diopside marble; talc ± tremolite(?) marble; dark grey, forsterite-phlogopite ± diopside ± spinel calc-silicate rock; rare, layered, wollastonite-clinopyroxene–bytownite calc-silicate rock

PM:LPp — Pelitic gneiss, locally associated with quartzite or mafic gneiss

PM:LPq — Quartzite and quartz-rich gneiss

Humber Zone (Slope and Related Rocks)

Neoproterozoic to Early Ordovician

Southern White Bay Allochthon

N-O:Wg — Fine- to medium-grained, dark green to grey greywacke; rare quartz–pebble conglomerate. Maiden Point Formation equivalents.

Iapetus Ocean

Dunnage Zone (Notre Dame Subzone)

N-O:Wm — Dark green, medium-grained metadiorite and mafic schist (epidote + chlorite + albite schist)

Figure 2 Legend.

Bitumen and Shale Oil

Several bitumen and shale oil occurrences have been reported for the Cormack map area, including Cormack I, Squires Park VIII and Squire Park XI (Hyde and Ware, 1980; Geological Survey of Newfoundland and Labrador, 2016a). Most of these occurrences are associated with sedimentary rocks of the Rocky Brook Formation. Here, bitumen and shale oil saturate calcareous red, grey and green mudstone, siltstone and dolomitic limestone. Some sedimentary rocks hosting brown shale oil also contain fossilized fish and plants.

Gold, Copper and Nickel

The only Au occurrence present within the study area is the Viking Gold (Viking Trend) prospect, located in the northeast part of the Silver Mountain map area (Geological Survey of Newfoundland and Labrador, 2016a). It has been explored by Northern Abitibi Mining Corporation (now CANEX Metals Inc.; Ebert, 2009). Mineralization is hosted within the Main River (granitoid) pluton that intrudes the Long Range Inlier rocks. The primary commodity is Au, which occurs as 50 micron particles and as electrum, hosted within quartz veinlets and as inclusions in sulphides (Minnett *et al.*, 2012). Secondary commodities are Ag, Cu, Pb and Zn, which are hosted within chalcopyrite, galena and sphalerite, and are reported to occur as both low-grade disseminations and high-grade veins (*ibid*).

A Ni showing, with subordinate Cu, Co and platinum-group elements (PGEs), named Layden (or Taylors Brook), is located in the centre of the Silver Mountain map area and has been previously explored by Northern Abitibi Mining Corporation (Geological Survey of Newfoundland and Labrador, 2016a). Massive to semi-massive sulphides identified within this prospect include pyrrhotite, chalcopyrite and pentlandite, and are hosted within the Taylor Brook gabbro, that intrudes the Long Range gneisses.

QUATERNARY GEOLOGY

This summary of the regional and local Quaternary framework, *i.e.*, the glacial and deglacial events associated with the Late Wisconsinan glaciation on the Island of Newfoundland, is based on work by Grant (1974, 1989); Batterson and Liverman (2001); Batterson (2003); Shaw *et al.* (2006); Batterson and Taylor (2008) and Putt *et al.* (2010).

Glaciers that affected Newfoundland were part of the Appalachian Ice Complex, characterized by smaller ice caps originating within the Long Range Mountains and The Topsails, and resulted in a complex ice-flow history for the region (Batterson and Liverman, 2001). The Laurentide Ice Sheet (LIS) as proposed by Shaw *et al.* (2006) coalesced with the glaciers developed within Newfoundland during glacial maximum; however, the LIS likely did not affect glacial flow within the study area.

At the onset of Late Wisconsinan glaciation, the study area was covered by glaciers originating in the Long Range Mountains, where topographically controlled glacial movement was east-southeast. Batterson (2003) proposed that ice from The Topsails covered the lower part of the Humber River Valley (south of the Cormack map area); however, its influence on the ice flow within the study area is unknown. The Topsails ice did, however, cross into Sandy Lake (which straddles the eastern boundary of the Cormack map area) and flowed out into White Bay.

As glaciation progressed, an ice divide formed along the axis of the Long Range Mountains, resulting in a southwestward-oriented glacial movement (Batterson, 2003). This proposed ice divide likely continued throughout the Late Wisconsinan, eventually disintegrating (*ca.* 12 000 years BP) as deglaciation proceeded.

