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QUATERNARY GEOLOGY OF THE BELLBURNS (12I/5 and 6) MAP AREA

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ABSTRACT

A 1:50,000 scale Quaternary terrain and sediment map of the Bellburns (12I/5 and 6) map area was completed in 1986. It is designed to provide a framework for glacial-dispersal and drift-prospecting studies. The map contains the following Quaternary units: a) low-relief hummocky plain of glacial origin, b) high-relief dissected plain that is a wave-modified hummocky moraine, c) low-relief plain containing subparallel ridges that are of subglacial origin, d) sand and gravel plains and fans of glaciofluvial origin, e) gravel, sand and pebbly mud plain of marine origin, f) flat organic plain, and g) colluvial fans.

An important aspect of the study is the differentiation of sediment of glacial, glaciomarine and glaciofluvial origin as an aid to drift prospecting. Surface Quaternary sediments were probably deposited by, or in association with, glaciers that flowed westward from an ice cap in the Long Range Mountains. Generally, the ice flowed down major valleys onto the coastal plain where piedmont glaciers spread out and coalesced to completely cover it. The age of this glaciation is Late Wisconsinan, with a possible local readvance after 12,800 ± 150 years B.P. (based on shells in till). Subsequent extensive postglacial modification of these sediments by wave action destroyed or masked their glacial origin in about 80 percent of the area that lay below 76 m a.s.l., leaving behind a gravel and sand lag.

INTRODUCTION

A map of Quaternary sediment at a scale of 1:50,000 was completed for the Bellburns (12I/5 and 6) map area during the 1986 field season (Figure 1). This report presents a generalized version of this map and provides a description of map units and glacial-flow directions, a preliminary Quaternary geological history, and a brief description of the implications of this work for drift exploration.

In 1985 a detailed drift-sampling program was conducted in the vicinity of the Trapper prospect in an attempt to explain the high concentration of zinc-mineralized float that occurs along the east side and on top of the hill that contains the prospect (Mihychuk, 1985, 1986). The project was expanded in 1986 so that interpretation of anomalies could be fit into a regional framework. In particular, work focused on the recognition of basal till, the optimal sampling medium (Hornbrook *et al.*, 1975), the documentation of glacial-flow directions and a study of the distribution of pebble rock types. During the 1986 field season, six new areas were selected for drift exploration. Selection was based on bedrock geology—stratigraphic position and proximity to northeast-trending faults (Lane, 1984; Knight, personal communication, 1986)—and sample sites located on top and down-ice of favourable stratigraphic zones. Evaluation of this sampling program will be conducted after geochemical analyses are completed. Ice-flow directions were determined from glacial-abrasion structures and the preferred orientation of pebbles in till.

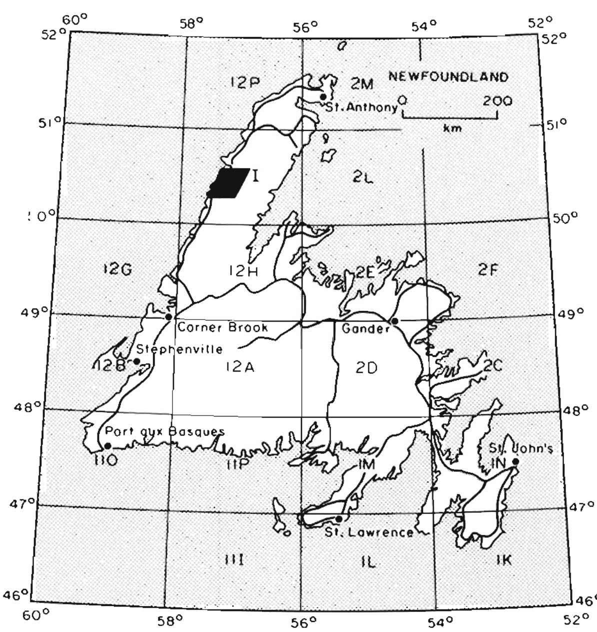


Figure 1: *Location of the study area.*

Regional Setting

The Bellburns map area is bounded in the west by a coastal plain at about 10 to 15 m above sea level (a.s.l.). Toward the east, this coastal plain rises gradually to about 180 m a.s.l. where it is truncated by the steep flank of the Long Range Mountains. On the coastal plain, local topographic relief of 50 to 100 m occurs adjacent to relatively flat-topped hills that are scattered across the area. Well drained areas are covered by black spruce and poplar, and poorly drained areas by bog and fen.

Glacial, fluvial and marine sediments occur as a blanket over more than 80 percent of the surface in the study area. Most of the surface geomorphology is controlled by differences in the weathering resistance of the bedrock. Hills are generally capped by stratigraphic units of resistant bedrock and valleys are floored by less resistant units or by fault zones.

Cambro-Ordovician rocks underlie the coastal plain and have been mapped by Knight (1985a,b). They are predominantly composed of carbonate and fine grained clastic rocks that are heavily deformed adjacent to the contact with granites of the Long Range Inlier, and only moderately deformed in most of the study area. The entire area is transected by north–northeast- and east-trending faults. Two horizons within Lower Ordovician rocks contain collapse breccias that are related to paleokarsting and have mineralization associated with them (Lane, 1984; Knight, 1985a, b). One occurs in dolostone along the base of the Boat Harbour Formation directly above the Watts Bight Formation. The other, which contains the Newfoundland Zinc Mine, occurs in the upper one third of the Catoche Formation.

QUATERNARY GEOLOGY

Field Method

Mapping was accomplished by field-checking an airphoto interpretation. Access by truck and all-terrain cycle is possible in much of the area because of an extensive network of logging roads. Helicopter access was used in the boggy area of the Bateau Barrens (Figure 2) and along the west side of the Long Range Mountains. Where possible, natural exposures were examined and sampled, supplemented by an extensive backhoe program in accessible areas of poor exposure.

