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QUATERNARY GEOLOGY OF THE SNEGAMOOK LAKE AREA, CENTRAL MINERAL BELT, LABRADOR[1]

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ABSTRACT

Quaternary mapping and geochemical sampling (lake sediment and till) were carried out in the Snegamook Lake area of Labrador. Upland areas have little glacial cover and the bedrock is glacially sculpted. Lowlands and valleys contain glaciofluvial sediments, mainly in the form of subaerially deposited outwash. Till deposits of varying thickness blanket the rest of the landscape. In areas of granitic bedrock, till is thick and hummocky, and contains abundant large boulders. East of the Seal Lake Group red sandstones and shales, the till has a red hue due to its derivation from this bedrock source. Glacial landforms include eskers, drumlins and minor moraines. The major ice-flow direction was northeast, followed by a later, more topographically controlled flow (northeast to east-southeast); the secondary flow likely occurred after the last glacial maximum. Regional flow trends are similar to those described for the study area, and an ice divide is implied for the Naskaupi River area. A re-evaluation of the Sebaskachu Moraine indicates that no major deglacial stillstands are recorded for this region.

INTRODUCTION

The Central Mineral Belt of Labrador, an east–west-trending suite of rocks that hosts a number of different mineral occurrences, has been a site of mineral exploration since 1929 (Wilton, 1996). Much of the exploration was carried out in the 1950s, mainly by BRINEX (Wilton, 1996). Currently, iron-oxide copper–gold (IOCG) type deposits and uranium are of interest in the area. This study builds on earlier work to the east and northeast of the study area by Batterson *et al.* (1987, 1988), which describes glacial history and Quaternary geology; and additional work by Batterson and Taylor (2004), which describes the regional till geochemistry of the study area. This paper discusses the Quaternary geology and glacial history of the Snegamook Lake region (NTS map areas 13K/3, 13K/6 and 13K/11, Figure 1). Results from geochemical analyses of till samples collected from this area will be released as an open-file report later in 2005. Lake sediment and water samples were also acquired from NTS map areas 13K/11 and 13K/14 and these results will be released as an additional open file.

The study area lies about 150 km north of Goose Bay and is accessible by float plane and helicopter, although Naskaupi and Seal lakes can be accessed, if necessary, by canoe from Goose Bay. A base camp for summer field operations was established at the eastern tip of Snegamook Lake.

SETTING

Rugged hills that make up highland plateau areas are the dominant feature of local topography. Large valleys separate plateau areas and smaller ones within the plateaux lend them an undulating character. The region north of Pocket Knife Lake is part of the George Plateau, and ranges from 300 to 500 m asl (Bostock, 1964; Sanford and Grant, 1976). The plateau west of Pocket Knife Lake rises to about 500 m asl, and a larger plateau south of Namaycush Lake reaches almost 700 m asl. The latter is part of the Hamilton Upland (Bostock, 1964; Sanford and Grant, 1976) and is deeply incised by the Naskaupi River, creating a relief of about 500 m. The rest of the study area consists of low, rolling hills that range from 200 to 400 m asl. Elevations range from 40 m asl on the Naskaupi River at the southern limit of the map area to 687 m asl at the highest point, which is 3 km south of Namaycush Lake. Bedrock is exposed at higher elevations and displays large-scale glacial stoss-and-lee features.

A large esker system crosses from Seal Lake to Otter Lake. Sinuous esker ridges, hummocks, kettles and flat plains associated with the esker infill a wide preglacial valley in this location.

On thick till or glaciofluvial substrates, trees are widely spaced and caribou moss and lichen form the understory.

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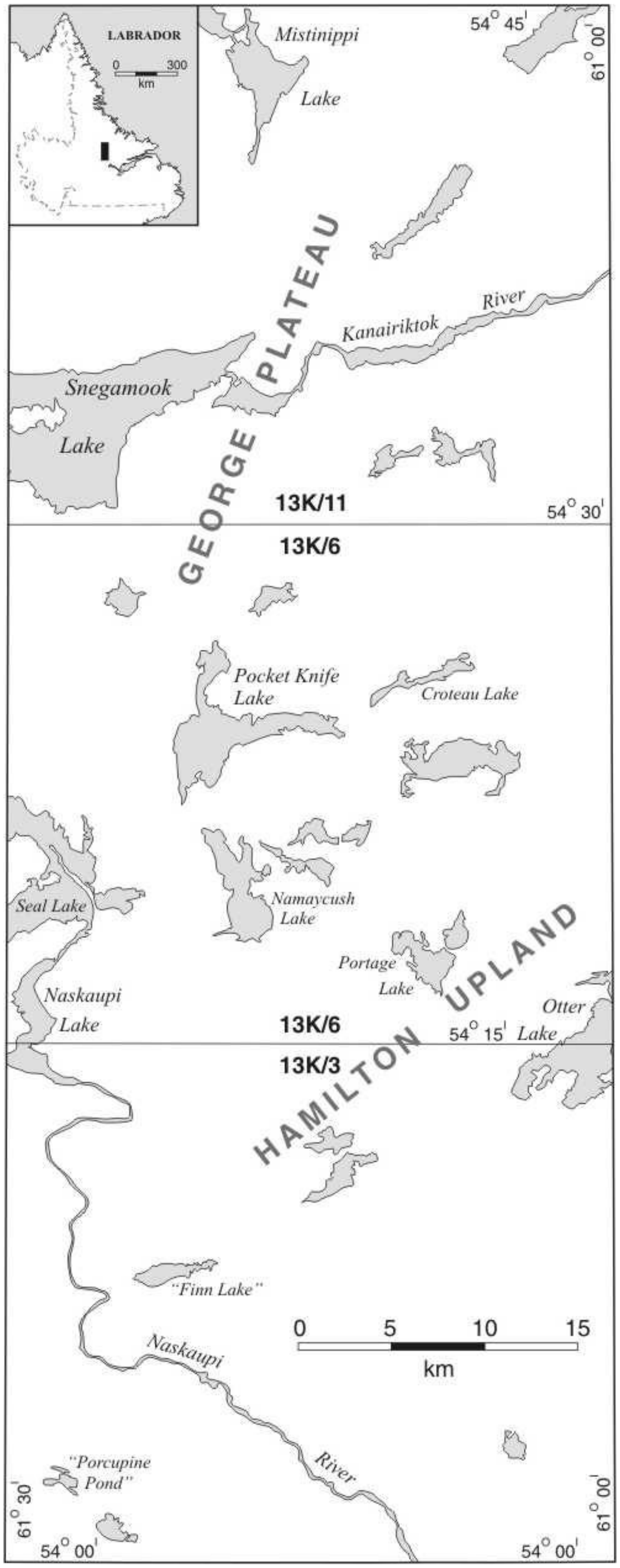

