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QUATERNARY GEOLOGY OF THE MOUNT SYLVESTER (2D/3) MAP AREA

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ABSTRACT

The Quaternary geology of the Mount Sylvester (2D/3) map area was completed during 1987. The study is aimed at providing a basis for drift exploration. It contains terrain that is dominated by glacigenic units: 1) ridges oriented transverse to glacier-flow direction, 2) ridges streamlined parallel to glacier flow, 3) hummocks and ridges, 4) hummocks, 5) boulder fields, 6) organic plains, and 7) colluvial fans and aprons. These units are arranged so that 1 to 3 above occur in zones that are transitional, one to another, in a down-ice direction. This distribution is closely associated with major bedrock units. Unit 4 is distributed across the map area and is superimposed upon most other glacial features.

Only one glacier-flow direction (170° ± 10°) has been preserved in the area. The surface material of the entire area down to a depth of about 1 m is less compact and contains less fines than the underlying till. Transverse- and streamlined-ridge features are interpreted to have been deposited subglacially, and are likely composed of mainly local material, whereas sediment in hummocky terrain is interpreted to have been deposited from an englacial position and is likely of more distant origin. Therefore, sampling for drift-exploration purposes should be directed at subglacially deposited parts of the terrain.

INTRODUCTION

This project was initiated in the Bay d'Espoir area (Figure 1) in 1987 as the beginning of a regional study to provide a framework for drift prospecting. The area was chosen because of its high mineral potential and the problems of unknown glacial-flow history and extensive areas of drift and bog cover. It also provides an opportunity to interact with current bedrock-mapping projects and active private-sector, mineral-exploration programs, and offers the possibility of stimulating new exploration. Prior to this study, there was no Quaternary mapping carried out in the area. However, Jenness (1960) extended his generalized map of the distribution of late Pleistocene glacial features into the area (inner and outer drift zones). Systematic Quaternary mapping, including sedimentology, geomorphology, pebble lithology and ice-flow direction studies, provides the basis for this work.

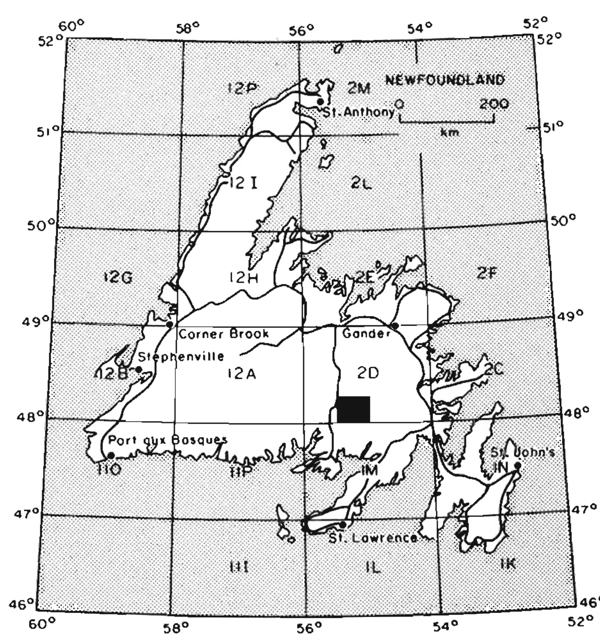
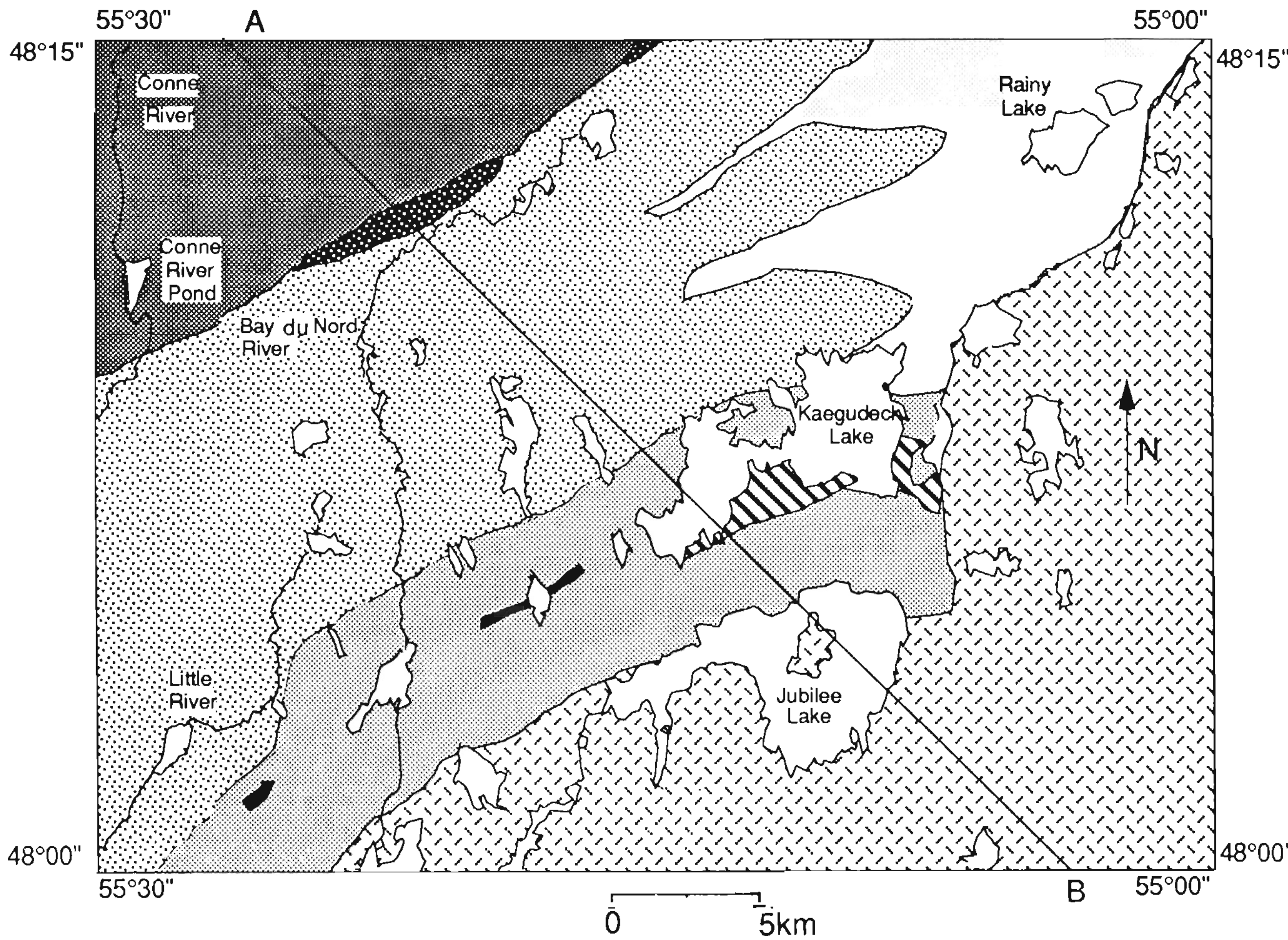