Ice retreat may have commenced between 13 000–10 000 years BP. Ice sheets disintegrated primarily *via* ablation and ice-stagnation, becoming isolated and shrinking into multiple ice-caps (Grant, 1974; Shaw *et al.*, 2006). As this continued, ice sheets became topographically controlled as they retreated back toward the Long Range Mountains (Grant, 1974; Shaw, 2006). Shelf ice-caps persisted until 11 000 years BP (Shaw *et al.*, 2006), when the Younger Dryas cooling period resulted in a limited glacial readvance (Shaw *et al.*, 2006). Deglaciation was mainly complete by 10 000 years BP (Grant, 1974; Shaw *et al.*, 2006).

REGIONAL ICE FLOW

The regional ice flow has been summarized previously by Batterson (2003; Figure 3) who described the glacial flow during glacial onset, maximum and deglaciation. Bi-directional, micro ice-flow indicators, such as striations and grooves and uni-directional, macro ice-flow indicators, such as crag-and-tail features, have previously been mapped in this region (Batterson, 2003). These previously mapped ice-flow indicators show that the initial ice movement, likely originated in the Long Range Mountains and Birchy Ridge.

In the west-central Cormack map area, the measured orientations of striations and grooves preserved on protected bedrock lees (and protected from later flows) range from 060° to 090°, indicating an east-northeastward flow (Geological Survey of Newfoundland and Labrador, 2016b). Micro ice-flow indicators (striations and grooves), pre-