Map Description

Subdivision of map units (Figure 2) is based on geomorphology. The legend includes bare rock and the predominant sediment types, geomorphic features, general topographic relief and a generalized interpretation of sediment genesis. Where possible, units are numbered on a relative age basis such that older units have lower numbers. They are grouped into glacial (meaning related to glaciers and their outwash) and non-glacial (meaning units of postglacial age) deposits because no preglacial Quaternary deposits were recognized. The term plain describes an area of low-relief Quaternary sediment that commonly drapes, but does not completely obscure, underlying preglacial geomorphology.

General Considerations

The maximum recorded Quaternary marine limit in the area, of about 145 m a.s.l., probably occurred shortly after retreat from the maximum extent of the most recent glaciation in the area. It is assumed that maximum crustal depression in response to glacial loading was the main factor contributing to a high sea level, and that it occurred during and after glacial retreat (Flint, 1940; Rogerson, 1981). Most of the study area is below marine limit; therefore glaciers must have terminated in the sea. This has two important ramifications:

1) Sediment deposited at or near the margin could have been deposited from the grounded basal zone of a glacier and from a floating ice shelf.

2) In areas presently below 145 m a.s.l. (marine limit), much of the glacial outwash was deposited in the proglacial sea.

An ice shelf could have existed along the western margin of glaciers that covered the Bellburns area. Based on the work of Oerlemans (1982), using modern examples from Antarctica, 250 m of water are required to sustain an ice shelf. Therefore, no ice-shelf sedimentation occurred within the study area because water depths were insufficient. It is more likely that the toe of the glacier(s) had a steep calving face so that iceberg deposits could have formed where water depths approached 100 m (i.e., below about 45 m a.s.l. today).

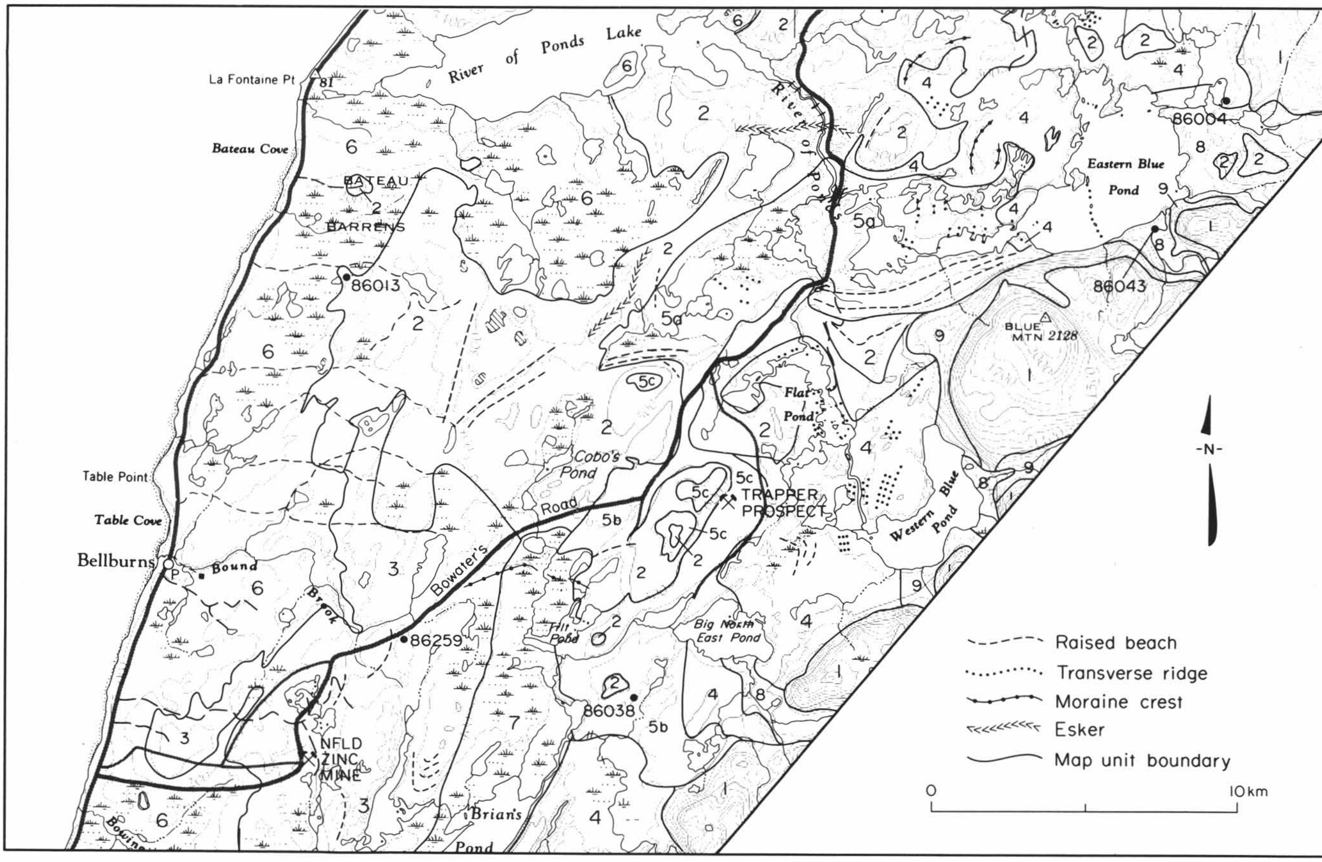
Another important consideration relates to the source of glaciers that flowed into the study area. It is most likely that ice flowed from a dome in the Long Range Mountains down valleys along the western flank of the highlands (Grant, 1974, 1977). At times these outlet glaciers must have coalesced on the coastal plain, but ultimately they had at least three different source glaciers or ice streams. These were located east of Eastern Blue Pond, Western Blue Pond and Big Northeast Pond (Figure 3).