Figure 1. *Location of the study area.*

Regional Setting

The Mount Sylvester map area (Figure 2) is located in east-central Newfoundland about 25 km northeast of Milltown, Bay d'Espoir. Geologically (Figure 2), the northeastern part of the area is underlain by metasedimentary rocks (quartz-rich psammite, phyllite and pelite) of the Gander Group (Dickson, 1983, 1986, 1987). The metasedimentary and metavolcanic rocks (fine- to coarse-grained clastics, chlorite schist, basalt, felsic tuff) of the Isle Galet Formation (Baie d'Espoir Group) cut across the central part of the area. The north-central and northwest parts of the area are underlain by rocks of the Riches Island, St. Joseph Cove and North Steady Pond formations of the Baie d'Espoir Group (slate, sandstone, siltstone, felsic tuff, pelite, quartzite, conglomerate, diabase, psammite, semipelite). The Ackley Granite underlies the southeastern part of the map area.

The area contains gold showings mainly within felsic volcanic rocks near Kim Lake (Figure 3) (McHale, 1985, 1986) and a number of base-metal showings (Bay du Nord



LEGEND

DEVONIAN

Ackley Granite: *massive, pink to buff, coarse grained granite and granodiorite*

ORDOVICIAN(?)

Kim Lake Granite: *pink, leucocratic granite*

MIDDLE ORDOVICIAN

Baie D'Espoir Group

North Steady Pond Formation: *metasedimentary rocks (psammite, semipelite, sandstone, minor siltstone)*

Riches Island Formation and St. Joseph's Cove Formation: *metasedimentary rocks (slate, siltstone, sandstone, quartzite)*

Kaegudeck diabase

Isle Galet Formation: *metasedimentary and metavolcanic rocks (fine to coarse clastics, chlorite schist, basalt, felsic tuff)*

