Current Research (2002) Newfoundland Department of Mines and Energy
Geological Survey, Report 02-1, pages 1-20

QUATERNARY GEOLOGY OF THE ALEXIS RIVER AREA, AND THE BLANC-SABLON TO MARY'S HARBOUR ROAD CORRIDOR, SOUTHERN LABRADOR

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ABSTRACT

The Quaternary geology and glacial history of the Alexis River area and Blanc-Sablon to Mary's Harbour road corridor were investigated, and the Alexis River region was systematically sampled for till-geochemistry studies. Till samples were also collected along roads in the Blanc-Sablon to Mary's Harbour area, but sample coverage was much less extensive in this area. In the Alexis River area, ice flowed eastward during the last glaciation, and deposited a thin, bouldery till. Subaqueous fans and glaciomarine till were deposited where ice was in contact with the sea. Marine limit was likely 150 m above the present sea level, based on the maximum elevations of marine sediments and outwash braidplains. During deglaciation, thick, extensive glaciofluvial deposits were laid down beyond the ice margin. Ice retreat halted for some time at the Paradise Moraine, an extensive ice-contact glaciofluvial deposit.

In the Blanc-Sablon to Mary's Harbour region, ice appears to have flowed semi-radially from a large lobe. The ice flowed eastward in the Mary's Harbour area, southeastward in the Red Bay area and southward in the Blanc-Sablon area. Glaciomarine sediments were deposited when ice was retreating, but was still in contact with the ocean. Ice-contact sediment complexes (the Brador Moraine), as well as sand and gravel deposits, formed when sea level was at its maximum of 150 m asl. As the sea level fell, raised beaches formed. Further retreat resulted in the formation of meltwater rivers, which laid down glaciofluvial sediments, most notably the Pinware Valley braidplain. These types of deposits are relatively rare, when compared with their abundance in the Alexis River region. Late in the area's history, glaciomarine and glaciofluvial sediments were reworked into dunes.

INTRODUCTION

Southern Labrador was extensively glaciated during the late Wisconsinan (Fulton and Hodgson, 1979; Grant, 1992; Klassen and Thompson, 1993). The Laurentide Ice Sheet eroded and sculpted the underlying rocks of the Grenville Province of the Canadian Shield, leaving numerous erratics and glacial deposits behind upon its retreat (Grant, 1992; Klassen and Thompson, 1989).

Mineral exploration in the Grenville Province has been sparse. Lake-sediment geochemistry studies from southern Labrador have shown that several areas may have significant mineral potential, however, more detailed work is required to define these targets (Gower *et al.*, 1995). Gower *et al.* (*op. cit.*) suggested that lake-sediment anomalies are affected by eastward glacial dispersion, which implies that detailed till-geochemistry work may assist in better defining areas of possible economic value.

Till-geochemical studies require rigorous sampling, so recognition of till and an understanding of the quality of samples is important. In addition, a synthesis of past ice-flow directions and the overall glacial history of an area are critical to the understanding of the data obtained.

The primary objective of the 2001 field season was to complete a detailed study of the Alexis River area. A secondary objective was to map and sample along roads between Blanc-Sablon and Mary's Harbour. Both are areas with mineral potential highlighted by Gower *et al.* (1995). The two areas are discussed separately.

ALEXIS RIVER AREA

There are three objectives of the Alexis River study. These are: 1) to map the Quaternary geology; 2) to obtain till-geochemistry data; and 3) to delineate the overall glacial history. To this end, three 1:50 000 map sheets in the Alexis

River region were mapped and sampled. Information on ice flow and glacial history were also recorded.

STUDY AREA

The study area is located in the Alexis River region of southern Labrador, west of Port Hope Simpson and Charlottetown (Figure 1). It lies between 56°30' and 57°30' W and 52°30' and 53°00' N and includes 1:50 000 NTS map areas 13A/10, 13A/14 and 13A/15.

The only road access to the study area is found on NTS map area 13A/10, the southeast corner of which (Bobby's Pond area) can be accessed from Port Hope Simpson. The road to Charlottetown is presently under construction, but the portion finished extends only a few kilometres into the northeastern part of NTS map area 13A/10. Access to the study area was provided almost entirely by helicopter, except for the Charlottetown road, which was mapped and sampled on foot, and the Bobby's Pond road, that was mapped by truck.

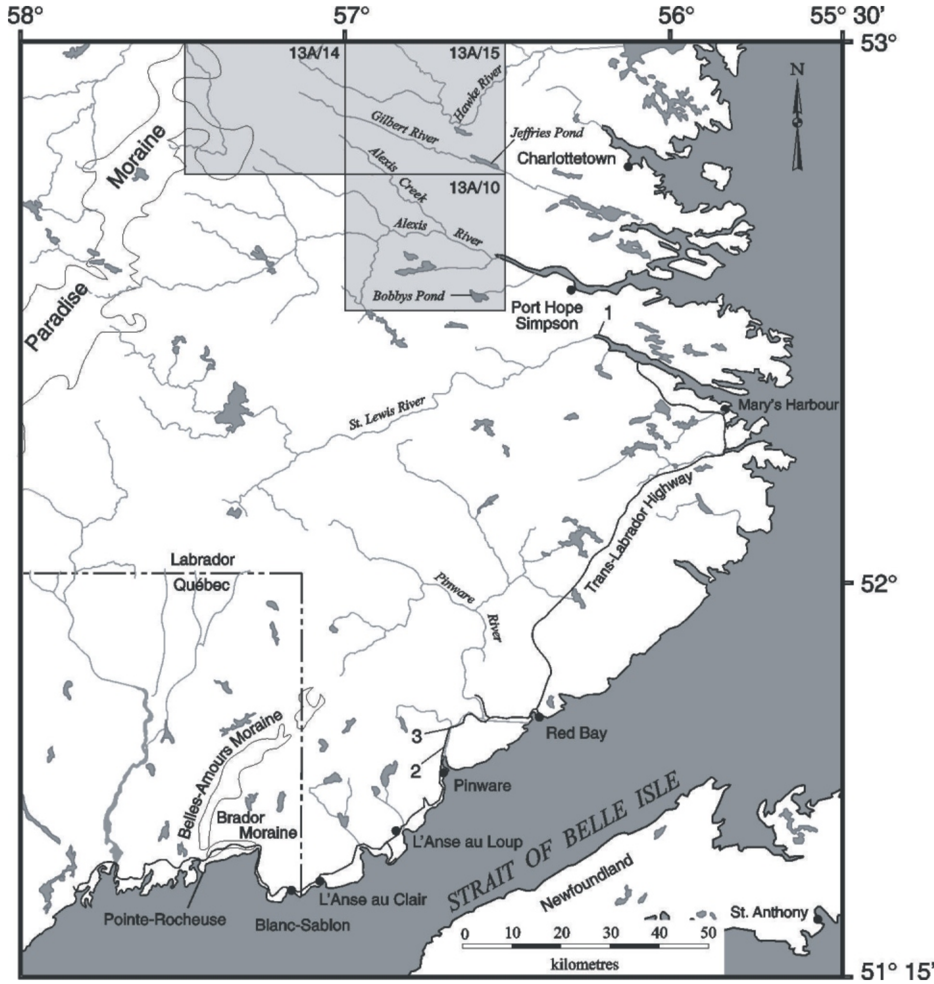

Figure 1. *Location map. The Alexis River study area is shaded and the Blanc-Sablon to Mary's Harbour road corridor follows the Trans-Labrador Highway. Numbers show the locations of logged sections: 1) St. Lewis River Section, 2) Pinware section 1, 3) Pinware section 2.*

PHYSIOGRAPHY

Southern Labrador is part of the Mecatina Plateau (Sanford and Grant, 1976). A maximum elevation of 580 m asl is reached in the hilly northern portions of the study area, but most of the Alexis River region lies below 500 m asl.

The NTS map area 13A/14 contains thick glacial deposits in its southern and western parts, imparting a low relief, hummocky look to those areas. Extensive string bogs in the hummocky zone indicate poor drainage within the glacial sediments; the rest of the study area, by comparison, is hilly, rocky and well drained.

The regional physiography reflects bedrock structure and composition because most of the glacial sediment cover is thin. The Alexis Creek, Alexis River and Gilbert River valleys have formed along major bedrock faults. The mountainous area northeast of Gilbert River reflects a major change in bedrock composition; this area is underlain by the White Bear Arm complex (Gower *et al.*, 1987; van Nostrand, 1992). Bedrock features, such as joints and faults, are visible in areas of thin to no glacial cover, but glaciation has left its physiographic mark in the major valleys. Valley floors are commonly flat due to a thick infill of coarse sediments.

BEDROCK GEOLOGY

Precambrian rocks of the Grenville Province underlie the study area. The Southwest Pond domain of the Mealy Mountains terrane and the Gilbert River shear belt of the Lake Melville terrane are the dominant bedrock divisions. A small part of the White Bear Arm complex (Hawke River terrane) is found in the northeastern corner of the study area.