Throughout this paper, the possible genesis of sediment is discussed. This interpretation is tenuous, based on the limited data available, but has been done to provide a basis for recommendations regarding optimal drift exploration sampling and interpretation of results. More work is required to substantiate these interpretations, and research will continue in 1987.

The orientation of elongate pebbles (50 where possible) in diamicton (till and till-like sediment) is referred to as a pebble fabric. It was measured at selected sites and is presented on stereographic projection scatter plots on Figure 3. The mean preferred orientation is calculated using eigenvectors, and is shown with an arrow beside each scatter plot. The degree of confidence for the mean preferred orientation is expressed by the value for s–values between 0.6 and 1.0 are acceptable, but the degree of confidence increases as s increases.

Pebble fabrics are used to interpret till and till-like sediment genesis, and in the case of till, to provide a direct indication of the direction that ice was flowing when it was deposited. It is useful to compare these with other flow-direction indicators or to use preferred fabric orientations in their absence. Generally, tills that are deposited subglacially have a relatively strong preferred orientation of pebbles (s equal to or greater than 0.6) (Boulton, 1971). Tills that are deposited from englacial and supraglacial positions generally have weaker pebble fabrics (s less than 0.6), as do other nonglacial deposits (e.g., debris-flow and slump deposits).

Pebble fabric is used in combination with sediment characteristics and, where possible, surface geomorphology to make genetic interpretations.



LEGEND

QUATERNARY

9 *Colluvial fans and aprons; occur along lower parts of steep slopes*

8 *Gravel and sand fans; confined to valley floors along the west side of the Long Range Mountains*

7 *Flat organic plain; poorly drained, <2 m local relief, organics are 1 to 4 m thick; overlies till and marine sediment*

6 *Gravel, sand and pebbly mud plain; occurs between 0 and 76 m a.s.l.; surface material is mainly marine lag that overlies till and bedrock*

5 *Sand and gravel plain;* 5a, *contains numerous low-relief (<2 m) subparallel ridges of glacial origin and raised beach terraces;* 5b, *featureless plain of glaciofluvial origin that has a marine-reworked surface;* 5c, *veneer of medium to coarse pebbly sand of glaciofluvial origin overlying till*

4 *Low-relief plain containing subparallel ridges; ridges are cobble covered and cored with till; formed by subglacial processes*

3 *High-relief (75 m) dissected plain; raised cobbly and pebbly beach terraces, and wave-modified hummocks; eroded and wave-modified hummocks; eroded moraine complex*

2 *Low-relief hummocky plain; hummocks 1 to 3 m high, thickest in low areas, and forms veneer over bedrock in high areas; contains till, sand and gravel*

PRE-QUATERNARY

1 *Bedrock*

Figure 2: *Generalized Quaternary geology map.*

Bedrock (Unit 1)

Mappable areas of bare rock occur in the Long Range Mountains (Figure 2). Elsewhere they are too small to be shown at this scale of mapping. The precise location of most rock outcrops is shown by Knight (1985b). Adjacent to the coast, extensive areas of naturally occurring bedrock outcrop have been substantially enlarged by aggregate mining during construction of the Viking Highway (not shown on Figure 2).

Low-Relief Hummocky Plain (Unit 2)

Unit 2 occurs between 76 and 183 m a.s.l. (Figure 2). It is characterized by hummocks that are commonly 1 to 3 m high and forms a blanket that is thickest (more than 8 m thick, e.g., site 86013) over topographically low areas, and is a discontinuous veneer overlying bedrock in high areas. Hummocks are generally obscured by vegetation–spruce and poplar in relatively well drained areas and bog and fen in poorly drained areas–and are best seen on airphotos. No exposures were available to show the composition of these hummocks. A pebbly sand esker about 5 to 8 m high, trending east to west, crosses River of Ponds, and a possible esker trending north to south occurs about 4 km to the southwest of it (Figure 2).

Unit 2 contains about 80 percent till and 20 percent sand and gravel. The till is pale brown (10 YR 6/3 moist)[1], has a silty sand matrix, is compact near the surface to very compact below 2.5 m, and contains abundant, subrounded, striated clasts and a few angular clasts. The till has no internal stratification but in places has a horizontal fissility. Gritty sand lenses occur locally beneath single cobbles and within some cobble concentrations. The preferred orientation of pebbles in this unit (9 fabrics measured at 7 sites) varies from relatively strong to none (Figure 3). The regional implications to glacial flow are discussed in a later section.

The areal distribution of Unit 2 requires some explanation. Specifically, northwest of Big Northeast Pond on top of the hill that contains the Trapper Prospect, Unit 2 surrounds two areas of Unit 5. The surface of Unit 2 appears to have been exposed by postglacial hillside erosion caused by slope wash. It was probably originally covered by sand of Unit 5. Northwest of Cobos Pond, irregular areas of sand and gravel and pebbly–cobbly raised beaches occur in higher concentration than elsewhere in this unit. A broad ridge that extends for more than 4 km (and has at least 8 m of till on it) occurs near the contact of Unit 2 with Unit 7, south of the west end of River of Ponds Lake.

Contacts between Unit 2 and Units 3 and 6 (Figure 2) are generally marked by a decrease in elevation and a change to more poorly drained terrain. This is reflected by a dramatic reduction in tree cover and an increase in bog. In many places this contact follows the 76-m contour (250-ft contour on NTS area 12I/5,6).

Till of Unit 2 is predominantly the product of melting out from basal debris-rich ice, mainly after clean overlying ice had melted off. Supraglacial transport and deposition were not likely, based on the following observations collected from several good exposures and many other shallow exploration pits:

1) The till has a moderate to high degree of compaction. Supraglacial till does not inherit any degree of compaction during deposition. Post-depositional desiccation, which can increase compaction substantially, is unlikely in this area because of high precipitation, which maintains the moisture content of most sediment in the area.