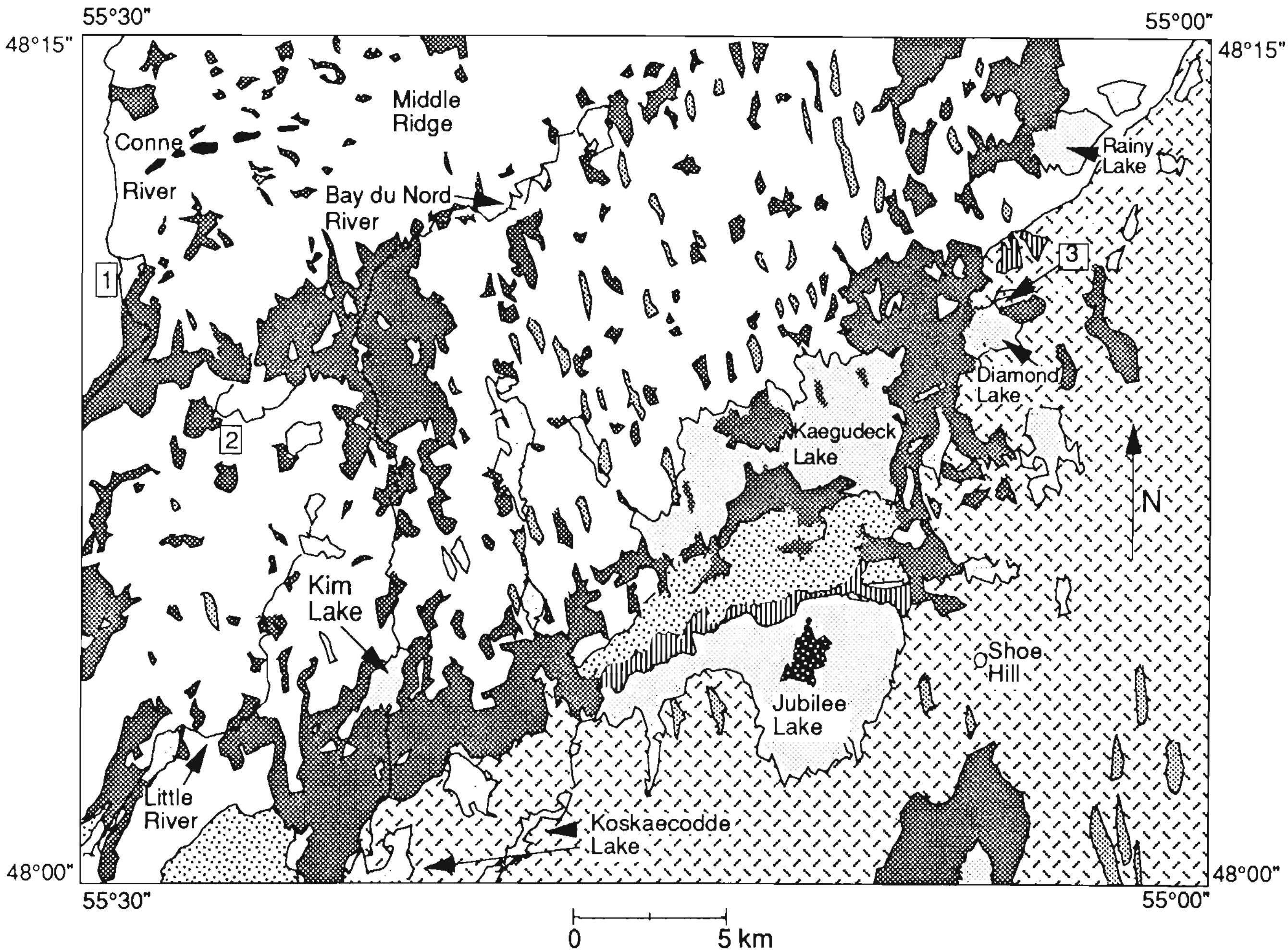
Gander Group

Metasedimentary rocks (phyllite, pelite, quartz-rich psammite)

CAMBRO-ORDOVICIAN

Serpentinized peridotite and dunite

Figure 2. *Generalized geology map (simplified from Dickson, 1986) of the Mount Sylvester (2D/3) sheet.*



POSTGLACIAL

Colluvial fans and aprons: *diamicton (pebbly-silty sand), gravel and sand occurs along the base of steep slopes; formed by gravity processes on slopes (poor sampling medium)*

Organic plain: *bog and fen; water saturated; organic accumulation is generally less than 1- to 4-m thick; (can be penetrated for sampling using hand auger)*

Boulder field: *ground surface is covered with an armouring of subrounded to subangular boulders and cobbles of predominantly local origin; there are no fine sediments as matrix*

GLACIAL (PREDOMINANTLY) OUTWASH

Terrain with pebbly and sandy hummocks and ridges: *areas of hummocky sandy till, sand and gravel; 5- to 15-m high; eskers in a few areas; well drained and poorly vegetated; (poor sampling medium)*