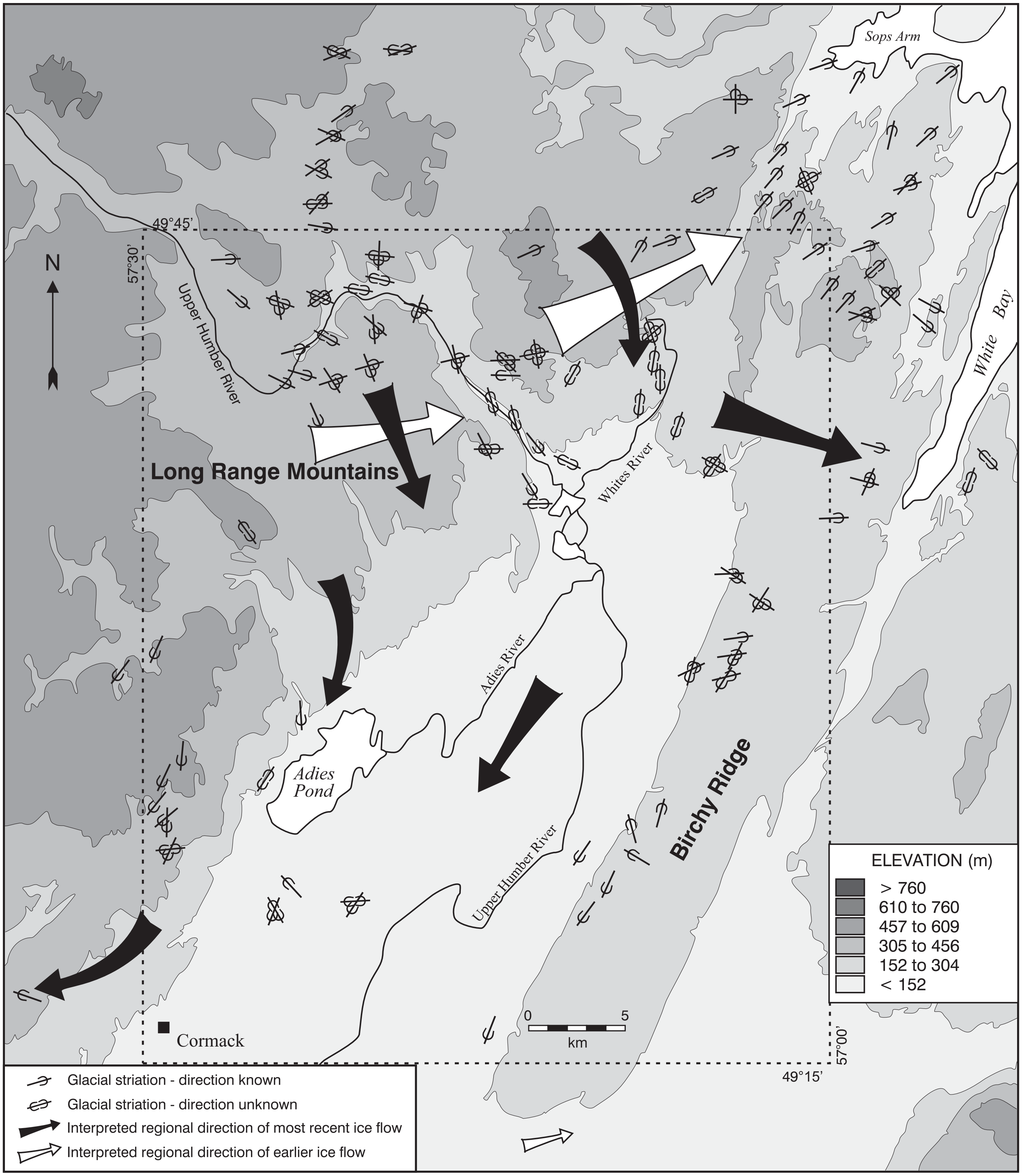

Figure 3. *Regional ice flow during glacial onset and glacial maxima. Modified after Batterson (2003).*

served on bedrock lees, were also measured atop northern Birchy Ridge. Their orientations range from 015° to 065°, indicating a north-northeastward ice-flow movement. In the centre of the Silver Mountain map area, orientation measurement of striations and grooves preserved on bedrock lees range 055° to 110° suggesting an earlier northeast to southeastward ice movement (*ibid*). Orientation measurements of micro ice-flow indicators preserved on “flat” and “top” bedrock surfaces in the west-central Cormack map area vary from 185° to 235°, indicating a south-southwestward flow, and those in the centre of the Silver Mountain map area, range from 160° to 215°, suggesting a southeast to southwestward flow (*ibid*).

Ice-flow reconstruction suggests that at the onset of the last glaciation, glacial ice accumulated in the Long Range Mountains and flowed east-northeastward into the study area. This initial ice flowed out into White Bay, east (and outside) of the study area. Striation orientation data from Birchy Ridge suggest that glacial ice developed here as well, and flowed out radially. As glaciation reached its maximum, ice in the Long Range Mountains thickened enough to create an ice divide along its axis, deflecting glacial movement from east-southeast to southeast to southwest.

METHODS

Till sampling and surficial geology mapping, with truck, all-terrain vehicle (ATV) and helicopter-assisted support, were completed between June and August, 2017.

MAPPING

Surficial geology will be mapped on aerial photographs and will be completed with the aid of ground-truthed surficial data collected during the field season, on a Trimble GPS unit. Information entered at mapped stations includes GPS coordinates, elevation, sediment type and characteristics and geomorphic signature. Orientation measurements of ice-flow indicators such as striations and grooves were also made at select sites (Plate 1A).

SAMPLING

Till sampling was completed following the sampling protocol of the Geological Survey of Newfoundland and Labrador (GSNL). Samples were taken at intervals of 1 km along forestry roads and trails, using truck and ATVs as well as by foot traverse. Inaccessible regions within the Cormack map area were sampled using a helicopter, where a sample spacing of one per 2–4 km^2 was followed. Equipment used for sampling till included a mattock, a shovel and a geological pick. At each site, the sediment face was cleaned and dug out to expose C-horizon till (Plate 1B). Most of the samples collected were C-horizon; however, at a few sites, B/C horizon till was sampled. C-horizon till is the optimal surficial medium to sample as it is mostly unaffected by physical and chemical weathering processes such as surface washing, pedogenesis, remobilization *via* gravity and/or element mobility *via* hydromorphic dispersion (Levson, 2001).