Figure 1. *Location map, Snegamook Lake area.*

Trees are more closely spaced on lower slopes and in wetter areas, and are nearly nonexistent on the higher ridges. Bogs, fens and string bogs are abundant and widespread and forest fires have stripped the vegetation in several areas.

BEDROCK GEOLOGY

The study area is within the Central Mineral Belt, a belt of sedimentary, volcanic and granitic rocks found along the northern boundary of the Grenville Province. These rocks unconformably overlie the Nain and Churchill provinces to the north and have experienced varying degrees of metamorphism and deformation.

The geology is described, in detail, by Ryan (1984) and a brief summary is given herein. Figure 2 shows the bedrock geology of the study area, as well as that of NTS map area 13K/14, where lake-sediment samples were collected.

Rocks of Aphebian to Neohelikian age make up most of the Central Mineral Belt. The Maggo Gneiss (the oldest rock unit) is tonalitic to granodioritic and contains pegmatite and aplite dykes, as well as amphibolite dyke remnants. The Kanairiktok Intrusive Suite, which is cut by gabbro and diabase dykes, comprises grey to pink granitic to gneissic tonalite to granodiorite. Adjacent rocks that are considered equivalents to the Maggo Gneiss and Kanairiktok Intrusive Suite are informally termed the Kaipokok Valley complex. To the north of the study area, marble, chert and volcanic rocks of the Florence Lake Group are found.

The Aphebian Moran Lake Group unconformably overlies the Archean basement. The Warren Creek Formation consists of slate, sandstone, siltstone, mudstone, dolostone, limestone and chert, while the overlying Joe Pond Formation contains mafic tuff and massive or pillowed basalt (North and Wilton, 1988; Ryan, 1984). The Bruce River Group contains a succession of conglomerate, mudstone and red sandstone of the Heggart Lake Formation, volcaniclastic sandstone, siltstone, tuff, porcellanite and conglomerate of the Brown Lake Formation and volcanic breccia, basalt, andesite tuff, agglomerate and volcaniclastic sedimentary rocks of the Sylvia Lake Formation. These rocks rest unconformably on Aphebian rocks. The younger Nipishish Lake Intrusive Suite is mainly granitic (granite, granodiorite, quartz-monzonite), whereas the Harp Lake Intrusive Suite consists of undeformed early Mesoproterozoic anorthosite (Kerr and Smith, 2000). The Snegamook Lake Intrusion (granitoid rocks) formed at the margin of the Harp Lake anorthosite (Kerr and Smith, 2000). The Seal Lake Group unconformably overlies older rocks and consists of quartzite, arkose, conglomerate, shale and basalt (Bessie Lake Formation), grey to red quartzite, red to black shale,