2) The till contains a low proportion of angular clasts and therefore was not derived from a supraglacial position. Glaciers that have their source in areas of high relief, such as the Long Range Mountains, generally carry debris (derived from nunataks) in englacial and supraglacial positions.

3) Pebble fabrics measured in till of Unit 2 have a variety of strengths from relatively strong to none (Figure 3). The preferred orientation of most of the pebble fabrics is relatively close to the orientation of striations on nearby bedrock. This agreement of directional data is unlikely to be preserved in the supraglacial environment because of the collapse and sediment-flow processes that dominate that environment (Eyles, 1979). Two pebble-fabric measurements from different depths at site 86013 indicate northward flow, and are not in agreement with nearby striations on bedrock. It is possible that reorientation of a large coherent mass of sediment occurred either as a result of slumping by melting out of buried glacial ice or by wave action or mass movement in postglacial time. Alternatively, these fabrics could have been formed by different debris flows. This hypothesis is unlikely given the high degree of compaction of the till and the lack of evidence for subsequent glacial overriding needed to produce the surface till that is exposed elsewhere in Unit 2.

4) The low-relief hummocky terrain of Unit 2 was likely produced as the basal debris-rich zone of the glacier melted out (Gravenor and Kupsch, 1959; Parizek, 1969; Eyles, 1979). First, mainly clean ice melted away to expose the basal debris-rich zone (Figure 4). Where sediment cover was thick, it acted as an insulator so that intervening areas melted faster to form depressions. Subsequently, sediment slumped into these depressions. This cycle of surface differential melting was repeated as high areas shed sediment cover and melted faster, and low areas were insulated by sediment. Ultimately, a hummocky moraine was formed. The sediment that underwent most of the reworking during melting out was about equal in thickness to the local relief of the moraine (Clayton and Moran, 1974). Beneath this surface, subglacial till was deposited by melting out. Pebble orientations were preserved in the subglacial till but were largely destroyed in the surface melt-out till. Till deposited earlier from active ice by lodgement and molding could also be preserved below this lithofacies.

[1] Munsell soil color chart

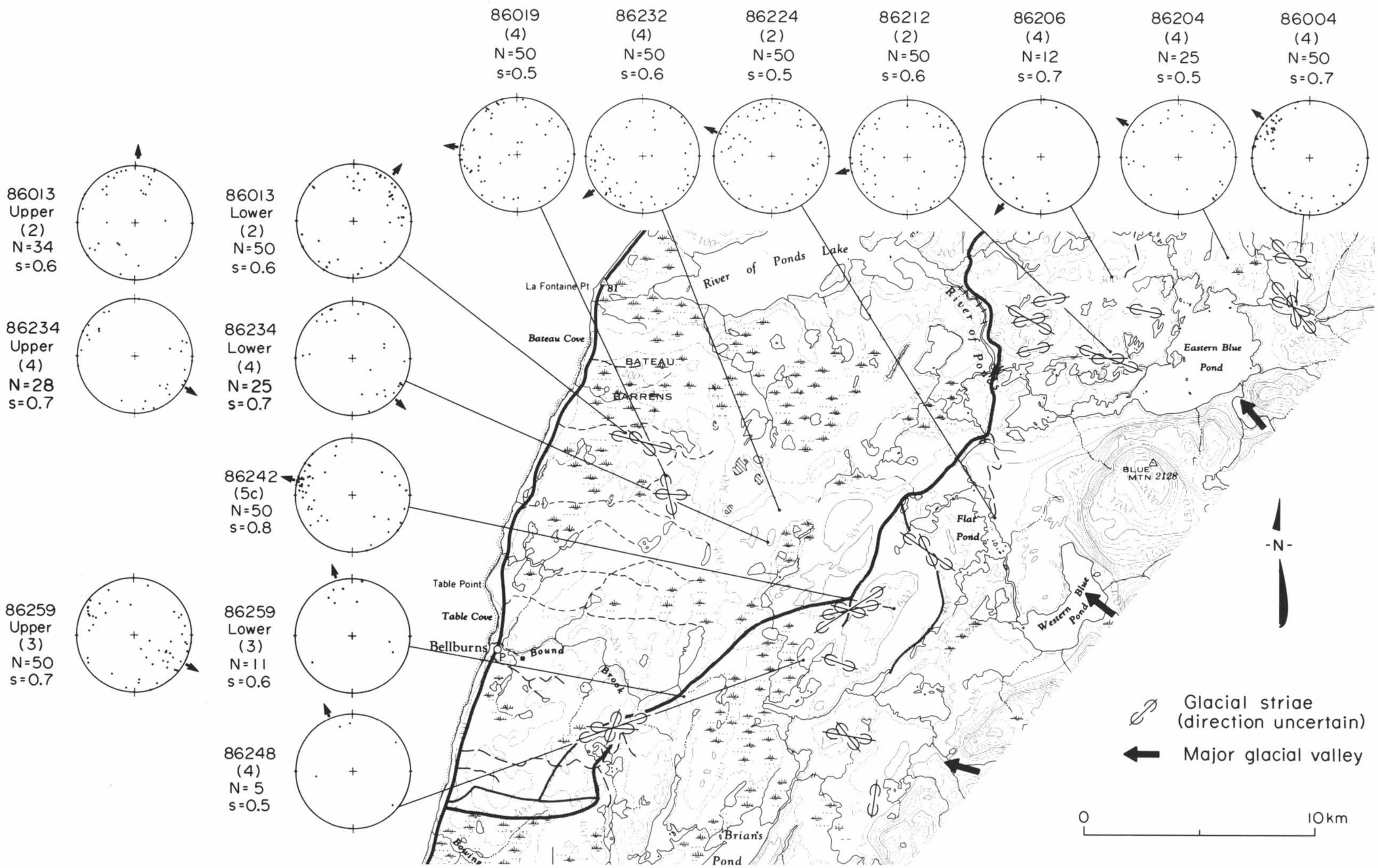


Figure 3: *Summary of glacial striations and pebble fabrics in till. The circles are stereographic projection scatter plots. Each point represents the orientation of one elongate pebble. The arrow beside each scatter plot is the mean preferred orientation of pebbles (as calculated using eigenvectors) and s gives a measure of the degree of confidence in the mean orientation. N is the number of pebbles measured, and the number in brackets is the map-unit number.*