The Southwest Pond domain includes metasedimentary gneiss; foliated granitoid rocks, some of which are K-feldspar megacrystic (Gower *et al.*, 1987, 1988; van Nostrand *et al.*, 1992); and mafic plutons (gabbro, norite and websterite; Gower *et al.*, 1995). These rocks are of high metamorphic grade, but are less deformed than rocks of the Gilbert River shear belt (Gower *et al.*, 1988). The Southwest Pond granite pluton, found within the metasedimentary gneiss, is undeformed (Gower *et al.*, 1987). The faulted boundary between the Mealy Mountains terrane and the Gilbert River shear belt is characterized by breccias and mylonites (van Nostrand *et al.*, 1992).

The Gilbert River shear belt is intensely deformed (van Nostrand, 1992). It includes metasedimentary gneiss and granitic to granodioritic gneiss. Potassium feldspar megacrystic granitoid rocks, foliated granite, pegmatite, calc-silicate gneiss and amphibolitic–dioritic gneiss are minor components (Gower *et al.*, 1988; van Nostrand, 1992). The Alexis River anorthosite is found within the belt, and comprises anorthosite, gabbro, gabbronorite, amphibolite and metamorphic equivalents of these rocks (Gower *et al.*, 1987; van Nostrand, 1992); it has a dioritic gneiss envelope (Gower *et al.*, 1988).

The White Bear Arm complex is a layered mafic intrusion (with metamorphic equivalents) consisting mainly of gabbro, norite and gabbronorite, as well as anorthosite, monzonite, syenite, granite and tectonically interleaved metasedimentary gneiss (Gower *et al.*, 1987; van Nostrand, 1992).

Mineral occurrences in the study area include Cu, Ni, Co, Mo and U (Davenport *et al.*, 1999).

PREVIOUS WORK

Glacial History

Despite suggestions that parts of southern Labrador were ice free in the late Wisconsinan (Vilks and Mudie, 1978; Fulton and Hodgson, 1979; Rogerson, 1982), Laurentide ice appears to have covered all of Labrador (e.g., King, 1985). The outer limit of ice extent was beyond the southern Labrador coastline, because the Laurentide Ice Sheet crossed the northern tip of Newfoundland (Grant, 1992). Josenhans *et al.* (1986) and Woodworth-Lynas *et al.* (1992) also found late Wisconsinan till in the Strait of Belle Isle and adjacent offshore areas.

Regional ice retreat from the glacial maximum began at 13 ka (radiocarbon years before present) in southern Labrador and progressed slowly until 11 ka (King, 1985). The Paradise Moraine (Figure 1) formed either at 11 ka (Vincent, 1989; Dyke and Prest, 1987) or 10 ka (King, 1985; based on lake-sediment radiocarbon dates). This moraine was once considered to mark the late Wisconsinan ice margin (Fulton and Hodgson, 1979). The area south of Alexis River was deglaciated by 10.4 ka (lake-core radiocarbon dates; Vincent, 1989). A 21 ka radiocarbon age has been obtained from lake sediments near Alexis River; however, this sample was likely contaminated by older carbon (Vincent, 1989). Ice-flow directions determined from airphoto interpretation show east–southeastward and southeastward flow south and west of the Alexis River and eastward flow north of it (Fulton and Hodgson, 1979). The main controlling factor on ice flow was the location of an ice divide in western Labrador, in the vicinity of the Smallwood Reservoir (Klassen and Thompson, 1993).

Quaternary Geology

Glacial depositional features are scarce in southeastern Labrador (Fulton and Hodgson, 1979; Grant, 1992). Glaciomarine deposits, exposed bedrock and thin till are found along the coast from Red Bay to Blanc-Sablon (Grant, 1992) and a few raised deltas and beaches are found elsewhere along the Labrador coast (Rogerson, 1982). Till in southern Labrador commonly has a sandy matrix (>50 percent) with little clay (Vincent, 1989). The Paradise Moraine, a hummocky moraine found west of Alexis River, about 110 km inland, is the only large-scale depositional feature in the region (Figure 1). It was suggested to be made up of hummocky till (Fulton and Hodgson, 1979). Free drainage to the Atlantic prevented the formation of major glacial lakes (Vincent, 1989).

Sea Level

All of southern Labrador has experienced postglacial uplift (Clark and Fitzhugh, 1991), which is a Type-A sea-level history of continuous emergence (e.g., Liverman, 1994). Marine limits are highest in southeastern Labrador, at about 150 m above present sea level in the Pinware area (Daly, 1921; Rogerson, 1982; Clark and Fitzhugh, 1991; Grant, 1992). No sea-level data is available for the study area. North of the study area, near Goose Bay, a marine limit of 135 m asl was reached at 7.5 ka (Fulton and Hodgson, 1979; Clark and Fitzhugh, 1991).

METHODS

Mapping

Surficial geology was interpreted from black and white aerial photographs. Photographic interpretation was field checked at all sample sites, as well as at additional sites that were not sampled because till was not present. Areas with extensive fire history were more intensively field checked.

Ice Flow

Ice-flow directions were determined by measuring striation, crescentic fracture and rôche moutonnée orientations. The granitic and gneissose bedrock of the region weathers easily and tends to crumble. As a result, striations are rare. No crosscutting striae were found. Ice-flow directions were determined by stoss-and-lee relationships, and by the orientation of crescentic fractures. Streamlined landforms, such as flutings, are absent and streamlined bedrock features are extremely rare.

Nine striations were measured at each site and the median direction and range of orientations was recorded using a Brunton or Silva compass. Striations that were difficult to see were soaked with water and wiped with a sponge for better viewing. Rôches moutonnées tend to occur in groups, so three to seven measurements were made at rôche moutonnée sites and the median orientation recorded.

Sampling

The NTS map area 13A/10 was sampled at a spacing of about 1 sample per 5 km^2, NTS map area 13A/14 at 1 per 31 km^2 and NTS map area 13 A/15 at 1 per 7 km^2. The NTS 13A/10 map area is fire scarred, so access via helicopter was good due to the availability of numerous landing sites. NTS map area 13A/15 is heavily forested and forest floors are commonly boggy, resulting in more difficult landing conditions and till deposits that are less accessible due to thick organic cover; a slightly wider sample spacing is the result. NTS map area 13A/14 was less densely sampled due to helicopter time limitations. The latter map area has good potential for more detailed sampling, as it was not difficult to obtain samples from heavily forested areas.

A total of 367, 1-kg samples were collected from hand-dug test pits, 40 to 70 cm deep. An attempt was always made to collect samples from the C-horizon; however, B- or BC-horizon samples were taken in areas where a C-horizon did not exist because the till was too thin or could not be accessed due to heavy concentrations of large boulders. Large boulders (50 to 100 cm in diameter) are common in the till, resulting in a challenging sampling environment. Very thin tills necessitated sampling near the bedrock contact at depths of 30 to 40 cm. The C-horizon samples were taken from an average depth of 55 cm; B- and BC-horizon samples average 45 and 50 cm depths, respectively. A few mudboils, present only at high elevations, were sampled at depths of about 35 cm. On NTS map areas 13A/10 and 13A/15, almost half of the samples are from the C-horizon, however, on NTS map area 13A/14, 65 percent of the samples are from the B- and BC-horizons.

The soils of southern Labrador are podzols that have very thick Ae-horizons (5 to 20 cm). The upper part of the B-horizon can form a very compact hardpan that can be difficult to penetrate. Where B-horizon samples were taken, they were acquired in the lower part of the horizon, below the cemented layer. The B-horizon samples are poorer samples because they may be enriched in iron and depleted in other trace elements. The highest concentrations of trace elements are found in C-horizon samples (Klassen and Thompson, 1993).

Geochemistry

The silt–clay fraction of the till samples was prepared for analysis of trace elements by ICP-MS at the geochemical laboratory of the Geological Survey of Newfoundland and Labrador; 70 to 80 g of the sample was used for analysis and the remainder was archived. The samples will also be analyzed by fire assay for platinum-group-elements and by INAA for gold, uranium and other elements. Data from these analyses will be released in 2002.

SURFICIAL GEOLOGY

Till

Till is derived from resistant granitic and gneissose rocks, and is generally thin (commonly < 50 cm thick) and discontinuous (Plate 1). Erratics are commonly found resting directly on bedrock (Plate 2). The thinness of the till precludes the formation of constructional landforms such as flutings and moraines.