GLACIAL (PREDOMINANTLY TILL)

Hummocky terrain: *single hummocks and hummocky zones (5- to 10-m high); contains mainly silty-sandy till with less than 20 percent sand and gravel (occurs mainly as lenses); sediment is 5- to 10-m thick in hummocks and 1- to 3-m thick between hummocks; typically forest or bog covered; deposited from englacial position; (sample compact massive till between hummocks)*

Streamlined terrain: *subparallel linear ridges (crag and tails, flutes) 5- to 10-m high; mainly composed of compact, silty-sandy till; bedrock cores are common; typically forest covered; deposited subglacially parallel to ice flow; (sample compact massive till)*

Ridges transverse to ice-flow direction: *Rogen moraine, crescentic ridges, and an elongate irregular discontinuous ridge; all are 5- to 15-m high; contain mainly silty-sandy till; deposited from subglacial and englacial positions; (sample massive compact till at base of ridges)*

PREGLACIAL

Rock: *Areas of bare bedrock and small areas of thin discontinuous till and pebbly sand*

Figure 3. *Generalized Quaternary geology map of the Mount Sylvester (2D/3) sheet. Numbers refer to the following localities: 1) Conne River Pond, 2) Ontwanic Lake, and 3) Mount Sylvester.*

River, Kim Lake and Kaegudeck Lake areas) within the Isle Galet Formation. Scheelite mineralization occurs in greywackes in the northwestern part of the map area. Dickson (1987) presents details regarding the history of mineral exploration in the area.

QUATERNARY GEOLOGY

Field Methods

Mapping was accomplished by field-checking airphoto interpretations. Access by truck is limited to a small part of the northwest corner of the map area adjacent to the Bay d'Espoir highway because of extensive bog cover. The only natural exposures available for examination and sampling occur within this area along the Bay d'Espoir highway and a few logging roads. The remaining area was accessed by helicopter. Material checking and sample collection were mainly from hand-dug pits (1 m deep). A small helicopter-portable backhoe (Cricket Tow—All) capable of excavating to 2 m depth was also tested (Plate 1). It was found to be slower and, therefore, more expensive than by hand, but with modifications it may prove to be effective, especially in obtaining bulk samples beneath shallow bog-cover where manual digging is impossible.

Plate 1. *A helicopter-portable backhoe, shown here, is effective in obtaining bulk subsurface bog samples that are used for material and stratigraphic control.*

Map Description

Subdivision of the map area into Quaternary map units (Figure 3) is based on glacial and postglacial geomorphology. The map legend includes areas of bare rock and the predominant sediment types, geomorphic features, typical topographic relief and a generalized interpretation of sediment genesis. The sampling potential for drift exploration is listed in parentheses at the end of each map-unit description. Where possible, map units are numbered on a relative age basis such that older units have lower numbers. They are grouped into glacial (related to glaciers), glacial outwash (deposited by glacial meltwater) and postglacial (nonglacial units of postglacial age). For mineral-exploration purposes, most glacial deposits within the map area that are optimal for sampling are covered with trees or bog.

General Considerations

The Mount Sylvester map area straddles three major rock-stratigraphic packages,which form the main topographic elements of the area because of their differences in resistance to erosion (Figure 4). The affects of glaciation occur as streamlined rock surfaces, moraines and outwash features. Glacial landform complexes coincide with regional bedrock-controlled topographic features, and are arranged transverse to glacial flow (cf. Figures 2 and 3). Streamlined landforms and glacial striations on bedrock indicate that the predominant ice-flow direction in the area was to the south and south-southeast (170° ± 10°), cutting across the regional strike of the bedrock. In the northwest on Middle Ridge, crescentic ridges, Rogen- and hummocky-moraine are the only recognizable glacial features. Along the southern slope of Middle Ridge the glacial geomorphology changes to streamlined terrain (flutes, crag and tails) that is underlain by relatively less-resistant, predominantly metasedimentary and volcanic rocks of the Baie d'Espoir Group. Farther down-ice and to the east, along the northern margin of the Ackley Granite, hummocky moraine and outwash predominate. This regional, glacial geomorphic transition is discussed later in the paper.

Throughout this paper, advice regarding drift-sampling strategies is given. These recommendations are based largely on general theoretical considerations and may be invalid in some places (laboratory investigations in support of these hypotheses are ongoing). In particular, it is assumed that the higher the material is transported in a glacier, the more likely it is to have travelled farther than the sediment that underlies it. Therefore, it is suggested that, where possible, sediment that is interpreted to have been transported and deposited subglacially be sampled.