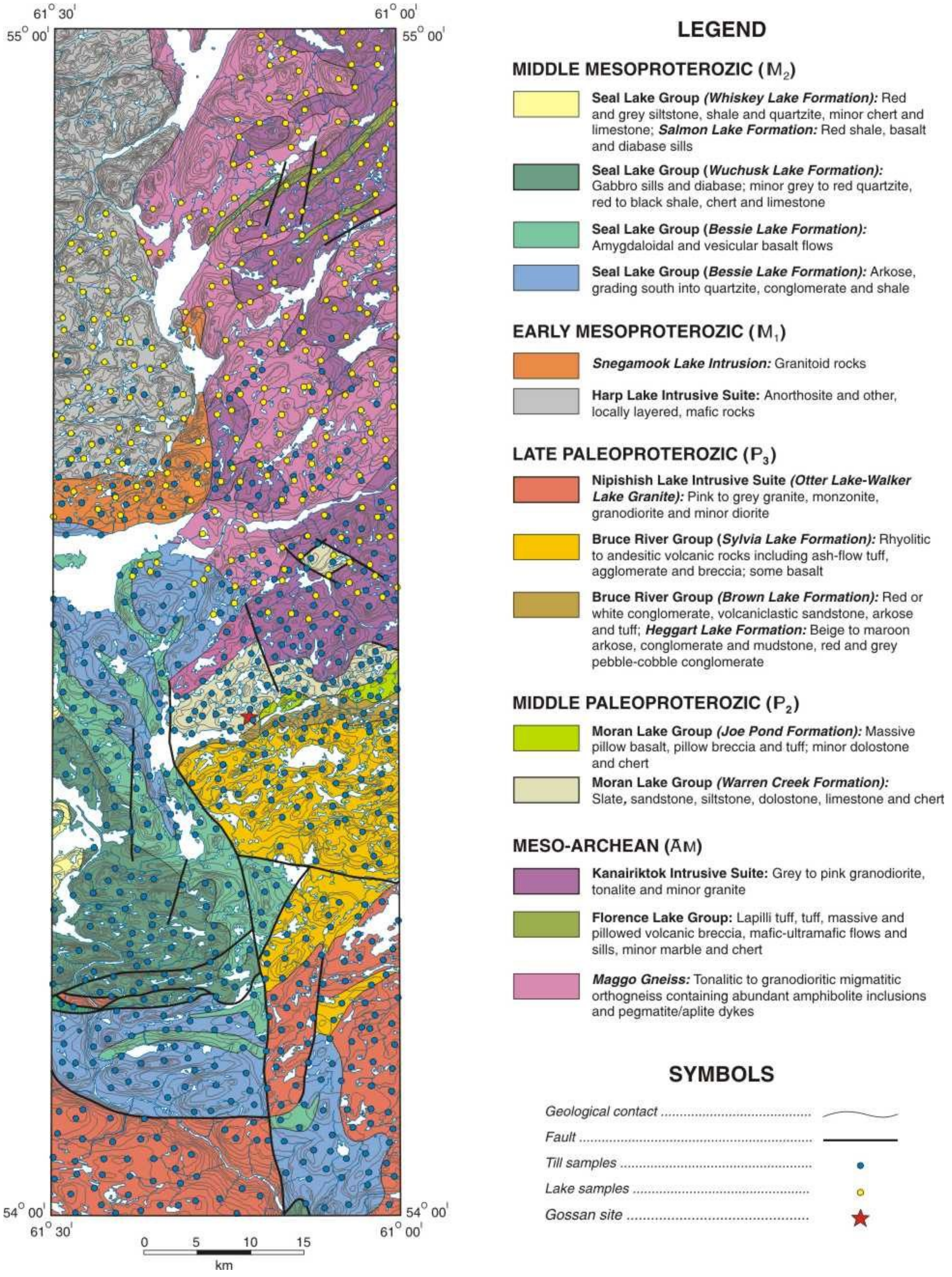

Figure 2. *Bedrock geology (after Ryan, 1984) and sample locations.*

limestone and chert intruded by gabbro sills and diabase (Wuchusk Lake Formation), and red shale, siltstone, quartzite, basalt and diabase sills (Salmon Lake and Whisky Lake formations).

Diabase dykes and gabbro intrude all of these units, making them the youngest rocks in the study area.

ECONOMIC GEOLOGY

The Central Mineral Belt has a long history of mineral exploration (Ryan, 1984; Wilton, 1996). Showings of gold, silver, iron, copper, lead, zinc, uranium, nickel, molybdenum, beryllium, fluorite, asbestos and rare-earth-elements have all been identified during mineral exploration surveys. Pyritic gossans are found in the Warren Creek Formation, near Croteau and Pocket Knife lakes, where copper and zinc showings have been located (Wilton, 1996). The Bruce River Group contains base metals and uranium, the Kanairiktok Intrusive Suite and the Moran Lake Group host uranium (Ryan, 1984; Wilton, 1996) and the Harp Lake Intrusive Suite hosts nickel and copper (Kerr and Smith, 2000). The Seal Lake Group exhibits numerous copper occurrences, some of which are native copper (Wilton, 1996). Rocks of the Bruce River Group are considered favourable hosts for gold and silver mineralization and tin, tungsten, native silver and nickel-cobalt arsenide could potentially be found in the Paleohelikian granitoid rocks (Ryan, 1984). The Florence Lake Group contains platinum-group-elements (PGE) and minor sulphides (Wilton, 1996), and the gabbro sills of the Seal Lake Group are considered to have potential for PGE enrichment (Wardle, 1987).

PREVIOUS WORK

Ice flow from the Laurentide Ice Sheet was to the east and northeast from a major ice centre to the west (Fulton and Hodgson, 1979). Ice flow east of the Snegamook Lake region ranged from east-southeast to north, becoming more topographically controlled in the later stages of glaciation. Early flow was to the northeast, while later flow was more variable, but generally eastward (Batterson *et al.*, 1988). Glaciers left behind deposits of till, glaciofluvial material and localized marine clay (Batterson *et al*., 1988; Klassen *et al*., 1992). The Sebaskachu Moraine, a large but narrow regional moraine (Fulton and Hodgson, 1979) estimated to have formed at approximately 8 ka BP (radiocarbon years), based on a 7.5 ka date from the Goose Bay area (King, 1985), terminates just east of Nipishish Lake.