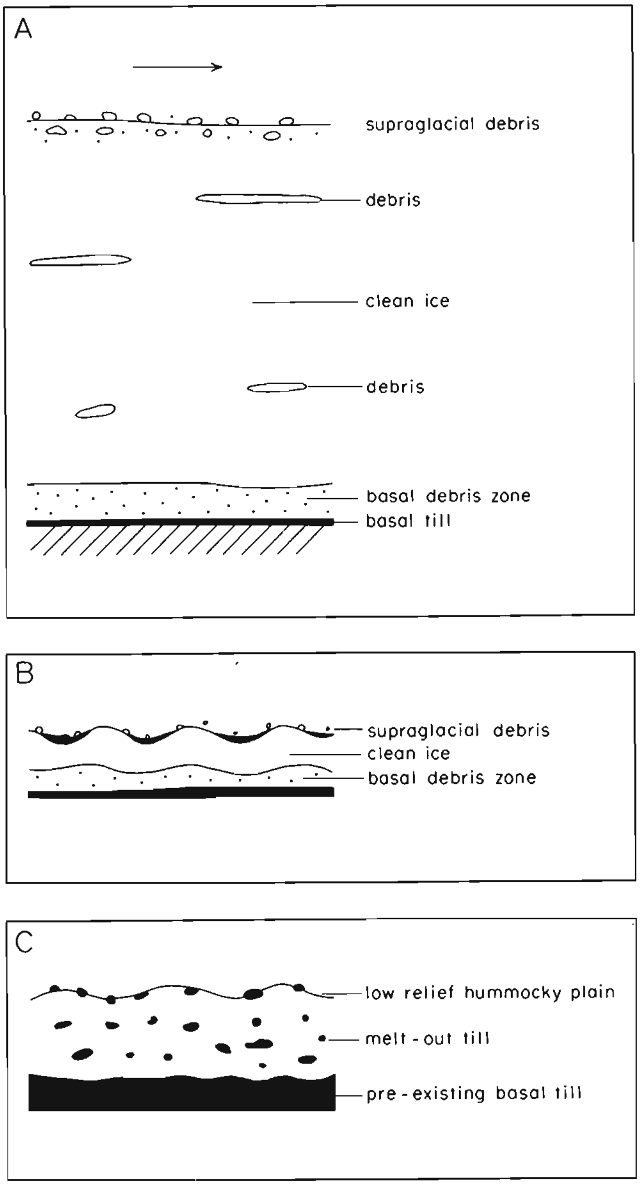


Figure 4: *Schematic diagram showing the formation of low-relief hummocky plain (Unit 2). A) active glacier, B) stagnant ice in advanced stage of melting, and C) final deposit.*

5) The pebbly sand esker found in the northern part of the map area probably formed englacially and subglacially as meltwater drained from all of the ice overlying the basal debris-rich zone of the glacier. This esker formed above Unit 2, further supporting a basal origin for till of this unit.

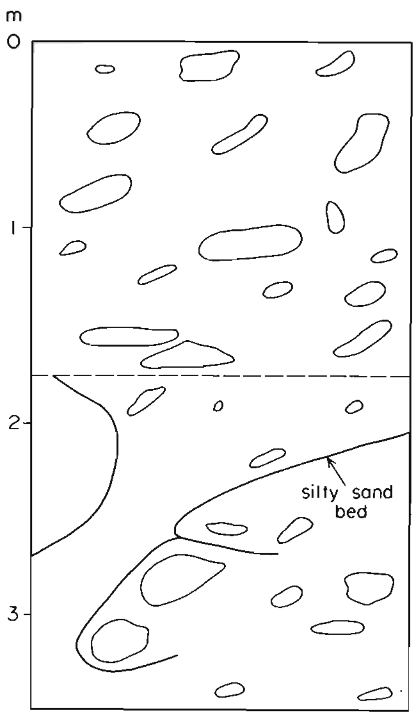
The irregular areas of sand and gravel that occur in many places across the map area below marine limit (145 m a.s.l.) were probably formed by two processes. First, where the ice-marginal marine basin had water depths of more than 100 m, deposition occurred from icebergs. This type of sedimentation observed in the modern glaciomarine environment (Ovenshine, 1970; Powell, 1981) produces isolated lenses of sand and gravel as a result of sediment dumping from top-heavy bergs that periodically roll over. Deposits of this type have not been positively identified in the study area, but some of the scattered patches of sand and gravel probably formed in this way. Subsequently, as sea level fell relatively continuously to the modern level, wave action winnowed and reworked the surface, forming beach ridges in some places. It is likely that local areas of sand and gravel are reworked berg deposits or juvenile beach deposits. Longshore drift was probably also active in the redistribution of sand and silt, although this type of deposit has not been positively identified.

For drift exploration, samples from moderately to well compacted till are most likely to provide satisfactory results because it was deposited subglacially and has a high probability of being a first-order derivative of its bedrock source.