Bedrock

Mappable areas of bare rock occur mainly to the southeast of the zone of streamlined terrain especially south of Kaegudeck Lake. There are numerous outcrops throughout the area that are too small to map at 1:50,000 scale (see map by Dickson, 1987).

Ridges Transverse to Ice-Flow Direction

Terrain characterized by transverse ridges is restricted to the northwest part of the area on a topographic high that is underlain by psammite, semipelite and pelite of the North Steady Pond Formation and a small area of pre- Gander Group peridotite and dunite. Three forest-covered ridge features, composed of silty-sand diamicton (till-like sediment composed of a broad spectrum of grain sizes: from silt and clay to boulders) and having numerous boulders and cobbles resting on their surfaces, occur within this map unit: 1) Rogen moraine (Plate 2), which appear as flat-topped, scalloped elongate ridges in plan view, are 100- to 1000-m long, 50- to

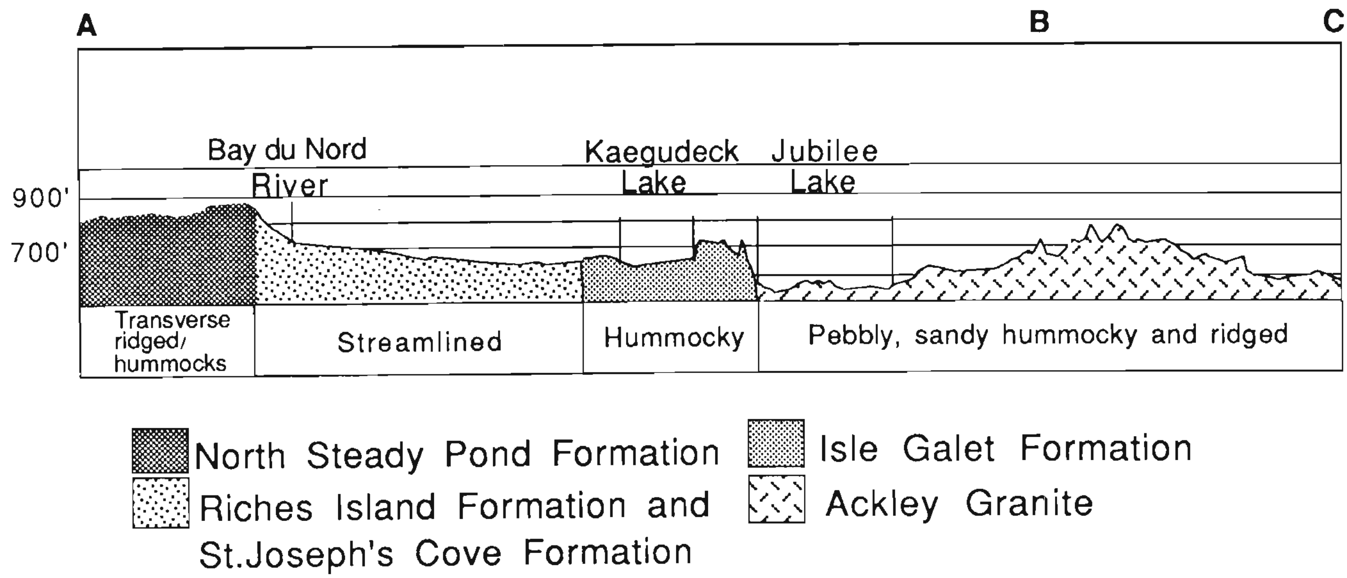


Figure 4. *Generalized topographic profile from northwest (A) to southeast (B) across the map area (Figure 2) showing major underlying rock types. The profile continues (B-C) into the Hungry Grove Pond map area (1M/14) south of the Mount Sylvester map area.*

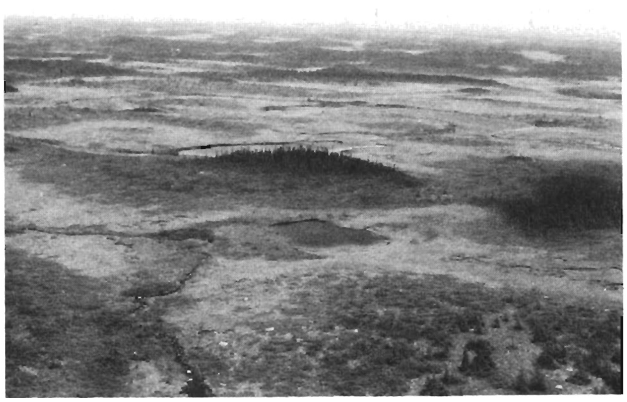


Plate 2. *Rogen moraine surrounded by bog in the northwestern part of the map area.*

100-m wide at their crest and are estimated to be 10- to 15-m high (measurement not possible because they are surrounded by bog that submerges their bases); 2) crescentic ridges that are 50- to 200-m long, 20- to 50-m wide at their crest and about the same height as the Rogen moraine; and 3) an elongate, irregular, discontinuous ridge about the same height as ridges 1 and 2 and 25- to 100-m wide, which can be traced for about 6 km more or less transverse to ice-flow direction. This feature occurs about 2 km north of Conne River Pond (locality 1 on Figure 3) and extends eastward. Several 3- to 5-m exposures within these features near the Bay D'Espoir highway have about 1 m of low-compaction diamicton containing less fines (silt and clay) than underlying till.