Plate 1. *Bedrock (background) and thin till on ridge top.*

The till is matrix-supported, generally very poorly sorted, structureless, and weakly to moderately compact. Crude stratification exists, but is extremely rare. The matrix consists of silty fine to coarse sand, but silty fine to medium sand is most common. On NTS map area 13A/10, medium to coarse sand matrices are also common. Clast content averages 35 percent and clasts range from granule to boulder size. Boulders up to 1 m in diameter are common, but

Plate 2. *Erratic of different lithology resting directly on bedrock.*

larger ones are also present. Clasts are subround to very angular and have medians that are generally angular or subangular. Striated or facetted clasts are extremely rare. Generally, till is highly bouldery and boulders are abundant on the surface of the till.

Fields of angular boulders are found throughout the study area, impeding sampling where they occur. They are found between 120 and 390 m asl, in areas where there is evidence of abundant meltwater activity. This suggests that the boulder fields are meltwater-washed lags of former till. Some of the lower elevation fields may also be wave-washed. At one site, near upper Alexis Creek, a sand infill was found between the angular boulders of a boulder field in an area of glaciofluvial deposits. The upper 20 to 30 cm of till in many areas may also be somewhat meltwater-washed, as boulder concentrations are higher here than at depth.

Glaciofluvial Deposits

Most glaciofluvial sediments were deposited beyond the ice-sheet margin by meltwater rivers. The only definitive subglacial deposits are a few eskers in NTS map area 13A/14 (Plate 3), and a few small canyons carved into bedrock that may be tunnel valleys. Outwash braidplains are common – they contain about 95 percent of the area's glaciofluvial sediment. Braidplains fill low-lying areas, such as the Alexis River and Hawke River valleys (Plate 4). Meltwater channels associated with these deposits are abundant, commonly intertwined and can be found cut into bedrock, till and glaciofluvial sediments.

Glaciofluvial sediments commonly consist entirely of fine to coarse sand, but medium sand is the most common grain size. Aeolian blowouts are common on the surface of sandy deposits (Plate 5). In some places, aeolian pavements of surface granule gravel protect the sand deposits below from further wind erosion. Coarser braidplain deposits are also present. Granule gravel is less common, whereas pebble and cobble gravel are more abundant. The coarser sediment is generally matrix-supported, has a fine to coarse sand matrix, and is moderately to well sorted (poor sorting is rare). Clast angularity ranges from rounded to very angular, but angular, subangular and subrounded clasts dominate the deposits; this can make the sediment difficult to distinguish from sandy till, especially when sorting is poor. The angularity of these clasts suggests that transport distances were minimal (Plate 6).

Glaciofluvial deposits are generally horizontally bedded, with a few lag deposits. Crossbeds and ripples are rare, and massive deposits are present in a few areas.

There were no river-cut sections suitable for detailed lithological analysis in the study area. However, a large sec-

Plate 3. *Rare ice-contact braidplain, northern part of NTS map area 13A/14. Dark area in centre and to left shows where ice sheet was; lighter toned area in foreground and to right is a large, flat braidplain that developed in front of the ice margin. An esker leading to the former ice front is arrowed.*

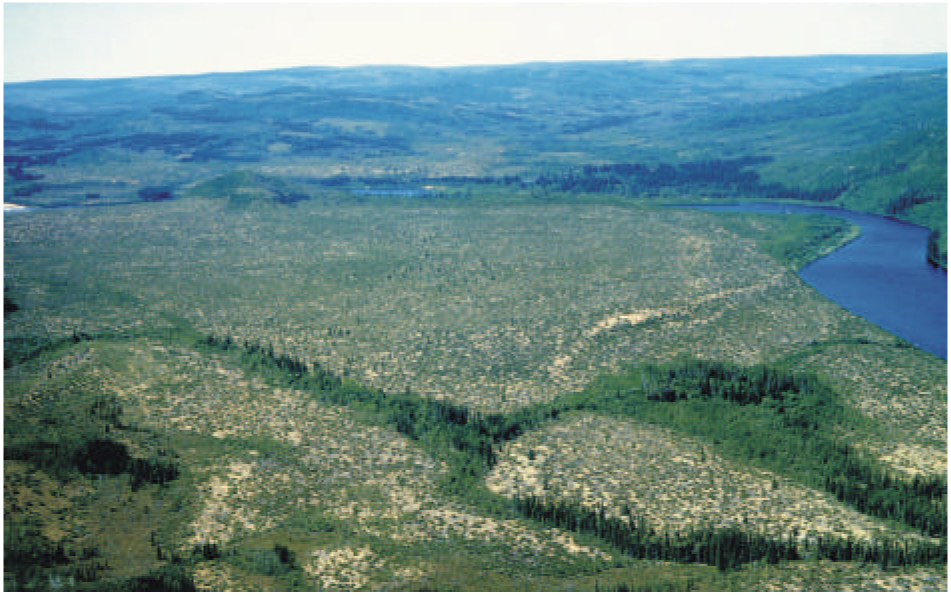

Plate 4. *Alexis River braidplain. Dark areas in foreground are former meltwater channels, and are the only places wet enough for tree growth.*

well as eastward (downflow) along the exposure, reaching a low of 5°.

The section is interpreted as a deltaic deposit. The low gradient, downlapping beds and their generally fine-grained nature and structures are consistent with an interpretation as bottomset beds of a Gilbert-type delta (Nemec, 1990), or as the low-gradient foreset beds of a Hjulström-type delta (Postma, 1995). The top of the section is at 22 m asl, but because no topset beds were seen, an exact sea-level stand cannot be inferred.

Marine Deposits

Marine sediments were identified in the southeast corner of the

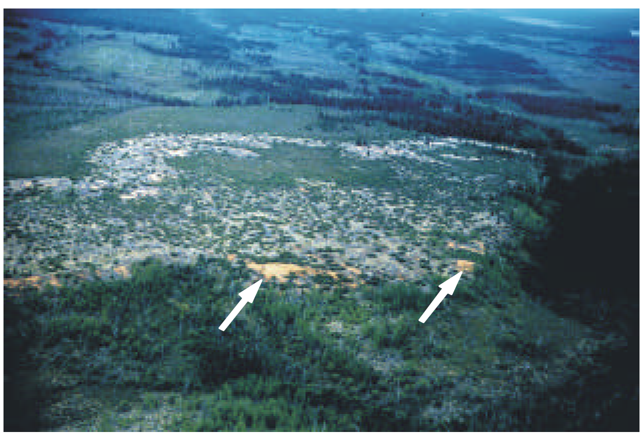

Plate 5. *Sandy braidplain in the Alexis River area. The highest elevation of these braidplains corresponds to the highest elevation of marine sediments. Note aeolian blowouts on the surface of the deposit (arrowed).*

Plate 6. *Gravel braidplain deposit, upper Alexis River. Note the angularity of boulders in the foreground.*

tion at the mouth of the St. Lewis River was examined (Figure 1). The section exposes downlapping, low-gradient, 1- to 10-cm-thick beds, and consists almost entirely of well to very well sorted, subhorizontally bedded, medium, fine and very fine sand (Figure 2). One thick granule to cobble gravel bed that has a coarse sand matrix is present in the upper part of the section. Planar crossbeds were identified in a few places. At 14.3 m, a coarse sand to granule gravel bed grades laterally to fine sand that contains ripples (Figure 2). The upper part of the section contains beds that dip 10 to 12°. Dips gradually flatten toward the bottom of the section, as