High-Relief Dissected Plain (Unit 3)

Unit 3 (Figure 2) is characterized by high relief (up to 75 m). Maximum elevations are similar to Unit 2, but Unit 3 is dissected by broad valleys, leaving isolated hills between them that are as high as 167 m a.s.l. Raised cobbly–pebbly marine beach terraces, wave-modified hummocks and thin (less than 2 m) discontinuous patches of sand and gravel are common. About 40 percent of the surface material in Unit 3 is till like and the remainder is gravel and sand. Where sediment is interpreted to be till, it is generally dark gray-brown (2.5Y 4/2 moist), has a silty sand matrix, is moderately compact, contains subangular to subrounded pebbles and cobbles, and has horizontal fissility near its base (e.g., site 86259). Small irregular sand lenses (5 by 20 cm) occur beneath some cobbles.

It is inferred from airphotos and a limited examination of sediment that Unit 3 is a hummocky-moraine complex that has been extensively modified by wave action. Small hummocks are common and many have a terrace ring around them that is interpreted to be the result of wave washing. This is consistent with the occurrence of raised beaches within Unit 3. It is likely that Units 2 and 3 were once part of the same moraine complex. While Unit 3 was submerged, the valleys focused wave energy on topographic highs causing much greater wave erosion than on the gradually rising, relatively smooth surface of Unit 2, which would have dissipated wave energy gradually. Only two pebble fabrics were measured in Unit 3. They were taken at a single site (86259) from different superimposed lithofacies, and have a different preferred orientation of clasts (Figure 5). The sediment is interpreted to be till for reasons similar to those discussed for Unit 2. Nearby striation orientations and regional ice-flow patterns indicate that flow was away from the Long Range Mountains, whereas one of these fabric orientations indicates flow toward the Long Range Mountains (Figure 3, site 86259). Therefore it is suggested that this sediment was reoriented in a similar way to that discussed previously for site 86013 (Unit 2). Shells found in the lower lithofacies occur within thin (less than 2 cm thick), discontinuous, attenuated sandy silt lenses that deform around cobbles (Figure 5). The host material is interpreted to be a till. The nearly intact shells were probably incorporated from nearby marine sediment and then redeposited by melting out



Surface truncated by road construction

Upper lithofacies

Till: silty sand matrix (more silt than lower lithofacies); moderately to well compacted and unlayered; contains 30 percent pebbles and cobbles (more pebbles than the lower lithofacies), most of which are striated and subrounded; does not contain lenses; bottom 20 cm has a moderate horizontal fissility; gradational basal contact

Lower lithofacies

Till: dark gray-brown (2.5Y 5/2 moist); silty sand matrix; moderate compaction and mainly unlayered but contains a few small dark-reddish-gray, irregularly shaped, silty sand lenses (2 by 5 cm) that generally occur beneath or between cobbles; 30 percent pebbles and cobbles including a few boulders (mostly striated and subrounded); a graded silty sand bed (shown on sketch) about 1 cm thick is attenuated and deformed around cobbles, and forms a recumbent fold – this bed contains nearly intact bivalve shells that have been dated at 12 800 ± 150 years B.P.; basal contact covered

Figure 5: *Two till lithofacies exposed in a backhoe pit in Unit 3 (site 86259). The lower lithofacies contains shell fragments that were incorporated by overriding ice.*

in a similar way to that discussed for Unit 2. These shells, dated at 12,800 ± 150 years BP (BGS 1080)[1] represent a maximum date for the advance.

For drift exploration, sampling should focus on the compact till within Unit 3, as discussed for Unit 2.

Low-Relief Plain Characterized by Subparallel Ridges (Unit 4)

Most of Unit 4 is a featureless plain that has 1 to 3 m of relief (Figure 2). It forms a blanket composed predominantly of till that is estimated to be less than 5 m thick. In many places it lies directly on the bedrock surface. Access to Unit 4 is limited so that few sites were examined. Low (1 to 3 m) subparallel ridges oriented transverse to major valleys that originate in the Long Range Mountains occur between 46 and 145 m a.s.l. (Plate 1). These ridges are typically straight, cobble and boulder covered, till cored, and irregularly spaced. They are most abundant north and west of Eastern Blue Pond and along Flat Pond where they are spaced as closely as 100 m. Other equally prominant ridges in Unit 4 highlight bedrock ridges resulting from folding and faulting of Cambro-Ordovician rocks, particularly west of Western Blue Pond. Unit 4 is predominantly composed of dark-reddish-brown (5YR 3/4 moist) to very dark-reddish-brown (10YR 3/2 moist) compact silty sand till, which in places has a horizontal fissility and contains predominantly angular to subangular pebbles and cobbles (e.g. site 86004).

Striations on bedrock surfaces and till pebble fabrics are oriented transverse to the long axes of nearby ridges in Unit 4 (Figure 3). It is likely that these ridges formed subglacially at or near the ice margin as a result of ploughing, squeezing and shearing (Minell, 1977). The absence of glacial streamlining (e.g., fluting) on these features indicates that no subsequent ice flow overrode them. This could have occurred during the last glacial retreat so that each ridge is a small moraine that was created by a minor readvance.

Plate 1: *Aerial view of transverse ridges in the vicinity of Flat Pond.*

Unit 4 is sufficiently close to the Long Range Mountains

[1] Brock University Geological Sciences Radiocarbon Lab Sample Number

that glaciers out of each of the three main valleys in the study area were not coalesced during the final stages of deposition. In the centre of the main part of Eastern Blue Pond, several ridges seem to form a discontinuous arc that extends for more than 2 km across the lake (Figure 2). The ends of these ridges terminate abruptly with steep slopes that were observed to continue for several metres beneath the lake's surface.

Contacts between Unit 4 and Units 3 and 5 are sharp on airphotos; however, they were not observed on the ground, possibly because they are gradational. In general, Unit 4 is topographically lower than Unit 2. Unit 4 is interpreted to be younger than Units 2 and 3 and was deposited by the last glaciers to leave the area.

From a drift-prospecting perspective, till of Unit 4 was deposited subglacially and is therefore a reliable sampling medium.

Sand and Gravel Plain (Unit 5)

Unit 5 forms a plain of sand and gravel that in places is more than 5 m thick (Figure 2). It is divided into three subunits.