Interpretation of these features is constrained by a lack of exposure and extensive bog cover in intervening areas. However, morphologically similar features are reasonably well documented in the literature, so that an airphoto interpretation augmented with a limited number of hand-dug pits (1 m deep) is used here for a preliminary genetic interpretation. The crescentic ridges and Rogen moraine were likely formed subglacially and transverse to ice flow (Lundqvist, 1969; Aario, 1977; Shaw, 1979). This is supported by the regional ice-flow direction, which was tranverse to the ridges. The long discontinuous ridge (number 3 above) appears to be part of a feature that formed along a particular transverse feature within or along the margin of the glacier. Its close proximity to Rogen- and crescentic-ridges, and the fact that it does not superpose them, suggests that it formed subglacially at the same time as the ridges.

For mineral-exploration purposes, sampling should be confined to the transverse features; hummocky features (discussed below) should be avoided. Also samples should be taken from at least 1 m depth to reduce the chances of sampling englacially transported or lag sediment.

Streamlined Terrain

Terrain predominated by depositional features that are streamlined parallel to the main direction of ice flow is confined mainly to the topographically lower northeast–southwest-trending rocks of the Baie d'Espoir Group. These rocks occur more than 3 km northwest (up-ice-flow direction) from its contact with the Ackley Granite (Figures 2 and 3). Several large streamlined ridges also occur southeast of Shoe Hill. This terrain is relatively flat (local relief of less than 20 m) and consists of subparallel streamlined ridges (an even mix of crag and tail and flute features) 5 to 10 m high. The ridges trend 170° (± 10°) and commonly are partially or completely covered by forest. Crag and tail features consist of a relatively steep-sided, resistant, glacially modified bedrock knob (crag) at the up-ice end with a tapering, gently sloping down-ice tail mainly composed of compact sandy-silty till. No up-ice ramps were observed. Flutes have a similar form but no crag is evident. Areas of hummocky moraine are interspersed with these streamlined features (e.g., northeast of Ontwanic Lake, locality 2 on Figure 3) and all features are surrounded by extensive areas of bog that cover about 60 percent of the topographic depression.

The streamlined features found within this area were formed by subglacial deposition and moulding. This interpretation is based on their geometry, which is well documented in the literature (Boulton, 1975, 1976; Aario, 1977), and the fact that they are parallel to glacially abraded striations found on resistant bedrock units in different parts of the map area. Preliminary pebble-lithology analyses indicate that at least the coarse fraction of the sediment that occurs within these streamlined features is of local origin.

Mineralization is well documented in rocks underlying the southeastern part of the area that is dominated by this terrain (Isle Galet Formation, Kim Lake gold prospect) and just northwest of the map area (scheelite). Drift sampling during mineral-exploration projects should be done within the compact massive till that occurs within 1 m of the surface of ridge tops. Sampling near-surface material (less than 1 m below surface) should be avoided because of the potential problem of sampling material that was transported englacially (or at least high up in the basal debris zone of the glacier), and therefore transported farther than basal material. Similarly, sampling near the base of steep ridge slopes should be done with caution because of potential accumulations of slope-wash sediment.

Hummocky Terrain

Single hummocks and small areas of hummocky terrain composed mainly of diamicton with a silty-sandy matrix occur between, and are superimposed upon, other glacial features throughout the map area. Hummocks are estimated to be between 3- and 10-m high and range from isolated features that are 50 m across to areas that are several square kilometers in area. Extensive areas of hummocky terrain occur northeast of Ontwanic Lake, south of Conne River Pond, north of the east end of Kaegudeck Lake, south of Shoe Hill and within about 3 km northwest of the contact between the Baie d'Espoir Group and the Ackley Granite. Where hummocky terrain occurs in small patches, it is surrounded by bog. On Middle Ridge the hummocky features are generally considerably thinner than the transverse ridge features, but they also have surfaces strewn with cobbles and boulders.