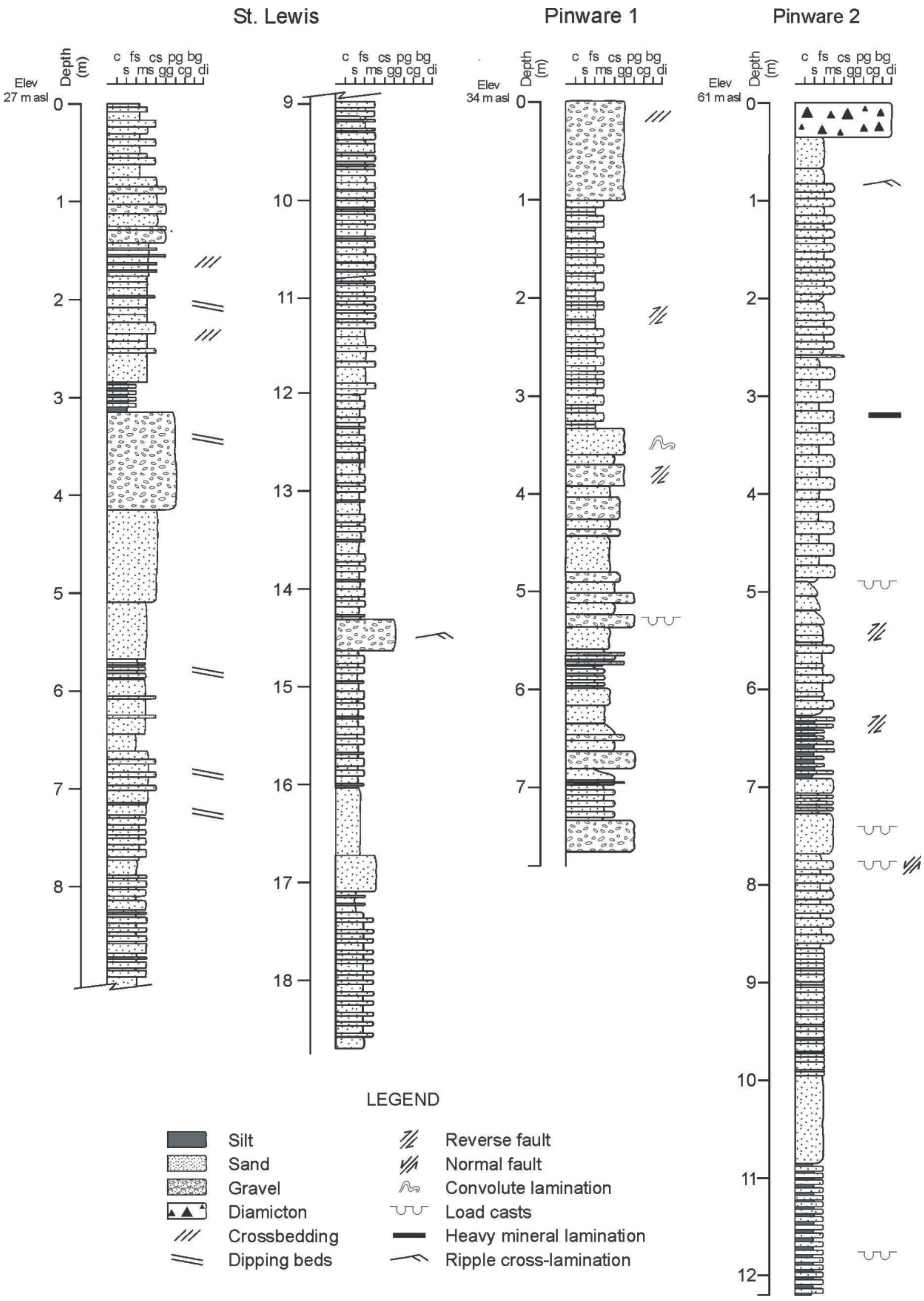

Figure 2. *Lithological logs of the three sections mentioned in the text.*

study area in the vicinity of Bobby's Pond and include laterally discontinuous beds of diamicton, pebble to cobble gravel, fine to medium sand, silt and clay. The gravels are poorly sorted and contain clasts that range from subround to subangular. Sand beds are well to very well sorted; diamictons are very poorly sorted and contain angular clasts. Structures in the sand, silt and clay units include horizontal bedding, rip-up clasts, ripple cross-stratification, disturbed bedding and crossbedding. Dropstones are present in some deposits (Plate 7) and massive beds are common. Fossil marine shells were found in horizontally bedded silty clay underlying the glaciofluvial braidplain deposits in the Alexis River valley; these have been submitted for radiocarbon dating.

Plate 7. *Dropstone in glaciomarine sand with disturbed bedding, southeastern part of NTS map area 13A/10. Trowel handle is 9 cm long.*

The interbedding of diamicton with gravel, sand, silt and clay in a laterally discontinuous manner, along with the presence of dropstones and in one case the presence of marine shells, is consistent with an interpretation of glaciomarine deposition. These deposits are considered to be glaciomarine diamicton and ice-proximal subglacial fan sediments. Bedded silty clay is a more distal deposit.

No definitive indications of marine limit (deltas, strandlines or beaches) were found. Marine deposits occur in the Bobby's Pond area at elevations of 110 to 150 m asl, so the marine limit is at least 150 m asl in this area. This is similar to the 152 m marine limit identified in the Pinware area to the southeast (Clark and Fitzhugh, 1991).

Fluvial and Organic Deposits

Modern fluvial sediments form narrow plains and terraces along river margins, are much more restricted in extent than the glaciofluvial deposits, and are commonly reworked from them; the fluvial sediments consist of gravel and sand, although silt is present locally. Modern deltas are rare, but a silty delta has formed in Jeffries Pond. The delta has extended out into Jeffries Pond as a long peninsula and possibly has been prevented from forming distributary channels by bog development along its sides.

Domed, slope and string bogs are very common and the latter commonly overlie low elevation braidplains. In the southern part of NTS map area 13A/14, numerous string bogs overlie the till.

Paradise Moraine

The Paradise Moraine (Figure 1) was described by Fulton and Hodgson (1979) as a large, linear feature consisting of hummocky moraine. However, within the study area, as well as west and southwest of it (on NTS map areas 13A/12 and 13A/13), it consists entirely of glaciofluvial sediment. Hummocks, hills, ridges and large kettles dominate the landscape, but small, steep-sided, mesa-like plateaux (Plate 8) and doughnut-shaped features (Plate 9) are also found. Meltwater erosion is evident in some areas, as large channel segments that end abruptly (Plate 8) or as small terraces along the edges of ridges, hills and hummocks.

Plate 8. *Large meltwater channel cut through tilting mesas (left) and mesas with central depressions (right).*

The sediments include horizontal beds of granule, pebble and cobble gravel, and fine, medium and coarse sand; silt and boulder gravel are rare. Beds are 1 to 20 cm thick, most commonly 4 to 10 cm thick. Coarser beds are matrix-supported and have a fine to coarse sand matrix. Fine sand or fine to medium sand are the most common matrix components. Clasts are subround to subangular. Finer beds are well to very well sorted; coarser beds are generally moderately sorted, but a few are poorly sorted.

The Paradise Moraine is interpreted as an ice-marginal deposit. It is well above marine limit (180 to 525 m asl within and west of the study area) and therefore marks a land-

Plate 9. *Doughnut-shaped features with bogs in their centres. These may have formed due to complex melting of stagnant glacier ice under a cover of sediment.*

based stillstand of the Laurentide Ice Sheet. There does not appear to be any bedrock control over its position. The numerous kettles on the surface of the moraine indicate that much of the sediment was deposited over stagnant ice, and meltwater channels show the directions in which water was carried away from the ice front.

The Paradise Moraine is an unusual feature and merits further study. It is different from other major ice-marginal moraine systems in that it appears to contain no till. The Belles Amours Moraine to the southeast (Grant, 1992) and the Québec North Shore Moraine system to the southwest (Dubois and Dionne, 1985) both contain till and till ridges, although kettled glaciofluvial deposits are also common in the latter system. If there is any till present in the Paradise Moraine, it will most likely be found on the ice-proximal western side (Dubois and Dionne, 1985), which was not investigated in detail in this study (although one large glaciofluvial deposit was found only 500 m east of the western edge of the moraine as mapped by Fulton and Hodgson (1979)).

The extensive braidplain deposits of the study area (east of the moraine) may have been fed by meltwater rivers that drained the ice sheet while it was at this stillstand position. If that is the case, then these features are also around 11 000 years old (*see* section on Previous Work, for age of Paradise Moraine). Given that ice appears to have been debris-poor in the study area (thin and discontinuous till), it is difficult to reconcile thick glaciofluvial sediments here with drainage of the ice covering the study area. It is more likely that they are a product of meltwater flowing from more debris-rich ice that halted for a time at the Paradise Moraine margin.

SEA LEVEL

No definitive information on marine limit was obtained from the study area. However, marine sediment in the southeastern part of the map area lies below elevations of 150 m asl. In the eastern part of the study area, terraced glaciofluvial braidplains are commonly graded to base levels of 100 and 150 m asl. From this evidence, it would seem that sea level was once as high as 150 m asl. Other base levels include 80, 60, 40, 30 and 20 m asl, the latter of which pertains to a large part of the Alexis River braidplain.

GLACIAL HISTORY

Age constraints on glacial events in the study area are meagre. Radiocarbon dates from one shell locality will be obtained later this year (2002). The last glaciation is presumably late Wisconsinan, and the timing of the glacial maximum is unknown. No evidence of prior glaciations was found. Erratics are found at all elevations, so ice must have covered the entire study area. This is consistent with continental ice reaching at least 925 m asl in the Mealy Mountains region to the north (Gray, 1969).

ICE-FLOW HISTORY

Striations are extremely rare, as the bedrock tends to crumble due to weathering. Striations within the study area and just east of it show unidirectional flow toward the east, ranging from 77 to 99°, with a median orientation of 82° (Figure 3). Rôches moutonnées were found only on NTS map area 13A/10. They range from 80 to 107° and have a median orientation of 85° (Figure 3). Striation elevations range from 115 to 300 m asl and rôches moutonnées range from 100 to 220 m asl. Eastward ice flow in this area is consistent with a dispersal centre located southeast of Churchill River (Klassen and Bolduc, 1984; Klassen and Thompson, 1989), and eastward flow north of the Alexis River, identified by Fulton and Hodgson (1979).

No evidence of earlier ice-flow directions was found. The unidirectional ice flow of the last glaciation is consistent with Klassen and Thompson's (1993) interpretation of simple ice flow near the ice sheet's coastal margin.