At each site, 2 to 3 kg of material were collected for geochemical analysis. Field duplicates were taken every 12 to 15 samples, to test site variability. A 10–15 kg bag of material was also collected at select sites for heavy-mineral separation, provided that abundant, accessible C-horizon till was available. Information collected at each sample site included: 1) GPS coordinates, 2) site description, 3) till colour, 4) relative percentages of clast and matrix (*i.e.*, % sand, silt and clay), and 5) general site observations such as

Plate 1. *A) Ice-flow measurement from striations and grooves on flat bedrock surface, taken in the north-central Silver Mountain map area. Bi-directional arrows indicate the ice-flow movement; B) Till sample site 17SH111-1099 in the central portion of the study area is scraped to expose C-horizon till.*

evidence of agricultural activity in the vicinity. Weathering and soil-horizon information were also recorded, and photographs taken at each site.

SAMPLE PREPARATION

Till samples collected for geochemistry have been submitted to the GSNL laboratory for preparation and analysis. Samples were dried and sieved to the -63 µm fraction (230 mesh) to recover the silt and clay fraction. This fraction is considered to be the optimal size fraction for analysis for two reasons:

1) It is easy, time- and cost-effective to sieve, and

2) Ore minerals, especially sulphides, are preferentially concentrated into this fraction, and as a result enriched with respect to the background (Levson, 2001; Spirito *et al.*, 2011; Hashmi *et al.*, 2015).

QUALITY ASSURANCE AND QUALITY CONTROL

Several measures were taken to ensure the integrity of the samples. Sampling tools were cleaned before the collection of each new sample to reduce the risk of cross-contamination. Field duplicates were taken to test site variability and reproducibility of results.

ANALYTICAL TECHNIQUES

Sieved samples will be analyzed at the Geological Survey's laboratory in St. Johns, where minor- and trace-element content will be analyzed using inductively coupled plasma-optical emission spectroscopy (ICP-OES) after a multi-acid ($HF/HCl/HNO_3/HClO_4$) digestion. Samples will also be sent for instrumental neutron activation analysis (INAA) to Maxxam Analytics (Mississauga).

PRELIMINARY FIELD RESULTS

MAPPING

Separate surficial geology maps, at 1:50 000 scale, are currently being completed for the Cormack and Silver Mountain map areas. Preliminary observations made in the field (and interpreted from air photographs) include the following:

The oldest and most extensive surficial deposit consists of lodgement till, deposited during glacial advance. It is a thin veneer over bedrock (*i.e.*, <1.5 m thick) on moderate to steep slopes, as a till blanket (*i.e.*, >1.5 m thick) on moderate slopes, and as a till-organic composite on flat terrain. The till is derived locally from *in situ* bedrock based on till colour and clast types. Four distinct tills have been identified in the study area and are inferred to have been deposited during the same glacial event.

Till A

Till A is a massive, greyish brown to light brown, silty sand (Plate 2A). It has a low clast content (field estimate 15–25%) and 75–85% fines, *i.e.*, sand, silt and clay. This till exhibits fissility and contains faceted, bullet-shaped, predominantly cobble-sized clasts. Clast types identified are predominantly of grey siltstone and olive-green to grey mudstone. Based on colour and clast types, this till is likely derived from rocks of the Rocky Brook and Humber formations.

Till B

Till B is a massive, reddish brown to maroon, silty sand (Plate 2B). It has a moderate clast content (20–40%, red sandstone and minor quantities of mafic intrusive rock) and approximately 60–80% fines. This till shows good fissility, and the clasts are dominantly pebble- to cobble-sized, silt-capped, faceted and bullet-shaped. Based on colour and clast types, this till is inferred to have likely been derived from the Fe-rich sandstones of the Rocky Brook Formation.

Till C

Till C is a light, pearly pink brown, massive, silty sand and has a high clast content (>40%) (Plate 2C). This till shows no fissility and has faceted, silt-capped, bullet-shaped clasts. Clast types identified within this till are predominantly of felsic to intermediate intrusive rocks. Based on its colour and clast types, this till is likely derived from Grenvillian granitic rocks (*e.g.*, K-feldspar-rich Main River granite) and Long Range gneisses.