Subunit 5a is mainly a featureless plain that occurs along the west end of Eastern Blue Pond and extends to northwest of Flat Pond. It occurs between 107 and 198 m a.s.l. and contains numerous low-relief (less than 2 m), dissected, subparallel ridges very similar to those described for Unit 4 (Figure 3). In places where ridges occur nearby in Unit 4, they are parallel to those in subunit 5a. Several prominent beach terraces occur along the south valley wall at the west end of Eastern Blue Pond. Subunit 5a consists mainly of pebbly sand except along the tops of truncated transverse ridges, which are covered with subrounded and rounded cobbles, and along the shore of Eastern Blue Pond, where it is cobbly–pebbly gravel. Plane bedding and cross-bedding occur in subunit 5a adjacent to Bowater Road. Limited access prevented the digging of backhoe pits farther to the east.

Subunit 5b is mainly a featureless plain that forms a blanket over till and rock surfaces. It is developed at elevations between 76 and 152 m a.s.l., and occurs around the hill that contains the Trapper prospect, to the southwest of Big Northeast Pond, and west of Flat Pond. The upper 1 to 2 m of subunit 5b are well exposed for about 4 km along a new logging road that trends southward on the east side of Tilt Pond. This material is pebbly sand that in many places is plane bedded and cross-bedded (Plate 2). The contact of subunit 5b with subunit 5a is gradational; however, its contacts with Units 3, 4 and 7 are sharp.

Subunit 5c is a veneer of pebbly sand overlying till. It occurs above the marine limit on the hill containing the Trapper Prospect and the hilltop to the northwest.

Unit 5 is interpreted to be of glaciofluvial origin. However, much of the unit occurs below the marine limit and therefore both continental and marine environments are considered. The sorting (lack of fines) and primary structures (cross- and plane beds showing some normal grading) suggest deposition from flowing water or turbidity currents.

Plate 2: *Cross-bedded and plane bedded sand of subunit 5b at site 86038.*

Surface geomorphology does not add to this interpretation because most of the surface was modified post-depositionally by marine and subaerial erosion. The hummocky surface of parts of subunit 5b, below the hill where the Trapper Prospect is located, could have formed by collapse as buried ice melted out. This interpretation is based entirely on the character of features observed on airphotos. Alternatively, it is possible that the hummocky surface is located beneath a veneer of pebbly sand.

As mentioned previously, glaciers that flowed across the study area terminated in the sea so that outwash reaching the glacial terminus must have been deposited in the marine environment. The pebbly sand lithofacies of Unit 5 does not change, whether above marine limit or at lower elevations, although the surface has been modified by wave action in some places. This suggests that the environment of deposition for Unit 5 was continuous, or at least similar, from place to place and through time. Unit 5 contains no shells, from which it is inferred that the deposit is either non-marine or that the environment of deposition was a highly turbid fresh-water tongue of meltwater in the marine basin. In the latter case, unfavourable environmental conditions would have prevented the migration of marine organisms into the area. A subglacial environment must also be considered for Unit 5. In this case, one or more subglacial cavities would act as conduits for meltwater. The pebbly sand might have been deposited during the late stages of water flow during glacial recession. The origin of the subparallel ridges that occur within subunit 5a influence this interpretation. As discussed for similar features in Unit 4, the ridges in subunit 5a probably formed subglacially, transverse to ice flow, at or near the ice margin. It is possible that they formed at the same time as those in Unit 4. The internal composition of the ridges in subunit 5a is unknown. Nonetheless, two genetic possibilities are most likely. They formed either by subglacial deformation of sand and gravel, or by subglacial pushing of till (as in Unit 4),

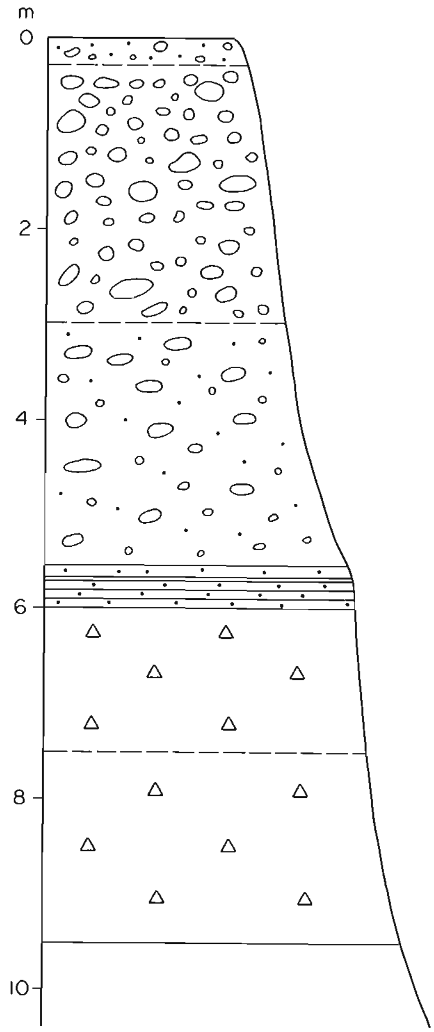


Figure 6: *Bateau Cove section—compact silty clay till overlain by bouldery beach gravel. The upper surface of the till has been truncated by wave action.*

which was subsequently dissected by flowing water and then covered by sand and gravel. Perhaps this latter possibility also explains the truncated morphology of the areas noted within subunit 5a in Eastern Blue Pond. They may have been part of the same moraine, which was eroded by escaping subglacial meltwater. The apparent continuity within subunit 5a may also be accounted for by a time-transgressive depositional environment that migrated with the retreating ice margin. In this case, deposition of Unit 5 occurred subglacially or proglacially near the ice margin.

Unit 5 is not a good medium to sample for drift-prospecting purposes because it is at least a second derivative of its bedrock source.