The hummocky features within the map area were likely deposited during glacial retreat after the ridged and streamlined features were formed, and probably from an englacial position by melting out of material carried above the basal debris zone of the glacier. They show no evidence of glacial overriding. The cobbles and boulders that lie on the surface of the hummocky terrain and the ridges were likely deposited from more or less clean ice during the last stages of glacial melting. They could also be part of a surface lag created by subglacial-meltwater escape during this time.

Preliminary analysis of the distribution of pebble lithologies from a small number of sample sites appears to support theoretical predictions that hummocky moraine is composed of material that is farther travelled because it is transported higher in the ice than subglacially deposited material (Boulton, 1970). Mineral-exploration sampling programs should be designed so that as few samples as possible are taken from hummocky terrain. Where sampling is necessary within this terrain, it should be done between hummocks.

Terrain with Pebbly and Sandy Hummocks and Ridges

Areas of hummocky sand and gravel overlie most of the Ackley Granite in the eastern and southern parts of the map area. This terrain is poorly vegetated, characterized by an absence of trees and only sparse shrub and grassy areas. The geomorphology within this area is complex because it includes irregular hummocky ridges parallel to the streamlined terrain along with short straight, irregular and arcuate ridges that span linear depressions between the hummocky ridges. In a few places, hummocky ridges form a reticulate pattern. The surface material (to 1 m depth) is predominantly pebbly, moderately- to well-sorted, moderately compacted, massive sand (till?) with scattered cobbles and boulders. Pebbles and cobbles are predominantly granite (probably Ackley Granite) and are generally subrounded.

Eskers occur east of Kaegudeck Lake and south of Koskaecodde Lake and other short, segmented, esker-like ridges occur in many areas. The sand in the eskers is generally better sorted than in the hummocks in the same area and is mainly grit sized. At one site, probable crescentic percussion marks were observed on some cobbles, supporting an esker interpretation (i.e., deposition from high velocity water). Like the hummocks in this area, esker surfaces are strewn with cobbles and boulders.

It is likely that this pebbly, sandy, hummocky terrain has a polygenetic origin beginning with the formation of streamlined ridges similar to those that predominate to the northwest of this area (streamlined terrain). This interpretation is based primarily on the fact that ridges in both zones are parallel, and were, therefore, likely formed during the same ice advance and, secondarily, on the apparent superposition of hummocks and eskers on these features. Within this sandy hummocky terrain, areas with a reticulate pattern of hummocks and ridges are interpreted to be crevasse-fill structures similar to the pattern of ice cracks on disintegrating modern glaciers (Johnson, 1975). The sandy matrix of the material that comprises this terrain is likely the result of sorting by water, although the supply of fines from the underlying granite was likely minimal. The presence of eskers supports this hypothesis. The modern surface is strewn with grit-sized mineral and rock fragments of granite that are the result of mechanical weathering.

Boulder Field

A small low-relief (less than 10 m) area completely covered with unoriented, subrounded to subangular boulders and cobbles of predominantly (greater than 80 percent) local origin that have no matrix (open-work texture) occurs on islands in the east end of Jubilee Lake. There are no abrasion structures preserved on these clasts and most are subrounded, presumably because the rock (mostly granite) is highly susceptible to weathering. Mapping of this unit required detailed ground control that was not always possible so that it may have been included within the bedrock unit in other parts of the map area. This unit was recognized only in an area that overlyies the Ackley Granite.

The genesis of this unit is somewhat problematic mainly because of a lack of subsurface data. However, a number of significant observations are: 1) most of the clasts are similar to the underlying bedrock (granite); 2) exotic rock types show some evidence of abrasion; and 3) the boulder and cobble field forms a relatively featureless surface that does not have consistent or significant slopes and is not confined to the base of slopes.

Two main conclusions can be drawn from this scant information. First, the boulder field was not deposited directly from glaciers because even along the up-ice contacts very few exotic rocks are present. This is in contrast to the abundance of exotic rocks on all rock types up-ice of the Ackley Granite. Second, the boulder field resembles felsenmeer (Washburn, 1973), that is, it formed by frost wedging (probably active at present) of glaciated bedrock that was overlain by a thin discontinuous cover of till. The fines from the till are likely buried at depth and are volumetrically insignificant. Felsenmeer forms predominantly over the Ackley Granite because of favourable jointing and easy mechanical breakdown (Washburn, 1973).

For the purposes of sampling for drift exploration, this map unit is unlikely to be an effective sampling medium.

Colluvial Fans and Aprons

Mappable areas of colluvial sediment (fans and aprons) occur along the steep slope on the north side of Jubilee Lake and about 0.5 km north of Mount Sylvester (locality 3 on Figure 3). The colluvium, although till-like, is generally clast supported and contains angular cobbles and boulders with a silty-sandy matrix. It is coarser grained, less compact and contains a much higher proportion of angular clasts than most till in the study area. These deposits are derived from gravity processes and continue to accumulate in the modern environment.