Till D

Till D is a grey to dark grey, massive, silty sand (Plate 2D). It has a medium to high clast content (30–40%) and approximately 60–70% fines. This till shows excellent fissility, and the clasts are faceted, silt-capped and bullet-shaped. Dominant clast types are of mafic to ultra-mafic intrusive rock. Based on the colour and clast types present, this till is inferred to have been derived from the mafic intrusive rocks of the Long Range Inlier as well as the Taylor Brook gabbro and/or the mafic Long Range dykes mapped throughout the study area.

Sediments associated with deglaciation include the following:

Plate 2. *Four distinct till types identified in the study area. A) Till sample 17SH111-1021 taken over Rocky Brook Formation rocks, in west-central Cormack map area; B) Till sample 17SH111-1038 taken over North Brook Formation rocks, in west-central Cormack map area; C) Till sample 17SH111-1066 taken over Taylor Brook gabbro, in central part of the study area; D) Till sample 17SH111-1131 taken over Long Range Inlier rocks, in west-central Silver Mountain map area.*

1. Unsorted, very fine to coarse sand and granule- to boulder-sized gravel are recorded in the northwest portion of NTS map area 12H/06 (within the Long Range Mountains; Plate 3A). The glacial sediment deposits form a hummocky topography likely associated with ice-stagnation in valleys during deglaciation.

2. Esker deposits, comprising crudely stratified, fine to coarse sand and granule- to pebble-sized gravel have been identified in the south-central Cormack map area (Plate 3B).

3. Normally graded, fine to medium sand (grading into granule- to pebble-sized gravel) has been identified in the northeastern Silver Mountain map area (Plate 3C). These deposits may represent littoral/nearshore deposits, possibly associated with small-scale localized meltwater ponding (?).

Postglacial sediments include alluvial and organic deposits. Alluvial deposits comprising sand, silt, minor clay and granule- to boulder-sized gravel have been mapped along modern river channels, including the Upper Humber, Whites and Adies rivers.

Organic deposits such as bog and fen have been mapped at low to moderate elevations (Plate 3D). They generally occur in bedrock depressions, and over till blanket. Most organic material has been mapped as a drift-organic or bedrock-organic composite.

SUMMARY OF FIELDWORK AND FUTURE WORK

A two-month Quaternary mapping and sampling program was undertaken in the Cormack (NTS 12H/06) and