Gravel, Sand and Pebbly Mud Plain (Unit 6)

Unit 6 is a relatively flat, gently sloping plain that rises from near sea level along the modern coast to 76 m a.s.l. inland (Figure 2). Its contacts with other units follow this elevation in most places. The unit is generally poorly drained and therefore is mainly covered by bog, which makes it relatively inaccessible. Cobbly gravel beach terraces and ridges are the most common Quaternary geomorphic features. They are most pronounced at about 76 m a.s.l. along the north—south part of the contact of Unit 6 with Units 2 and 3. It is suggested that this marks the most prolonged sea-level stage in the study area above the beach terraces that occur at about 15 m a.s.l. adjacent to the modern coastline. Other materials within Unit 6 include sand and till. Extensive areas of bare rock are also common, particularly near the coast. A section exposed along the modern shoreline in the vicinity of Bateau Cove contains about 6 m of well sorted, rounded, cobbly marine gravel and sand overlying a sandy bed about 10 cm thick that contains shell fragments. This bed truncates a grayish brown (2.5Y 5/2 moist), very compact, silty till (Figure 6). Many of the cobbles in the base of the gravel that overlies this sand have intact shells or shell-attachment bases cemented to them. Much of Unit 6 has a discontinuous blanket of gravel and sand that contains shells and is of marine origin. Compact till occurs beneath this surface veneer in some places.

The surface material of Unit 6 is predominantly of marine origin. It formed when sea level was at or near 76 m a.s.l.

and continued to form until present sea level was reached, as wave action and longshore drift reworked the underlying till (e.g., Figure 6). The till that is exposed along the coast is likely of subglacial origin. This interpretation is based on its high compaction and lack of stratification or lenses. Pebble-orientation measurements were not possible because of the hardness of the till.

From a drift-prospecting perspective, Unit 6 has limited potential as an aid to tracing geochemical anomalies because it has not been correlated with surface tills and the other sediment is at least a second derivative of its bedrock source.

Flat Organic Plain (Unit 7)

Unit 7 is a flat, poorly drained plain that lies between 76 and 107 m a.s.l. It has less than 2 m of local relief and is mainly covered with bog. The organic material that forms these bogs is estimated to be 1 to 5 m thick and probably overlies marine sand and gravel across much of the area. Along the shores of Brian's Pond, a well sorted, rounded cobbly to pebbly gravel is exposed at about 76 m a.s.l. In one place it forms a spit that extends into the pond. Based on the juxtaposition of Unit 7 with Unit 6, it is likely that a discontinuous layer of till similar to those found in Unit 3 underlies bog in much of this unit.

Unit 7 was likely a low-lying till plain that was heavily modified by wave action while sea level stood at about 76 m a.s.l. Subsequent to marine recession, a large bog formed on the poorly drained plain.

Unit 7 surface materials are unlikely to provide useful information for drift prospecting. However, a till that is worth sampling probably lies within 3 to 5 m of the surface of the bogs.

Gravel and Sand Fans (Unit 8)

Unit 8 forms fans of sand and gravel that cover the floors of valleys that drain westward from the Long Range Mountains (Figure 2). Sediment consists of about 60 percent medium to coarse sand and 40 percent subrounded pebbles and cobbles. Channel-fill cross-bedding, graded bedding and pebbly gravel beds are common. At site 86043, more than 12 m of sand and gravel are exposed in a stream cut. Unit 8 is glaciofluvial and fluvial in origin. It formed during the last stages of meltwater flow from wasting glaciers in the Long Range Mountains. During postglacial time, sediment accumulation and reworking by streams have modified this deposit to its present form.

Unit 8 has limited value to drift prospecting because it is at least a second derivative of its bedrock source.

Colluvial Fans and Aprons (Unit 9)

Colluvial fans and aprons that are large enough to be mapped occur along the lower parts of steep slopes on the western flank of the Long Range Mountains. The colluvium is generally clast supported, and contains angular cobbles and boulders in a silty sand 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.

With respect to drift prospecting, Unit 9 is only useful for local bedrock anomalies.

CONCLUSIONS

The deepest buried (oldest?) Quaternary sediment found in the area is a till that underlies Unit 6. It has only been found along the modern coast in the vicinity of Bateau Cove and La Fontaine Point. The upper surface of this till is truncated by postglacial beach gravels and its age is unknown. This till may correlate with Unit 2 (Figure 2), which is the oldest surface Quaternary sediment in the study area. The glaciers that deposited Unit 2 probably covered most or all of the map area and advanced to beyond the modern coastline. Units 3, 6 and 7 probably formed on this sediment surface. They differ from Unit 2 and from each other by their degree of wave modification. Unit 3 has been affected much less than Units 6 and 7. Shells, dated at 12,800 ± 150 years BP, occur within till of Unit 3 (site 86259). A readvance of ice must therefore have occurred after this time. Subsequently, Unit 4 was deposited probably during the last stages of glacial retreat from the area. The transverse ridges in this unit could have formed at a calving glacial margin, possibly as a result of minor readvances. During glacial recession, the pebbly sand of Unit 5 was deposited as meltwater drained the glaciers. The trend of Unit 5 on the map appears to indicate flow first to the west and then to the south, but this has not been substantiated. The sand and gravel of Unit 8 were deposited during the final stages of recession, and during the Holocene. Colluvium of Unit 9 was deposited throughout postglacial time.

Drift Prospecting

Specific comments regarding the suitability of materials for drift prospecting sampling have been made for each map unit. Generally, compact till found within any of the units is likely to be useful. Regionally, glacial flow originated in valleys along the west side of the Long Range Mountains (Figure 3). The glaciers flowed westward but spread out laterally as piedmont glaciers on the coastal plain so that localized flow occurred toward the northeast and the southwest. Topographic highs on the coastal plain seem to have had little effect on ice-flow direction.

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