Marine limit is about 125 m asl in the Kaipokok Valley (Awadallah and Batterson, 1990; Batterson *et al.*, 1988), and a major sea-level stand is recorded at 105 m asl (Batterson *et al*., 1988). Dates from the deltas that establish these marine limits show that ice was present in Kaipokok Valley near Moran Lake at 7.7 ka BP (Awadallah and Batterson, 1990).

METHODS

The surficial geology was mapped at every field site as well as at many locations between, and was recorded on air photographs and maps for later digital mapping (NTS map areas 13K/3, 13K/6 and 13K/11).

Ice-flow directions were determined mainly by measuring striations, however, crescentic fractures and rôche moutonnée orientations were also measured, where present. Several striations were measured at each striation site and the median orientation was recorded. Direction was determined by stoss/lee relationships (micro- and macro-scale), cross-cutting relationships and by preservation of older striae in the lee of younger ones. The presence of exotic clasts was used to support the ice-flow data.

Till samples were taken for geochemical analysis at a spacing of about 1 sample per 4 km^2 (Figure 2). The northeastern part of NTS map area 13K/6, including the area north of Pocket Knife Lake, was sampled on a tighter grid spacing (1 sample per 2 km^2), as the area to the east of it has been shown to have high till geochemistry values for several elements (Batterson and Taylor, 2004) and because the area contains known mineralization (Ryan, 1984). Samples weighing about 1 kg were placed in paper bags and labelled. Most of the samples were taken from test pits at depths of 30 to 60 cm (average 45 cm). Mudboils, common at higher elevations, were sampled at shallower depths (average 25 cm) and in areas of thin till, samples were taken at similar depths from the bedrock-till interface. B- and BC-horizon samples were acquired in areas where the soil was too thin for a C-horizon to be present or where till was too bouldery to penetrate to greater depths. However, 90 percent of all samples are either from the BC- or C-horizon (67 percent are from the C-horizon). A total of 630 samples were acquired and the silt–clay fraction of each will be analyzed for trace-element content at the Geological Survey laboratory (ICP and AAS analyses) and at Activation Laboratories in Ontario (INAA analyses).

The locations of lake-sediment samples acquired from the northern two map areas are also shown in Figure 2.

RESULTS

BEDROCK

Bedrock ridges above 400 m asl commonly have a thin (<70 cm) and discontinuous glacial sediment cover. The ridge orientations are bedrock-controlled, however, most show strong stoss and lee features due to glaciation.

A gossan was located northeast of Pocket Knife Lake during fieldwork and has been added to the Mineral Occurrence Database System (MODS). Shale-hosted pyrite and a fine-grained mineral (possibly galena) were identified at this location (Figure 2). However, analyses of two samples were unremarkable, possibly because of weathering. Copper values from the two rock samples are 7 and 16 ppm, lead values 19 and 21 ppm, nickel values 9 and 15 ppm, vanadium values 5 and 291 ppm and gold values are 5 and 12 ppb.

QUATERNARY GEOLOGY

Till

Till is the most common glacial deposit in the Snegamook Lake region, coating the bedrock at elevations below 400 m asl. Generally, it has a silt to coarse sand matrix and is very poorly sorted. Clasts range in size from pebbles 0.5 cm in diameter to boulders 200 cm in diameter, but house-sized boulders are found locally (Plate 1). Clasts are mainly subangular to angular, ranging to very angular at higher elevations. Striated clasts are rare, but striations are more common on softer clasts derived from the Seal Lake Group.

Plate 1. *Very large boulder, Portage Lake area.*

Large boulders are common on the till surface, and may or may not be found at depth. Clast size tends to decrease below a bouldery upper 50 cm. In areas of granitic bedrock, the till is extremely bouldery, and boulders commonly reach several metres in diameter (Plate 2). Boulder fields lacking any matrix are abundant and are generally found near lakes and ponds and are commonly associated with till and glaciofluvial sediments. The boulder fields are interpreted to be meltwater-washed remnants of till.

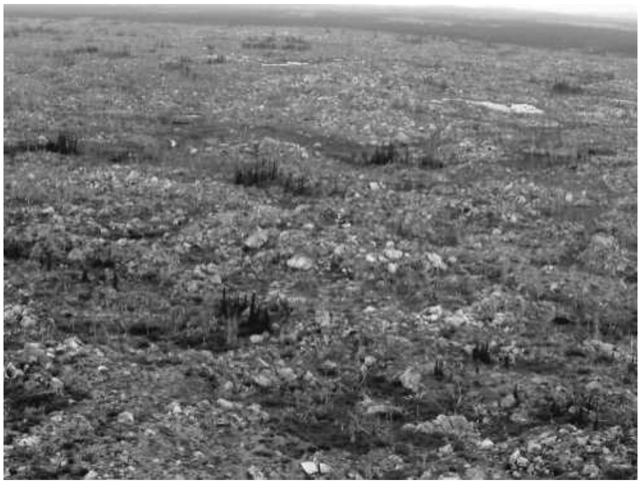

Plate 2. *Bouldery till overlying granitic bedrock south of Otter Lake.*

Local bedrock tends to dominate the clast content of till, but Seal Lake Group clasts can be found displaced at least 60 km eastward of their source area. Till that is found east of, or overlying, the Seal Lake Group red sandstone and siltstone commonly exhibits a reddish colour (Plate 3). Red beach gravels along the southern edge of Pocket Knife Lake owe their colour to the red till from which the gravels are eroded (Plate 3). To the south, till is yellow grey or light grey, a direct reflection of local bedrock in that area, which includes quartzite and granitoid rocks.