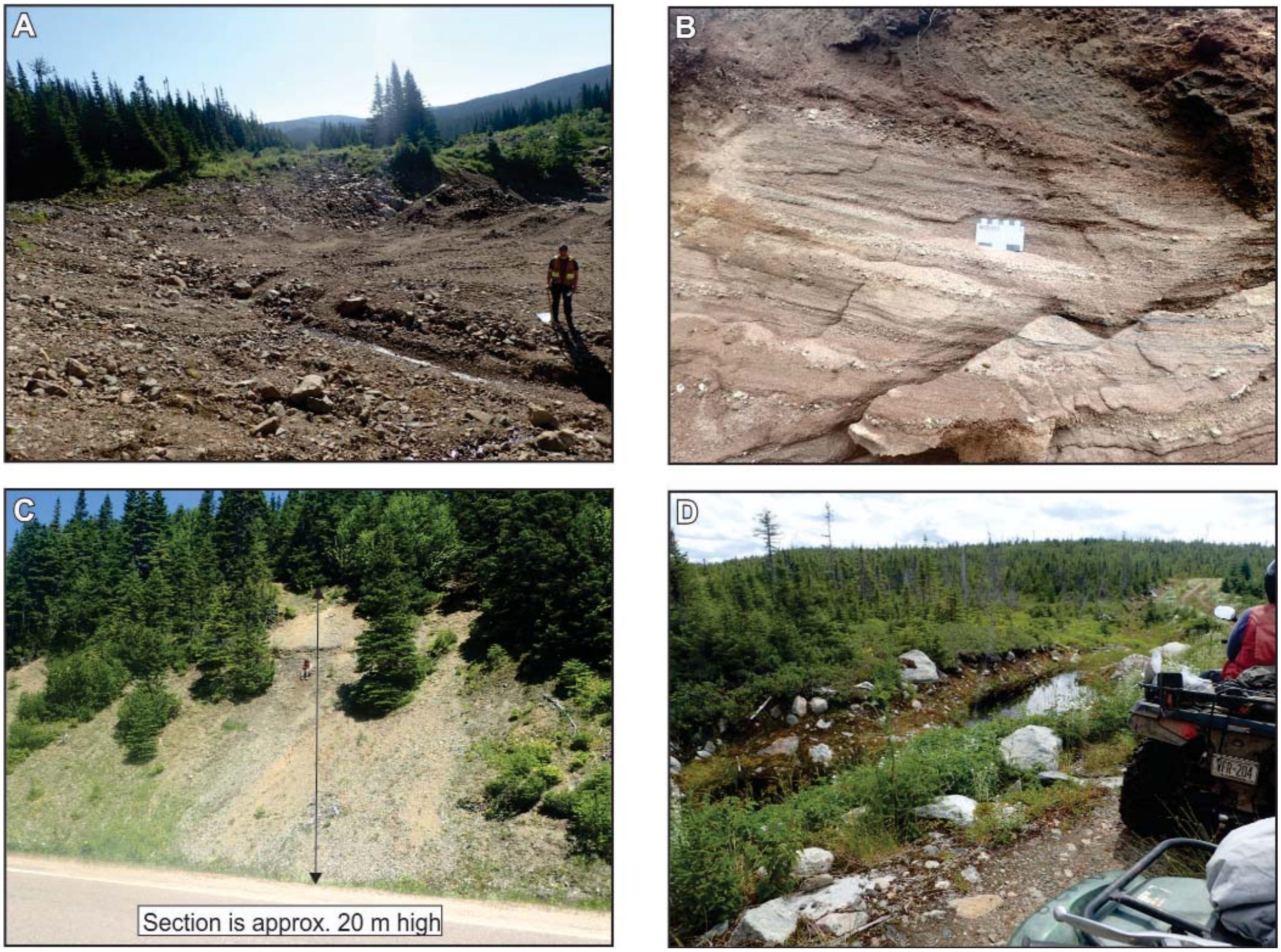

Plate 3. *A) Sand and gravel forming hummocky topography, mapped in the northwest corner of the Cormack map area; B) Crudely stratified sand and granule- to pebble-sized gravel mapped in the southwest corner of the Cormack map area; C) 20-m-high section comprising sand and grading downward to cobble-sized gravel mapped in the northeast corner of the Silver Mountain map area, D) Organic-till complex mapped at low elevations in the north-central Silver Mountain map area.*

Silver Mountain (NTS 12H/11) map areas. This region was previously mapped almost 30 years ago and is prospective for Au, bitumen/shale oil, Cu, Ni and U. Therefore, the three main objectives of this study are to: 1) update the surficial geology of the two map areas, 2) reconstruct the glacial history of the region; and 3) carry out a regional till-sampling program to characterize the regional till geochemistry.

ACKNOWLEDGMENTS

The following are acknowledged for their help with various aspects of this project: Steve Amor, Martin Batterson and Heather Campbell are thanked for their help with project generation, logistical support and guidance throughout the course of the fieldwork. Larry Hicks, Hamish Sandeman and Greg Sparkes are thanked for providing insight into the bitumen/shale oil, Au and U mineralization potential of the region, respectively. Brittany Baker, David Haines, Peter Macintosh, Sandra Murphy and Cody Spurrell provided enthusiastic field assistance. Andy and Roseann White of Rocky Brook Cabins in Cormack, and Laureen Britt of Hampden, are thanked for providing lodgings. Field support was provided by Gerry Hickey. Steve Amor, Heather Campbell, Pauline Honarvar, Bruce Ryan and Hamish Sandeman reviewed earlier drafts of this report.

REFERENCES

Batterson, M.J.
1994a: Ice-flow indicators, Cormack map sheet (12H/06). Map 94-083. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Open File 12H/1286.

1994b: Surficial geology and landform classification of the Cormack map sheet (NTS 12H/06). Map 94-121. Government of Newfoundland and Labrador, Department of Mines and Energy Geological Survey Branch, Open File 12H/1289.

2003: Quaternary geography and sedimentology of the Humber River Basin and adjacent areas. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 03-2, 194 pages.