IMPLICATIONS FOR MINERAL EXPLORATION

The thinness of the till in much of the study area, as well as abundant glaciofluvial deposits and boulder fields, are some hindrances to more detailed till sampling of prospective areas. Till is quite common throughout the region, and thus is still a good option for sampling. In areas where B- or BC-horizon samples are taken, the samples

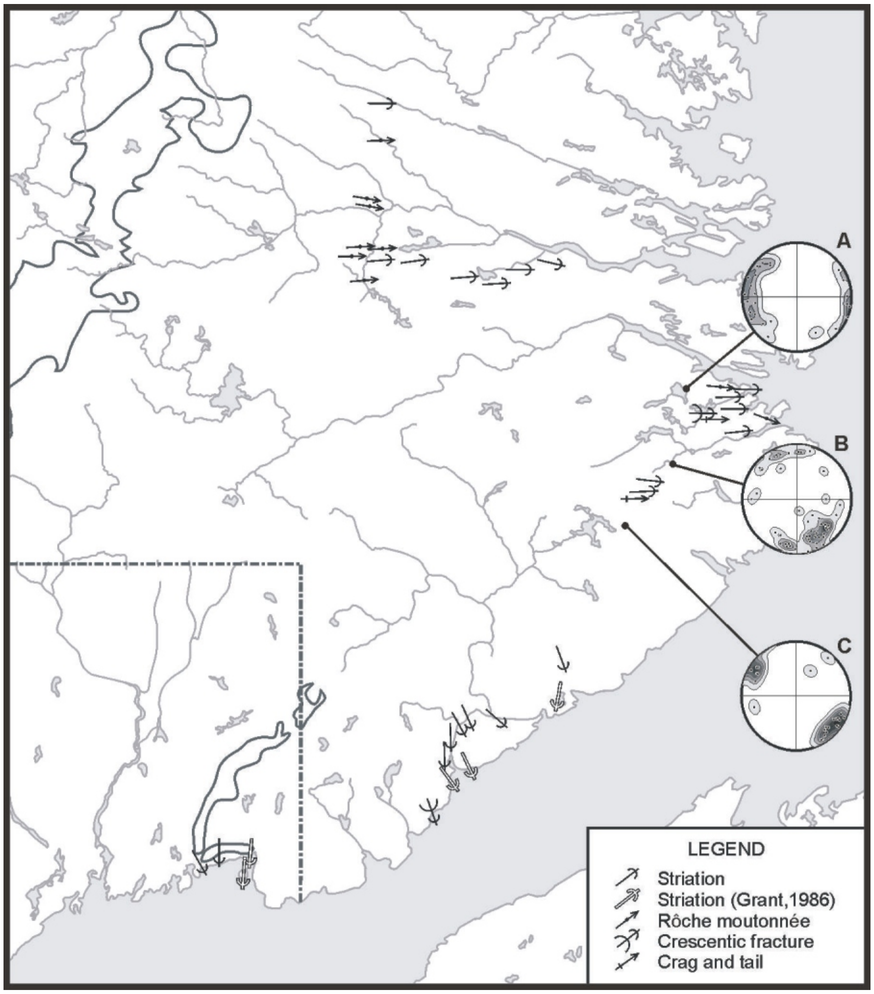

Figure 3. *Ice-flow indicators and till fabrics. Where indicators are closely clustered, some have been omitted for visual clarity.*

should be noted, as they can be depleted in some elements and enhanced in others. The angularity and poor sorting of some glaciofluvial sediments is problematic in that these deposits can be easily confused with till.

It is important to note that the Paradise Moraine does not appear to be composed of till. Till geochemistry may be difficult to accomplish along this feature, at least at its northeastern end, where glaciofluvial sediments are the dominant deposits.

SUMMARY AND CONCLUSIONS

During the last glaciation ice flow was not complex. Ice flowed toward the east from a dispersal centre west of the study area. Till deposited by this ice is widespread, but is generally very thin and bouldery, except in the southern parts of NTS map area 13A/14, where it is hummocky. Subaqueous fans and glaciomarine till were deposited at the ice front where Laurentide ice was in contact with the sea. Glaciomarine sediments occur only below 150 m asl, which suggests that this elevation is the local marine limit. During deglaciation, subaerial meltwater rivers draining the ice sheet laid down extensive glaciofluvial deposits that consist mainly of sand. Till deposits were winnowed by meltwater and possibly by marine water, leaving angular boulder lags on the land surface.

Ice halted for a time west of the study area, depositing an extensive ice-marginal glaciofluvial sand and gravel complex (the Paradise Moraine). This complex was partially deposited on remnant ice at the ice front. The extensive braidplain deposits in the study area may have been deposited by rivers draining the ice sheet while it was in this stillstand position.

Lake-sediment geochemistry patterns showing eastward-trending dispersal trains in this area (Gower *et al.*, 1995) are consistent with the ice-flow directions determined in this study. This supports the idea that the identification of geochemical fingerprints has merit as a mineral exploration tool.

BLANC-SABLON TO MARY'S HARBOUR ROAD CORRIDOR

The area along the highway between Blanc-Sablon and Mary's Harbour was investigated as a second component of the summer's fieldwork. This road is now known as the Trans-Labrador Highway. To date, no Quaternary geology studies have been done in the northern part of the study area. The southern part of the study area, south of Red Bay, was mapped at 1:125 000 scale by Grant (1986). However, no till geochemistry was done at that time and now there was an opportunity for more detailed field investigations. In addition, two major moraine systems were investigated (Figure 1).

STUDY AREA

The study area includes roads between Blanc-Sablon and Mary's Harbour, southern Labrador (Figure 1), which lie between 51° 25' and 52°20' N and 55° 45' and 57°07' W. The Trans-Labrador Highway is the main road in the area. It runs close to the coast in the southern half of the region, and shifts inland to a higher elevation between Red Bay and Mary's Harbour. Construction of the road between Mary's Harbour and Port Hope Simpson is scheduled for completion in 2002.

PHYSIOGRAPHY

The undulating Mecatina Plateau is dissected at the coastline and reaches a maximum elevation of 470 m near the Trans-Labrador Highway. Farther inland (>25 km from the coast), elevations of 520 m asl are reached. Numerous lakes occupy low areas between rolling, rocky hills. The Forteau Tablelands (Grant, 1992) are four flat plateaux of limestone and sandstone along the coast from Blanc-Sablon to Pinware. The plateaux end at steep cliffs, which commonly drop straight into the ocean. Small coves between these cliffs are sheltered flat areas that host small fishing communities.

BEDROCK GEOLOGY

Precambrian rocks of the Grenville Province also underlie this region, and have been assigned to the Pinware Terrane. Well-banded gneisses and mylonites are found along the boundary between the Pinware and Mealy Mountains terranes to the north (Gower *et al.*, 1988).

The Pinware Terrane consists of supracrustal rocks, mafic rocks, highly deformed gneissic granitoid rocks, less deformed granitoid rocks, and undeformed granitoid plutons (Gower *et al.*, 1995).

The supracrustal units include quartzofeldspathic rocks that are commonly banded, banded quartzite, pelitic metasedimentary gneiss, calc-silicate gneiss and amphibolite gneiss (Gower *et al.*, 1994). A group of metasedimentary rocks northeast of Red Bay form a U, Cu, Mo and Ag mineral exploration target (Gower *et al.*, 1995) and consist of schist and quartzofeldspathic gneiss; minor granitic plutons are also present (Gower *et al.*, 1994).

The strongly deformed granitoid rocks are recrystallized, and foliated to gneissic. They include granite, syenite, amphibolite and some monzonite (Gower *et al.*, 1988, 1995). The strongly to weakly foliated granitoid rocks comprise monzonite, syenite and granite (Gower *et al.*, 1994, 1995). Undeformed circular plutons of granite are younger than the other rocks and postdate regional tectonism (Gower *et al.*, 1988, 1993, 1995).

The mafic rocks include dykes and layered intrusions of gabbro, norite and gabbronorite, but these are less common along the coast. Minor conglomerate, sandstone and basalt are found near the coast (Gower *et al.*, 1988).

Cambrian sedimentary rocks unconformably overlie Precambrian basement rocks in the Forteau Tablelands. The Bradore Formation comprises pebble conglomerate and subarkosic and quartz-rich sandstone (Schuchert and Dunbar, 1934; Hiscott *et al.*, 1984). It is conformably overlain by the Forteau Formation, which is composed of limestone, dolostone, siltstone and mudstone (James and Kobluk, 1978; Schuchert and Dunbar, 1934).