For drift-prospecting purposes, anomalies can normally be interpreted to be of local origin from steep slopes above.

Organic Plain

Extensive areas of bog and fen cover over half of the map area. These areas consist of an organic accumulation that is water saturated and generally less than 2 m thick (maximum thickness measured was 3.5 m). Most areas are flat lying with less than 2 m of relief, but along the south side of Middle Ridge the bog and fen is gently inclined to the south so that there is water flow across and through the organic material.

This organic cover not only obscures bedrock but presents problems for drift-exploration sampling. In particular, it is difficult to know what material is being sampled below the organic cover. In general, bog forms in low areas that were formerly ponds that acted as sediment traps before the establishment of vegetation. It is therefore important that subsurface bog samples be taken from at least 1 m beneath the top of the underlying drift. Evaluation of geochemical-drift anomalies should take into consideration the reducing environment within and beneath bogs, which can cause misleading high and low values because of great differences in the mobility of ions within this environment. Selected sites should be bulk sampled using a backhoe so that this type of problem can be eliminated.

DISCUSSION

The glacial-landform complexes in the map area can be subdivided into three zones based on landforms that are streamlined parallel to, or formed transverse to glacier flow. They form an apparently transitional lateral sequence arranged along the direction of ice flow. Each zone roughly coincides with underlying bedrock type. The transverse and streamlined zones were overlain subsequently by a discontinuous cover of hummocky and reticulate-ridged sediment. The resulting landscape is divided into three zones based on geomorphology and sediment type. From northwest to southeast they are: 1) terrain dominated by transverse ridges that are composed of silty-sandy diamicton, 2) terrain dominated by streamlined ridges composed of silty-sandy diamicton, and 3) terrain dominated by pebbly, sandy hummocks and ridges that form complex features parallel and transverse to ice flow.

The downglacier-flow transition from transverse features (crescentic ridges and Rogen moraine) to streamlined features (flutes, crag and tails) that formed parallel to ice flow is interpreted to be the result of subglacial processes (Lundqvist, 1969; Boulton, 1976; Aario, 1977). Throughout the map area, hummocky features superimpose streamlined and transverse features. This suggests that sediment comprising the hummocks was deposited from higher in the ice, probably after the ice had stopped flowing, since there is no glacial-flow disturbance of hummocks. The concentration of hummocky terrain composed of silty-sandy diamicton just north of the northern contact of the Ackley Granite has two possible origins. It could be the result of subglacial accumulation (infilling) in the topographic depression that contains Kaegudeck Lake. A local thickening of the basal debris-rich zone of the glacier within this depression would result in a much thicker sediment accumulation, which because of its ice content, would form hummocks during meltout. Alternatively, it could be an accumulation that formed when the glacier margin was stopped in this area during retreat. The abrupt change to hummocky and ridged pebbly sand down-ice of the Ackley Granite is in part related to the material available for excavation by the advancing glacier (disintegrated granite), but it could also have been the site of a stagnant ice margin. This is inferred from the reticulate ridge and hummocky geomorphology and the obvious abundance of flowing water (eskers and esker-like ridges) that characterize such an environment.

Implications for Drift Exploration

Despite the complexity of the landscape and its genesis within the map area, there are some clear implications for drift exploration. To begin, the ice-flow history of the sediment and clasts that form the landscape is simple. One ice-flow direction (170° ± 10°) dominated to the point of destroying any evidence, if any, for earlier flow directions. Therefore the interpretation of drift anomalies is unlikely to be complicated by complex glacial dispersion. A second point is that throughout the area there are subglacially formed landforms (crescentic ridges, Rogen moraine, flutes, crag and tails) that contain compact subglacial till that is optimal for sampling because the sediment is likely to be of relatively local origin. Third, features within hummocky terrain are less likely to contain material that is locally derived and therefore should not be sampled. Finally, the surficial landscape exposed above bog cover is strewn with boulders and cobbles that are interpreted to have been deposited in the late stages of hummocky terrain deposition. Furthermore, deeper exposures (greater than 2 m) show that the near-surface sediment (less than 1 m deep) is less compact, contains less fines and was probably deposited in the late stages of hummock formation. Therefore it should not be sampled.

In much of the area, bog cover is a major problem. Work indicates that the bogs are generally less than 1.5 m deep, and therefore samples can be obtained from beneath them. Routine subsurface bog sampling by hand auger should be supplemented using portable backhoe pits to ensure that the material being sampled is till, and to provide some bulk samples for control purposes.

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