Geomorphic Features Developed in Till

Till is most commonly found as a blanket or thin veneer over bedrock. However, a few areas contain large geomorphic features composed of till.

Cross-valley moraines that are found at the eastern end of informally named “Finn Lake” (Plate 4), are 200 to 400 m long, but only several metres high. The moraines are either perpendicular to, or curve toward, but are not connected to, larger lateral moraines that are best preserved on the north side of the valley. The till is white and contains mainly locally derived clasts of white quartzite, suggestive of a short transport distance. The moraines are interpreted as recessional moraines associated with ice retreat to the west, at a time when the Laurentide Ice Sheet had been reduced to valley glaciers in this region.

Large, elongate drumlins are found in an area of thick till cover south of Naskaupi River. The drumlins are composed of till, at least at their margins, where a few till samples were collected. The drumlins are 500 to 1800 m long, 100 to 300 m wide and are subdued (20 to 30 m high) (Plate 5). Some do not have a noticeable stoss end, and are considered to be flutings. The drumlins and flutings are closely

Plate 3. *Red beach developed from red till, southern end of Pocket Knife Lake. Inset: red till, which is common east of Seal Lake.*

Plate 4. *Recessional moraine ridges, "Finn Lake".*

spaced around informally named "Porcupine Pond", but are more dispersed to the east. They are parallel to the most recent ice-flow direction (100°) recorded in the area.

There are conflicting hypotheses regarding drumlin formation. If they were formed by ice flow (Boyce and Eyles, 1991), then these drumlins represent the 100° flow event. If they were formed by an erosive subglacial flood however (Shaw and Sharpe, 1987), the flood would simply have been parallel to this event.

The Sebaskachu Moraine, found just east of the field area, has been described briefly as a continuous feature that marks a major ice margin (Fulton and Hodgson, 1979). It was examined in this study with the intent of sampling large boulders on its surface for cosmogenic dating. However, the moraine was found to be a subdued (<10 m high), discontinuous feature, considerably less well defined and more limited in extent than previously suggested (Figure 3). Therefore, this moraine does not mark a major stillstand of the Laurentide Ice Sheet. The hummocky moraine west of it (Figure 3) indicates that ice stagnated at this location after forming the small moraine, so a minor stillstand of a glacial lobe probably did occur at this location. The granitic surface boulders were unfortunately too weathered for dating, so the 8 ka age of the moraine could not be corroborated. The 7.5 ka BP date from Muskrat Falls on Churchill River from which its age is estimated (King, 1985) may no longer be a valid correlative date, as the moraine does not extend to Lake Melville and Churchill River.

Glaciofluvial Sediments

Glaciofluvial sediments consist of massive or vaguely horizontally bedded sand and gravel or pebbly sand. Beds are up to 50 cm thick, but are generally 1 to 10 cm thick. They are matrix-supported and can have irregular, erosive or sharp lower contacts. Sorting varies from very well sorted sand to moderately sorted sandy gravel or gravelly sand. Clasts are subangular to well rounded. Ripple cross lamination (with or without a silt drape) and trough crossbeds are present. Planar crossbeds and cross laminations developed in sand are commonly highlighted by heavy mineral concentrations. Rip-up clasts, soft sediment deformation, flame structures and load casts are rare. Some of these sediments were deposited in subglacial tunnels (eskers), but most are of subaerial origin. Glaciofluvial infill of meltwater-washed till and boulder fields is common and likely indicates subaerial deposition.

Subaerially deposited outwash is the major type of glaciofluvial deposit in the region. Large outwash plains at

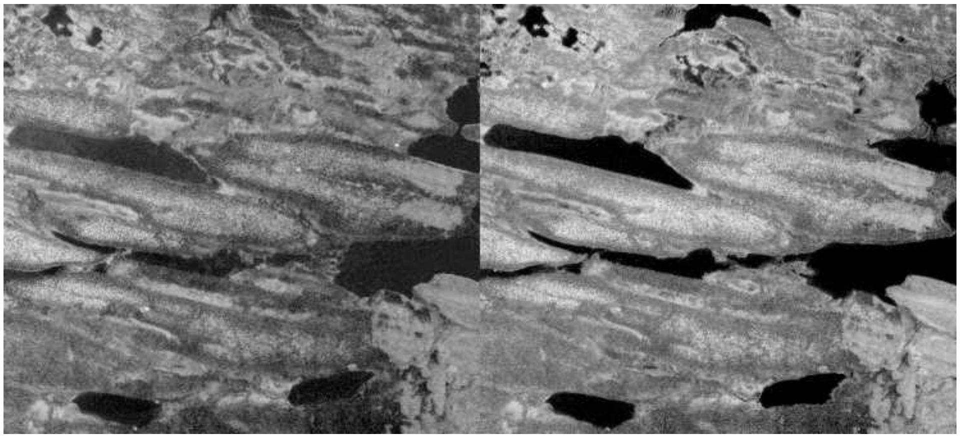

Plate 5. *Stereo pair of drumlins in "Porcupine Pond" area. Ice flow from upper left to lower right (east-southeastward).*

lower elevations (<200 m asl) appear to contain the highest volume of glaciofluvial sediment, most of which is sand. Outwash fills larger valleys, including the Naskaupi and Kanairiktok River valleys (Plate 6). Channel scars are prominent on the surface of these extensive deposits and kettles are present locally.