PREVIOUS WORK

Glacial History

At the last glacial maximum, the Laurentide ice margin extended past the coastline into the Strait of Belle Isle (Woodworth-Lynas *et al.*, 1992), and some Labrador ice reached the northern tip of Newfoundland (Grant, 1992). Glaciomarine sediments were deposited where ice was in contact with the sea. Ice later retreated to the modern coastline and the Brador and Belles Amours moraines were deposited (Grant, 1992). The Brador Moraine formed along the ice margin at the local marine limit (Grant, 1992). It is estimated to have formed at about 12.6 to 12.5 ka (King, 1985; Grant, 1992), and the Belles Amours Moraine at 12.4 to 12.0 ka (Vincent, 1989; Grant, 1992; Dyke and Prest, 1987) or 11 ka (King, 1985). The Belles Amours Moraine is thought to indicate resurgence from a new outflow centre, shortly after the Brador Moraine was deposited. The oldest radiocarbon date in the area comes from marine shells in glaciomarine silt near the Pinware River, east of the moraines (10 900 ± 140, GSC-2825, Grant, 1992). This, and correlation with the Piedmont Moraine in Newfoundland, led Grant (1992) to infer that the moraines are more than 12 000 years old. Kames and other ice-contact deposits to the northeast formed at the same time as the Brador Moraine. Meltwater-fed glaciofluvial braidplains developed in a few valleys after ice retreated from the coast, the largest of which is found along the Pinware River (Grant, 1992).

Grant (1992) thought that the Brador Moraine formed when ice was flowing southward in the Blanc-Sablon area. Ice flow then changed to southeastward and the Belles Amours Moraine was deposited at a recessional position. Some southeastward ice flow is also shown near Pinware and Red Bay (Grant, 1992).

Quaternary Geology

Exposed bedrock, thin till and coarse glaciomarine deposits are found along the coast from Red Bay to Blanc-Sablon (Grant, 1992). The Belles Amours Moraine consists of many small moraines of thin bouldery till. It terminates at the coast at an ice-contact delta graded to marine limit and two large gravel deposits (Grant, 1992). Grant (*op. cit.*) also suggested that it crosscuts the Brador Moraine, which is composed of thick, bouldery, sandy till and current-bedded, ice-contact gravelly sand; marine boulder lags cap parts of the moraine. Parts of the Brador and Belles Amours moraines are possibly ice-contact deltas graded to 145 and 130 m asl, respectively. Kames, ice-contact deltas and melt-water channels as far north as Red Bay are related to the Brador Moraine (Grant, 1992).

Offshore Deposits

Till and bouldery ribbed (DeGeer?) moraines were identified by sidescan sonar imagery in the Strait of Belle Isle, south of L'Anse au Clair (Woodworth-Lynas *et al.*, 1992). They were formed in the late Wisconsinan by an approximately 225-m-thick Laurentide Ice Sheet that was grounded. Sea level was at its maximum level when the moraines formed by lift-off of the ice margin at the grounding line and by high-energy glaciomarine deposition (Woodworth-Lynas *et al.*, 1992). Tthe till and moraines are overlain by ice-proximal glaciomarine sediments. Till of probable late Wisconsinan age is found offshore on the Labrador shelf at distances of 50 to 100 km from the shore (Josenhans *et al.*, 1986).

Sea Level

Marine limits in southeastern Labrador are about 150 m asl (Daly, 1921; Rogerson, 1982; Clark and Fitzhugh, 1991; Grant, 1992). Sea-level curves extrapolated from archeological data show that a 152 m marine limit was probably reached at Pinware by 14 ka (Clark and Fitzhugh, 1991). A 148 m marine limit was identified adjacent to the Brador Moraine (Grant, 1992) and the Brador Moraine has marine limits of 130 to 140 m asl. Emergence was rapid and decreased exponentially, so that most of the sea-level fall was accomplished before 6 ka (Clark and Fitzhugh, 1991; Grant, 1992).

METHODS

Sampling

Samples were collected mainly along roads from road cuts and ditches. Test-pits were dug where necessary. In the Mary's Harbour area (NTS map areas 3D/4, 5), where foot and boat traverses were done in addition to road work, most of the samples were taken from test-pits.

Ninety-two 1-kg samples were collected. Mainly C-horizon samples were taken south of the Mary's Harbour area, having an average depth of 120 cm. Most of these samples were taken above 150 m asl. In the Mary's Harbour area, sample site elevations range from 12 to 73 m asl, so these samples could be glaciomarine diamicton and may be washed. Most of the Mary's Harbour samples are from B- and BC-horizons having an average depth of 50 cm. The samples are currently being analyzed for geochemistry and data will be released as an open file report in 2002.

SURFICIAL GEOLOGY

Till

Till in this region is derived from resistant granite and gneiss, resulting in a thin cover of till. As in the Alexis River region, it is highly bouldery (Plate 10). In all areas, the diamicton is massive and matrix-supported. Generally, it is very poorly sorted; less commonly, it is poorly sorted. The matrix ranges from fine to coarse sand and lesser quantities of silt. Clasts range from granule to boulder size, with pebble gravel the median size. Clast content averages about 35 percent. Fissility, where seen, is weak to moderate. Clasts were not striated and facets were extremely rare. Compaction is moderate to strong, except in the Mary's Harbour area, where it is weak to moderate. Clasts are subround to very angular and have medians of subangular or angular in the Mary's Harbour area. South of Mary's Harbour, clasts are subround to angular, where most medians are subangular.

Glaciofluvial Deposits

These deposits take the form of braidplains in larger valleys such as the Pinware River valley. Smaller, localized deposits are also found scattered throughout the rest of the study area. Neither eskers nor glacial lake sediments were found along the roads, but small eskers are associated with the thin, discontinuous ridges of the Belles Amours Moraine.

Sediments are moderately to very well sorted and range from fine sand to cobble gravel, having an even abundance distribution among all of the size range classes. Clasts are subround to angular having a median of subround. The angularity of the clasts suggests that transport distances were variable.

Horizontal bedding is very common. Other structures include lenses, ripple and climbing ripple cross-stratification, high-angle reverse faults, lag deposits, convolute lam-

Plate 10. *A recent fire has exposed thin, highly bouldery till near Red Bay.*

Plate 11. *Horizontally bedded sand and gravel, Pinware section 1.*

The section is interpreted as a glaciofluvial braidplain deposit, based on the horizontal bedding of variable grain size (indicating variable flow), crossbeds showing a paleoflow direction oblique to the valley orientation, subround clasts (fluvial transport) (Miall, 1985) and high-angle reverse faults that indicate the former presence of buried ice. Erosive contacts point to scouring, whereas loaded contacts and convolute laminations indicate rapid deposition (Leeder, 1982). In addition, there is a 4-m-deep and 10-m-wide cut-and-fill channel feature at the north end of the section that includes a cobble–boulder gravel lag above the erosive channel contact.

Diamicton is present at the top of the Pinware section 2 (Figure 2). The rest consists of very well-sorted horizontal beds of fine and medium sand. Coarse sand beds are a minor constituent and contacts are conformable. Three fining-upward beds are present at 4.9 m. Structures include climbing ripple cross-stratification, heavy mineral laminations, load casts, normal faults and reverse faults. Beds are generally 1 to 10 cm thick, but a few beds are thicker.

ination, load casts, fining upward beds and heavy mineral concentrations.

Two sections were logged in the Pinware River valley. Their locations are shown on Figure 1 (#'s 2 and 3).

Pinware section 1 is a gravel pit exposure (Plate 11). Horizontal beds of medium, coarse and very coarse sand are interbedded with granule gravel and pebble gravel (Figure 2). Contacts are generally conformable, but some are erosive and a few are loaded. At the top of the section, a poorly sorted, matrix-supported pebble gravel unit has a coarse sand–granule gravel matrix. The gravel unit contains rounded to angular clasts that have a median of subround. Both horizontal beds and crossbeds indicating a 135° paleocurrent direction are present within this unit. The rest of the section contains 0.2- to 20-cm-thick horizontal beds and laminations of moderately to well-sorted granule gravel, coarse sand and medium sand and a few poorly sorted pebble gravel beds. Structures include high-angle reverse faults (Plate 12), convolute lamination and load casts.

Pinware section 2 is generally finer grained than Pinware section 1, but the horizontal bedding, fining-upward beds and overall structures are consistent with a glaciofluvial braidplain interpretation (Leeder, 1982; Miall, 1985). The upper diamicton is interpreted as colluvium derived

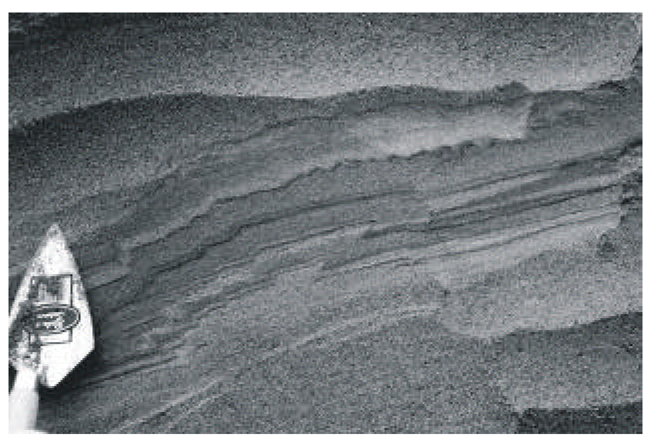

Plate 12. *High-angle reverse faults, Pinware section 1.*

from the steep bedrock valley-side slope adjacent to the section.