Batterson, M.J. and Liverman, D.G.
2001: Contrasting styles of glacial dispersal in Newfoundland and Labrador: methods and case studies. *In* Prospecting in Areas of Glaciated Terrain. *Edited by* M.B. McClenaghan, P.T. Bobrowsky and N.J. Cook. The Geological Society, Special Volume 185, pages 267-285.

Batterson, M.J. and Taylor, D.
2008: Ice-flow history and regional till-geochemistry sampling of the southern part of the Red Indian Lake Basin. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 08-1, pages 25-34.

Colman-Sadd, S.P., Hayes, J.P. and Knight, I. (compilers)
1990: Geology of the Island of Newfoundland. Map 90-01. Scale 1:1 000 000. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Open File NFLD/2192.

Ebert, S.
2009: Seventh year assessment report on drilling and trenching at the Viking property, mineral licenses 014079M, White Bay area, Newfoundland, NTS sheets 12H/10 and 12H/11, GeoFile Number: 012H/2003.

Geological Survey of Newfoundland and Labrador
2016a: Mineral Occurrence Database System (MODS). Newfoundland and Labrador Geoscience Atlas Online. http://gis.geosurv.gov.nl.ca/resourceatlas/viewer.html.

2016b: "Striation Database" Newfoundland and Labrador GeoScience Atlas OnLine. Last update: 2016. http://geoatlas.gov.nl.ca/. [retrieved 30th August 2017].

Grant, D.R.
1974: Prospecting in Newfoundland and the theory of multiple shrinking ice caps. *In* Report of Activities. Geological Survey of Canada, Paper 74-1B, pages 215-216.

1989: Quaternary geology of the Atlantic Appalachian region of Canada. *In* Quaternary Geology of Canada and Greenland. *Edited by* R.J. Fulton. Geological Survey of Canada, Geology of Canada, No. 1, pages 391-440.

Hashmi, S., Ward, B.C., Plouffe, A. and Leybourne, M.I.
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.

Hinchey, A.M.
2010: Geology of the northern portion of the Silver Mountain map area (NTS 12H/11), southern Long Range Inlier, Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 10-1, pages 245-263.

Hyde, R.S. and Ware, M.J.
1980: Geology of Carboniferous strata in the Cormack (12H/6) and Silver Mountain (12H/11) map areas. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 29-36.

Ivany, J.C.
2011: Mineralogical and geochemical comparisons of mineralized and non-mineralized sandstones from the Rocky Brook uranium prospect, Deer Lake Basin, western Newfoundland. Department of Earth Sciences, Memorial University of Newfoundland and Labrador, St. Johns, B.Sc. thesis, 172 pages.

Levson, V.
2001: Regional till geochemical surveys in the Canadian Cordillera: sample media, methods and anomaly evaluation. *In* Prospecting in Areas of Glaciated Terrain. Geological Society of London, Special Publications 2001, Volume 185, pages 45-68.

Minnett, M., Sandeman, H.A. and Wilton, D.
2010: Regional setting of gold mineralization at the Viking property, southern White Bay, Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 10-1, pages 51-64.

2012: Geochemistry of the host rocks and timing of gold-electrum mineralization at the Viking property, Newfoundland. *In* Current Research. Government of

Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 12-1, pages 61-84.

Putt, M.M., Bell, T., Batterson, M.J. and Smith, J.S.
2010: Late Wisconsinan ice-flow history of the tip of the Northern Peninsula, northwestern Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 10-1, pages 171-182.

Shaw, J., Piper, D.J.W., Fader, G.B.J., King, E.L., Todd, B.J., Bell, T., Batterson, M.J. and Liverman, D.G.E.
2006: A conceptual model of the deglaciation of Atlantic Canada. Quaternary Science Reviews, Volume 25, pages 2059-2081.

Sparkes, G.
2011: Uranium mineralization in Newfoundland: an overview of geological characteristics and metallogenic affinities. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 11-1, pages 185-214.

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, 83 pages.

Vanderveer, D.G.
2011: Surficial geology of the Silver Mountain map area (NTS 12H/11). Map 2011-02. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File 012H/11/2058.