Subglacially deposited eskers contain sediment similar to that deposited subaerially: vaguely horizontal or irregular bedding is evident in sandy granule to pebble gravel. Beds can be either clast-supported or matrix-supported. Some eskers are coarser grained at the crest of the ridge, becoming sandier and more intensely crossbedded near the edges. A major esker system crosses from Seal Lake to Otter Lake (Plate 7) and beyond. The main esker ranges from 20 to 40 m in height and contains sand and minor gravel. The esker is flanked by subordinate esker ridges and glaciofluvial material that forms hummocks or planar surfaces, the latter of which commonly contain a few kettles.

Small, short eskers (<10 m high) are common at all elevations. These are generally associated with discontinuous packets of ice-contact glaciofluvial material.

Glaciolacustrine Sediments

Glaciolacustrine sediments are ubiquitous but patchy in distribution. A veneer of silt (or more rarely, fine sand) overlying till is found in many localities throughout the study area. Thicker lacustrine deposits are rare. The silt is highly discontinuous both vertically and laterally: in many instances, till can be found at the surface only a few metres away, despite the fact that the adjacent silt deposit may be over 70 cm thick. The silt is generally massive and appears to be evidence of supraglacial ponding during ice retreat, although it is not necessarily associated with hummocky moraine.

Holocene Sediments

Recent deposits include modern fluvial sediments and blocky colluvial debris. The modern Naskaupi and Kanairiktok River floodplains vary in coarseness downstream, alternating between gravel and sand, rather than fining downstream. This is probably related to changes in the grain size of the glaciofluvial terrace deposits from which

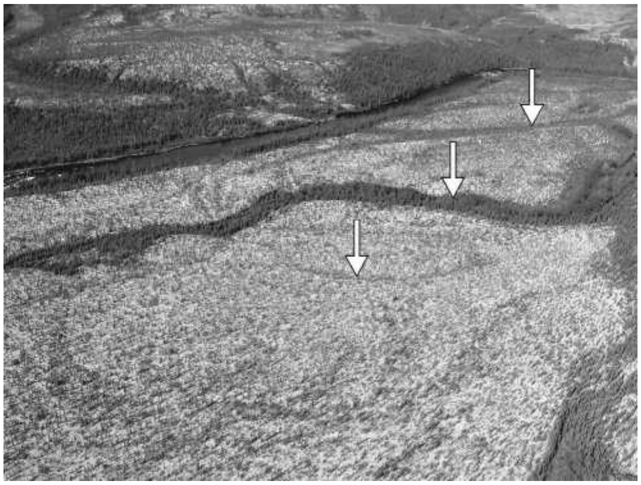

Plate 6. *Outwash deposited by a large meltwater river, Naskaupi River Valley. Note channels on surface where the braided river once flowed (arrows). This deposit is mainly made up of sand.*

Plate 7. *Large, sandy esker extending into Seal Lake. The esker system crosses the study area from Seal Lake to Otter Lake.*