Plate 13. *Boulder gravel overlying cobble gravel in tombolo beach deposit at Pinware.*

Marine Deposits

Marine deposits are common along the coast. They include glaciomarine diamicton, beach sediments, subglacial fan sediments and other deposits.

Glaciomarine diamicton consists of very poorly to poorly sorted sediment ranging from granule gravel to cobble or boulder gravel. The matrix generally consists of silty, clayey fine sand. The diamicton is matrix-supported and massive, although crude stratification was seen at one site. Clasts are subround to angular with a median roundness of subangular.

Other glaciomarine sediments, which include subglacial fan deposits, are more variable. Grain sizes range from clay to boulder gravel, but medium to coarse sand and pebble to cobble gravel are most common. Poor sorting is uncommon; deposits are generally well to very well sorted and may be clast-supported. Matrices are sandy and clast angularity ranges from subround to angular having a median of subround or subangular. A variety of structures are present, of which horizontal bedding is the most common. Dropstones up to boulder size, lenses, climbing ripples, lag deposits, crossbeds and heavy mineral concentrations were all identified. Some deposits are massive. Regressive marine sequences were seen in two localities, where silt beds are overlain by sand and, at one site, granule gravel.

Raised beach sediment deposits are generally well to very well sorted, but poor and moderate sorting are also present in some localities. Grain size ranges from fine sand to boulder gravel, with fine sand, medium sand and pebble gravel beds most common (Plate 13). Coarser beds may have a matrix of coarse sand. Deposits are generally horizontally bedded and clast-supported. Swash crossbeds, heavy mineral concentrations (Plate 14), and discoid clasts were observed at a few sites. Beach clasts are subround to well rounded, with a median of subround.

Aeolian Deposits

Marine sediments are reworked into dunes in the Blanc-Sablon to Pinware region. Dunes generally consist of well-sorted fine to medium sand, deposited in irregular horizontal beds. In places, buried organic horizons are visible.

Plate 14. *Horizontally bedded marine sand that contains heavy mineral concentrations (including magnetite), northeast of L'Anse au Loup.*

Fluvial, Organic and Modern Marine Deposits

Modern fluvial sediments in this region, as in the Alexis River region, form narrow plains and terraces along river margins. Where they cut through glaciofluvial deposits, they tend to be coarser grained than the glaciofluvial sediments (e.g., Pinware River). Gravel and sand are the most abundant materials.

Domed, slope and string bogs are common throughout the area. They commonly overlie bedrock or low-elevation glaciofluvial deposits.

L'Anse au Loup Brook has been displaced to the northeast in the town of the same name by longshore current action that has moved the modern beach sediment in this direction. The mouth of the Pinware River has been considerably constricted by encroachment of a large spit across its mouth.

Brador Moraine

The Brador Moraine was first described by Grant (1992). Field examination shows that this feature is a thin deposit (<5 m thick), in places occurring only as a bouldery veneer resting directly on bedrock.

The sediments comprise matrix-supported granule, pebble, cobble and boulder gravel and a coarse to very coarse sand and/or granule gravel matrix. Sandy or silty diamicton is also present. Clasts are subround to subangular, with larger (outsized) clasts set individually into horizontal or dipping finer grained beds (Plate 15). Some gravel lenses are also present. At one site, near the east end of the moraine, both matrix-supported debris-flow type and clast-supported fluid-flow type deposition were identified. This style of deposition has been identified as that of a submarine moraine complex (McCabe *et al.*, 1984). The stratified diamicton is deposited by cohesive debris flows, whereas the gravel is a result of high-density sediment gravity flows (McCabe *et al.*, 1984). There is additional evidence that the feature was subaqueously deposited. At the eastern end of the moraine, perched boulders resting on bedrock are present above the moraine. Below it, only smoothed, boulder-free bedrock is present. A similar situation is described by Grant (1992) as marking marine limit. In addition, a linear concentration of boulders just west of this location is interpreted as a beach, which also marks marine limit. The upper elevation of the moraine and boulder line is 137 m asl. From this evidence, it is inferred that the Brador Moraine is an ice-contact moraine sequence that suggests a former sea-level stand of about 140 m asl (in agreement with marine limits proposed by Grant, 1992).

Plate 15. *Stratified diamicton, Brador Moraine. Note outsized clasts within dipping beds.*

In the Pointe Rocheuse area (Figure 1), bedrock that was sculpted by subglacial meltwater is striated parallel to the direction of sculpting at 159°. Just east of this site, slightly southeast-dipping beds of medium sand to pebble gravel overlain by cobble to boulder gravel include cross-beds that show variable paleoflow. Outsized clasts within sand beds and diamicton lenses are also present. The Pointe Rocheuse deposit may be associated with either the Brador or the Belles Amours moraines, due to its location at the terminal ends of both. The sediments are similar to those in the Brador Moraine, but are found at 104 m asl, below the Brador Moraine's general elevation. Further investigation in this area might reveal the relationship of this deposit to the two moraines. Pointe Rocheuse itself is a sandy and gravelly deposit that is probably also related to the moraines. It has several bouldery beach ridges on its surface. Grant (1992) suggested that it comprises subaqueous outwash gravel and is an extension of the Belles Amours Moraine.

Belles Amours Moraine

The Belles Amours Moraine consists of many narrow, discontinuous, sinuous ridges, rather than one large ridge. There are two different kinds of ridges that occur within this zone.

The first type is about 6 to 10 m high, commonly sharp-crested, and covered with large (up to 2 m in diameter), angular boulders. The surrounding hillsides are covered with similar boulders. Sediments consist of poorly to very poorly sorted diamicton, at least at the surface. The subround to subangular clasts range from granule to boulder size, and the sediments have a fine to coarse sand matrix. The median roundness is subangular. Clast content is 40 to 60 percent. Large boulder fields and boulder lines associated with the ridges suggest some meltwater activity. The ridges are also narrow and sinuous, resembling eskers on air photos.

The second ridge type is found at slightly lower elevations and has a subdued or flattened shape. These ridges are 1 to 6 m in height and commonly form a ridge complex. Sediments are moderately to well sorted. Vague horizontal beds of granule, pebble and cobble gravel have matrices of medium to coarse sand. Medium and coarse sand beds are also present. Clasts are subround to subangular, with subround clasts slightly more common. These features are interpreted as eskers, but their relationship to the moraines is unclear. For example, an esker-type ridge leads to a large fan-shaped feature in one area, but the fan-shaped feature contains poorly sorted diamicton. At another site, two moraine ridges converge down-ice, and meltwater-washed boulder fields are present between them (Plate 16). More work needs to be done to draw out the relationships between

Plate 16. *Converging ridges, Belles Amours Moraine. There are several boulder fields between the two ridges.*

the two types of ridges. The incorporation of larger scale air photos would be helpful in mapping out the ridge relationships and more fieldwork could certainly be done.

SEA LEVEL

The Brador Moraine, washing limits and a beach boulder line mark marine limit in the Blanc-Sablon area: it is between 130 and 148 m asl, as had previously been suggested by Grant (1992). The 152 m marine limit extrapolated from archeological data in the Pinware area (Clark and Fitzhugh, 1991) is not unreasonable, given marine limits to the southwest. Marine deposits, including large gravel plains and raised beach ridges, occur below these elevations. The highest elevation marine deposit found was a veneer of sediments at 130 m asl near L'Anse au Loup. Most marine deposits lie below 110 m asl. From L'Anse au Loup to Blanc-Sablon, till veneer, bedrock and weathered bedrock are present above 130 to 140 m asl.

Beach ridges or other marine limit markers are extremely rare in the Mary's Harbour area. The highest beach ridge is found at 73 m asl, and the highest identified elevation of marine sediment is 80 m asl. At higher elevations, only bedrock and weathered bedrock are exposed, so the marine limit in the Mary's Harbour area is unknown.

GLACIAL HISTORY

Glaciomarine sediments were deposited when ice was in contact with the sea at the last glacial maximum. Ice was still in contact with the ocean by the time it had retreated to the position of the Brador Moraine. After further retreat, the southern coast was ice-free, and coarse glaciomarine deposits were reworked into beaches, each forming at successively lower elevations as sea level fell. In the Mary's Harbour area, there may not have been enough sediment available to rework into beaches, as raised beach deposits are extremely rare there. Glaciofluvial sediments were laid down in the larger valleys by meltwater rivers draining the ice sheet; the largest such deposit is in the Pinware River valley. Finally, sandy beach and marine sediments were reworked into aeolian dunes in several places.