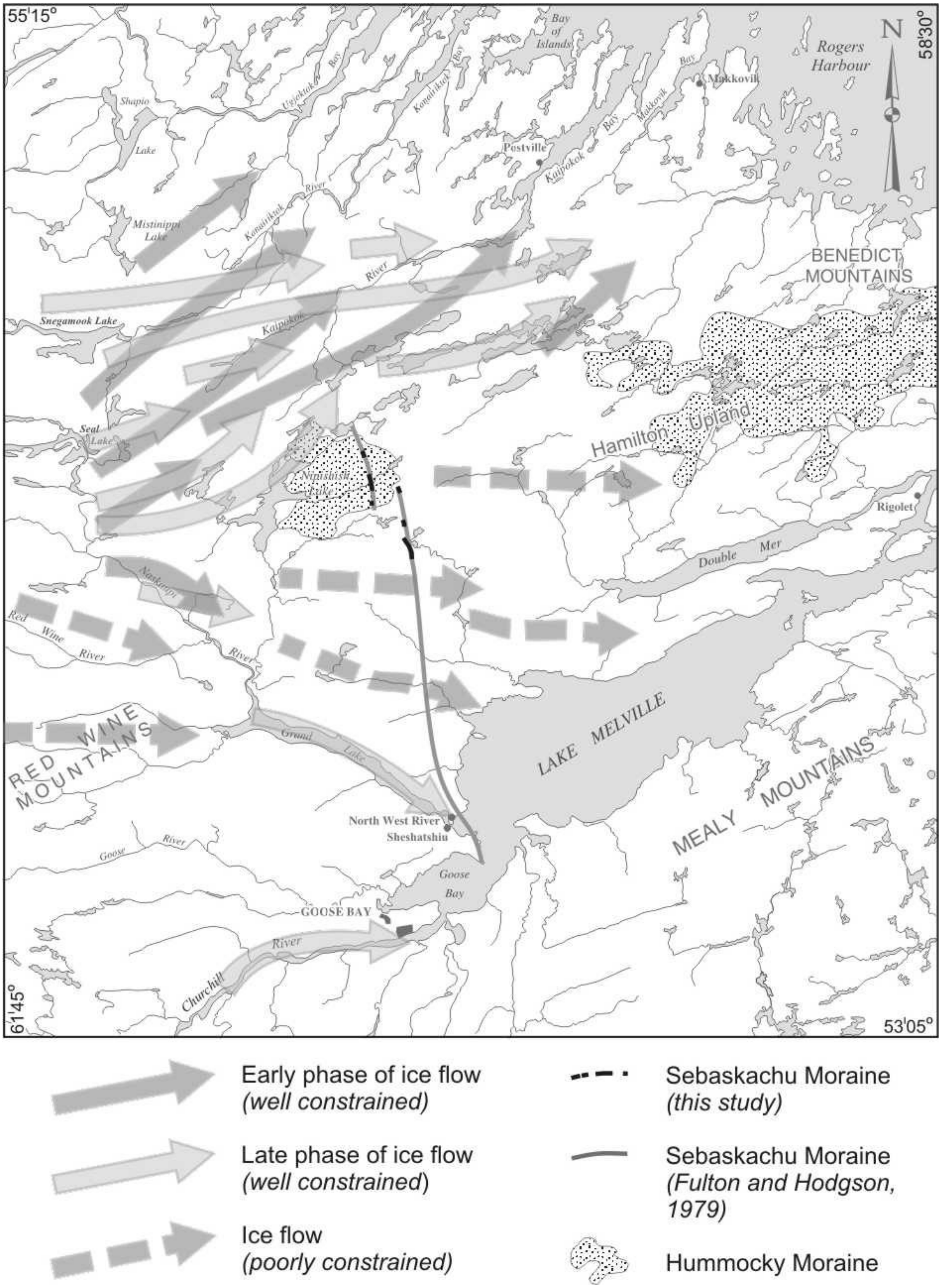

Figure 3. *Regional ice flow, central Labrador. The location of the Sebaskachu Moraine, this study, and its location as given by previous workers are also shown.*

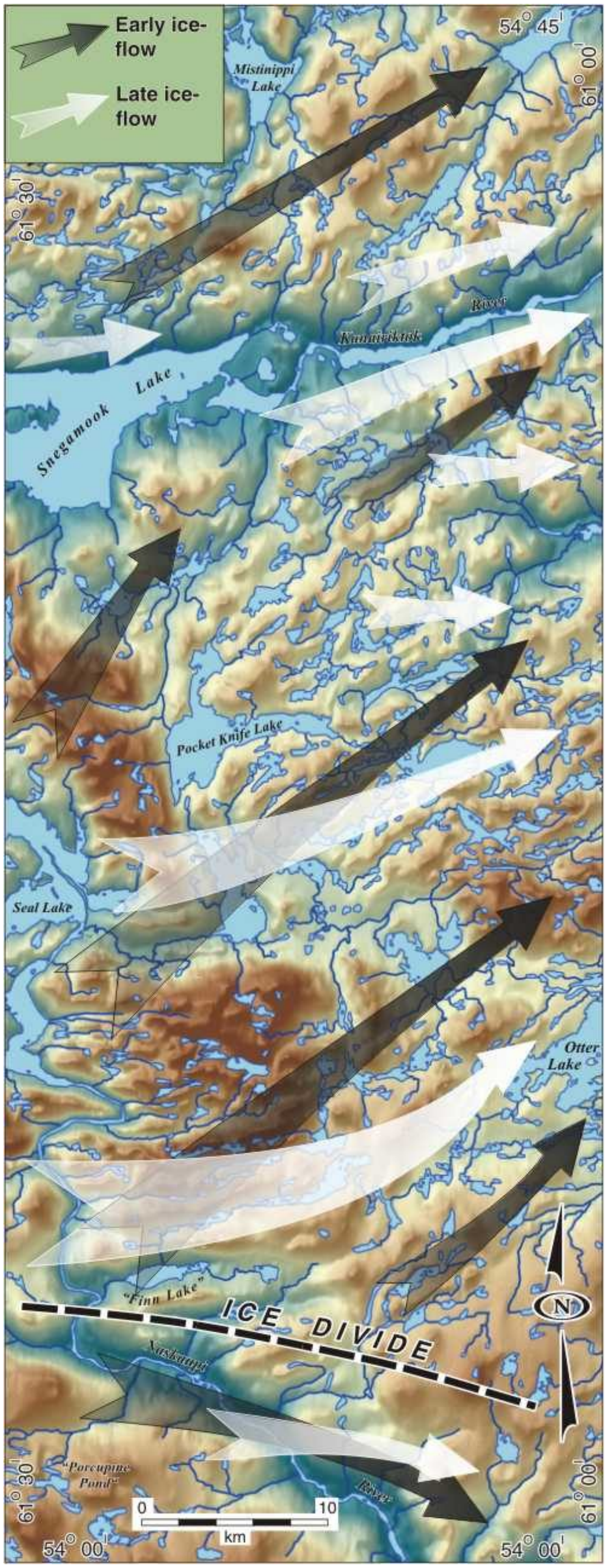

Figure 4. *Ice flow, Snegamook Lake region.*

they are mainly derived. Rockfalls are the most common type of colluvium: colluvial fans and aprons are common at the foot of steep slopes. Colluvial input may be responsible for some of the coarse fraction of the modern river sediment load.

ICE FLOW

Striations are most common above 350 m asl and are not visible at the lowest elevations due to glaciofluvial infill. Fresh, unweathered striations were commonly found after the removal of till from the bedrock surface. Weathered grooves on exposed surfaces are also present, but to a lesser extent. Ice-flow directions range from 10 to 130°, however, most fall within the 40 to 90° range. Ice flowed first in a northeastern direction across the study area, regardless of topography, suggesting that this flow phase represents ice flow at the glacial maximum when ice was thickest (Figure 4). Later, ice flow curved around topographic highs and followed larger valleys, likely reflecting thinner ice during deglaciation. After flowing around highlands, ice veered northeast in the central part of the study area (Figure 4). In the southern part of the study area, there is a clear deflection of ice toward the Naskaupi River valley. This deflection remained during the later flow phase (Figure 4) and suggests that an ice divide was present in the vicinity of "Finn Lake" at the glacial maximum, and that it persisted into the deglacial period, possibly due to drawdown toward Lake Melville. The drumlins south of Naskaupi River parallel this flow direction (east-southeast).

Distinctive clasts for dispersal pattern studies were easiest to identify at mudboil sites on hilltops, so high elevation areas may be over-represented by these studies. Clast transport distances average 1 to 2 km, but longer distances (20 to 40 km) were also observed. Gabbro and quartzite in the southern part of the study area are dispersed to a distance of at least 80 km, mainly in an eastward direction; however, some east-southeastward dispersal of similar distance is also noted. The Seal Lake Group provides distinctive clasts of red sandstone and siltstone for dispersal studies. These clasts were commonly found east of their source area. East-northeast dispersal was evident in the north and east-southeast movement was recorded in the south. The maximum dispersal distance of Seal Lake Group rocks recorded was 60 km. The ice-flow directions given by clast dispersal parallel the ice-flow information obtained from striation data.

Regional flow patterns were further evaluated by plotting Batterson *et al.*'s (1987, 1988) striations alongside those from this study on a digital elevation model and overlaying the surficial geology map of Labrador (Klassen *et al.*, 1992). Regional flow trends given by striation data are shown in Figure 3 as solid arrows. Dashed arrows show ice-flow directions given by the orientation of landforms in areas where no striations have been measured, and as a result, their relative timing is uncertain (Figure 3). These are shown as poorly constrained possible ice-flow directions because it is possible that drumlins and flutings used to obtain these ice-flow directions could have been formed by subglacial flooding. Careful striation measurements are needed from these areas to confirm these flow directions and to provide more flow information, including relative age relationships.

The overall regional trend shown in Figure 3 is that of initial flow to the northeast, which was topographically independent. An ice divide formed in the vicinity of "Finn Lake" (and possibly continued to the Nipishish Lake area): ice to the north of the divide flowed northeast, and ice south of it flowed toward Lake Melville and possibly also eastward across the Hamilton Upland. These findings are in general agreement with ice-flow patterns postulated by Klassen and Thompson (1989), but provide more detail.

Later ice flow was controlled by topography. Ice flowed east and then northeast around highlands in the Otter Lake/Nipishish Lake areas, then moved eastward toward Rogers Harbour, again following topographic lows. South of the divide, ice continued to flow east-southeast, indicating that the divide persisted through late glacial time. Ice also flowed down large valleys near Goose Bay, probably as valley glaciers. The deflection of ice around the Hamilton Upland may have led to more sluggish ice movement and eventually stagnation in that area, possibly resulting in the deposition of large tracts of hummocky disintegration moraine (Figure 3).

CONCLUSIONS

Ice in the region flowed in different directions over time and smoothed bedrock ridges as it passed over them. Till was deposited throughout the region and is widespread enough to be useful for detailed geochemistry for mineral exploration. Low-lying areas and major valleys were infilled with glaciofluvial sand and minor gravel during deglaciation. These areas should be avoided when sampling till, as should eskers, which are found at various elevations. A particularly large esker system extends from Seal Lake to Otter Lake and continues eastward beyond the study area. Glaciofluvial sediments may be useful for other types of geochemical study, however, such as indicator mineral tracing for diamond exploration.

Ice flow was mainly northeast at the last glacial maximum; however, an ice divide existed near "Finn Lake". South of the divide, ice flowed in an east-southeast direction. Later (probably deglacial) ice flow was east-northeast, with some deflections due to topography. These trends are also noticeable on a more regional scale.

The Sebaskachu Moraine was considered previously to be a major feature marking a temporary glacial stillstand about 8000 years ago. In this study, the moraine was visited and mapped in more detail, which revealed its very limited size and length. As a result, no major stillstand is implied for this part of Labrador.

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