ICE-FLOW HISTORY

Ice flowed both southward and southeastward in the Blanc-Sablon to Red Bay region and mainly eastward near Mary's Harbour (Figure 3).

Striations are extremely rare. Orientations in the Mary's Harbour area range from 81 to 116°, with a median orientation of 91°, based on 10 striation, 2 crescentic fracture, 3 rôche moutonnée and 2 crag-and-tail measurements. These measurements were taken at elevations between 0 and 55 m asl near Mary's Harbour and between 213 and 312 m asl southwest of the town.

Farther south, in the Red Bay – L'Anse au Loup area, 4 striations and one crescentic fracture have orientations from 117 to 158°, with a median of 144°. Their elevations range from sea level to 244 m asl. In the Pinware Valley, between 8 and 30 m asl, 3 striations measure 174°, 179° and 191°. Since the valley is oriented at 200°, two of these may not represent late valley-directed flow. However, the latter two were measured on slightly sloping surfaces, so deflection may be a problem. Farther up the Pinware Valley, toward Red Bay, striae are perpendicular to the valley (144° and 152°, included in the L'Anse au Loup – Red Bay striae). Near Point Rocheuse, a 159° and a 183° striation were measured. As these are near both the Brador and Belles Amours moraines, they may reflect the separate flow events that may have formed the two moraines (Grant, 1992).

In the Mary's Harbour region, 18 till fabrics were measured along the new road. Most of these are girdle fabrics having low fabric strength (Figures 4 and 5) (Woodcock, 1977), indicating either sediment flow, glaciomarine diamicton or disturbed basal till origins (Dowdeswell and Sharp, 1986). Many are found below marine limit (about 150 m asl), but a few are above it. It is possible that all are sediment gravity-flow deposits, but some of them may be glaciomarine diamicton.

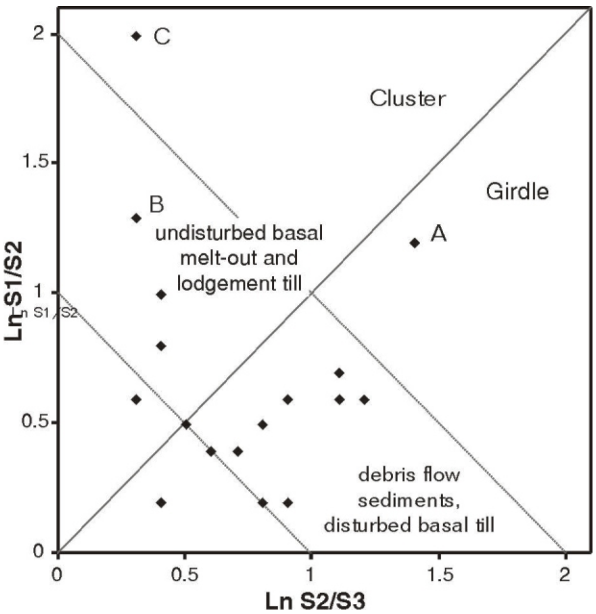

Figure 4. *Graph of eigenvalue ratios showing girdle vs. cluster fabrics (after Woodcock, 1977). Stronger fabrics plot farther from the origin.*

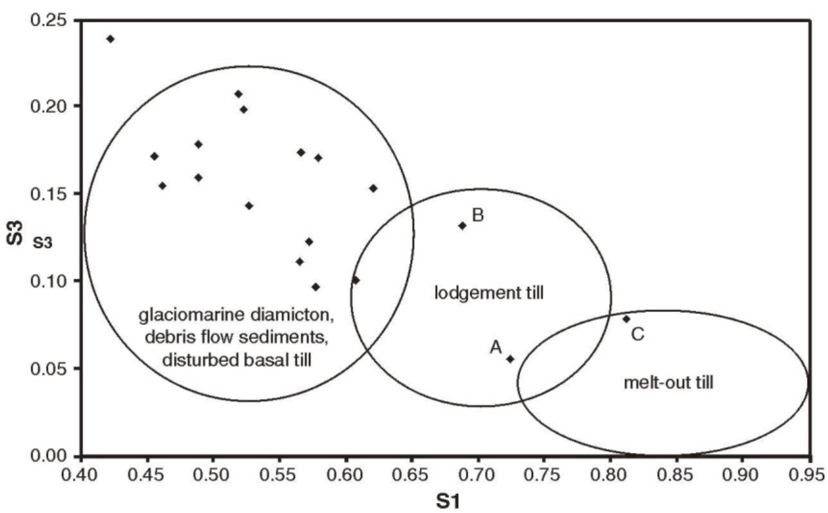

Figure 5. *Eigenvalue graph showing possible genesis of tills (after Dowdeswell and Sharp, 1986).*

Only three of the fabrics have strong enough orientations to infer ice-flow directions. Fabric A (Figures 3, 4 and 5), from 21 m asl, shows eastward flow, with a principal azimuth of 95°/275°, which is similar to the eastward ice-flow data obtained from striations in the area. As it is well below marine limit, this could be glaciomarine till. Fabrics B and C (Figures 3, 4 and 5) show southeastward flow, with principal azimuths of 156°/336° and 126°/306° respectively. Fabric B was measured on a massive, compact diamicton, which is interpreted as a lodgement till. Lodgement till was also identified 200 m to the northeast of this site. It also plots in the lodgement till zone of Figure 5 (Dowdeswell and Sharp, 1986). Fabric C plots in the melt-out till zone (Figure 5). This till is massive and weakly fissile. Nearby sites include stratified till and crudely bedded till that was interpreted as melt-out till.

Of 17 ice-flow indicators in the Mary's Harbour area, one, a rôche moutonnée, shows east–southeastward (116°) rather than eastward flow (Figure 3). This, together with the flow evidence from fabrics B and C, indicates that southeastward flow did occur in the Mary's Harbour area, but is less easily identified. Southeastward flow could be an earlier ice-flow phase, but these sites may also be topographically influenced.

Southward flow in the Blanc-Sablon area, southeastward flow near Pinware and eastward flow in the Mary's Harbour area (Figure 3) are interpreted as representing a large ice lobe that formed over southern Labrador, from which ice flowed radially.

IMPLICATIONS FOR MINERAL EXPLORATION

The thin and discontinuous nature of the till is a hindrance to more detailed till sampling, but till is found throughout the study area above marine limit. It can also be found below marine limit, as glaciomarine diamicton or as basal till, which makes the interpretation of results somewhat more difficult in these areas.

As with the Alexis River region, B- or BC-horizon samples must be taken in many areas due to the thinness of the till. In the Forteau Tablelands, much of what looks like till may actually be weathered bedrock (clasts are 100 percent local bedrock), so some caution must be exercised when sampling in that area.

Ice flow was radial, with ice flowing eastward in the Mary's Harbour area and radiating to southward in the Blanc-Sablon area.

SUMMARY AND CONCLUSIONS

Although the age relationships of ice-flow events are not clear, it appears that ice flow was semi-radial. In the Blanc-Sablon area, the retreating lobe was flowing southward. In Red Bay and Pinware, it was flowing southeastward and in the Mary's Harbour area, ice flow was eastward.

Thin, bouldery till was deposited beneath the ice that was flowing in these various directions.

At its maximum, Laurentide ice crossed over the Strait of Belle Isle to Newfoundland (Grant, 1992). As it calved back toward Labrador, ice was in contact with the sea. Glaciomarine sediments, including sand, gravel and the Brador Moraine, an ice-contact moraine complex, were deposited at this time. Sea level was about 150 m above its present level at its highest. As the land rebounded and sea level fell, glaciomarine sediments were exposed and were reworked into flights of raised beaches. Ice retreated to the west and meltwater rivers formed braidplains. These are much less widespread than in the Alexis River region. The Pinware Valley contains the only large deposit of this type in the area. The glaciomarine and glaciofluvial sediments were later reworked into dunes.

ACKNOWLEDGMENTS

John Sinnott, Jennifer Smith and Darrell Strickland are thanked for able assistance in the field, and for creating early drafts of Figures 1 and 2. Jennifer Smith helped with mapping and with database quality control. Joyce Wheaton provided excellent meals and camp assistance. Wayne Tuttle, Wayne Ryder and Sid Parsons helped with logistics and Zoë Webb provided safe and efficient helicopter transport. Harvey Rumboldt provided boat access to the St. Lewis River section and loaned a canoe for work around Mary's Harbour. Thanks are also due to the people of Mary's Harbour, who were friendly and helpful. Charlie Gower was a source of information on bedrock geology and Dave Liverman provided advice in the field on sampling and mapping. Dave Leonard drafted the final versions of Figures 2 and 3. Dave Liverman, Martin Batterson and Charlie Gower are thanked for insightful reviews of the manuscript.

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