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QUATERNARY GEOLOGY OF THE GOOSE BAY AREA

D.G.E. Liverman
Geochemistry, Geophysics and Terrain Sciences

ABSTRACT

Surficial mapping of the Goose River, Goose Bay and North West River 1:50 000 map areas (NTS 13F 7, 8 and 9) was conducted in 1996. The area was glaciated during the Late Wisconsinan by the Labrador sector of the Laurentide Ice Sheet. Ice flow was mostly east to east-southeast, with southeast flow in the Grand Lake valley. Deglaciation took place prior to 7500 BP, and was followed by deposition of thick sequences of glaciomarine sediment below 135 m asl. Terminal ridges of subaqueous outwash are found at North West River. Since deglaciation, the sea level has fallen continuously with the formation of closely spaced strandlines below 35 m asl.

Fluvial sedimentation and down-cutting resulted in the formation of extensive terrace systems in the Churchill and Goose River valleys. Ancient and modern fluvial sediments are dominated by sand because sediment source is mostly glaciomarine muds or older fluvial sands. Parabolic dunes are developed on the surface of some terraces.

INTRODUCTION

This study surveyed and mapped the Quaternary geology of three 1:50 000 NTS map areas around Goose Bay, southern Labrador (Figure 1); the three areas are the Goose River (NTS 13F/07), the Goose Bay (NTS 13F/08), and the North West River (NTS 13F/09) regions. This area contains the second largest community in Labrador, the town of Happy Valley – Goose Bay, and smaller settlements at North West River, Sheshatsheits and Mud Lake, all lying at the eastern end of Lake Melville (Figure 2).

OBJECTIVE AND RATIONALE

The objective of this project is to provide basic 1:50 000-scale surficial mapping for the Goose Bay area. Labrador, has little surficial mapping at scales more detailed than 1:500 000. Mapping projects in Labrador generally require considerable logistical and financial support, and thus 1:50 000 scale mapping is sparse with less than 5 percent of Labrador covered, mostly small areas mapped in support of mineral exploration. The rationale for mapping in Goose Bay is to provide improved geological understanding to assist in the environmental geology work in the area, and in exploration for granular aggregates. The developed parts of the study area are situated in areas of thick Quaternary sediments, and these have a profound influence on groundwater, slope stability, and other factors. Thus, understanding the distribution and stratigraphy of Quaternary sediments is of considerable assist-

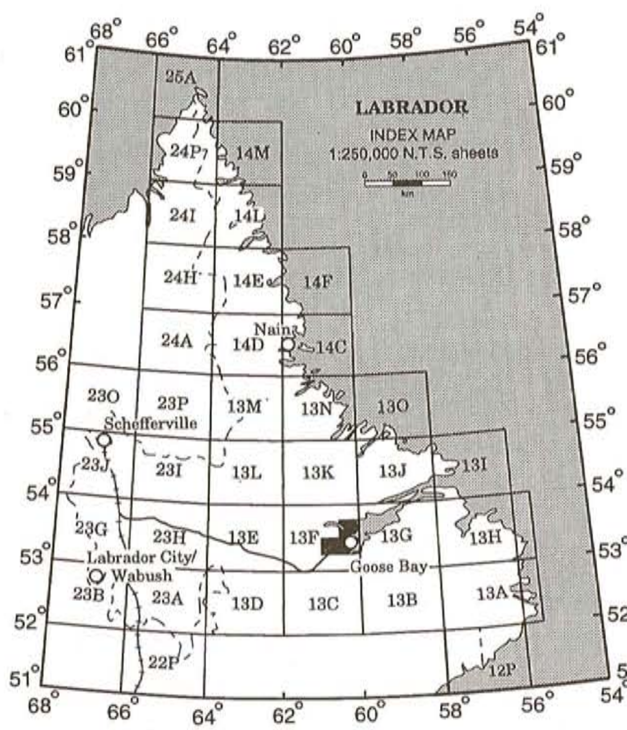

Figure 1. *Location map.*

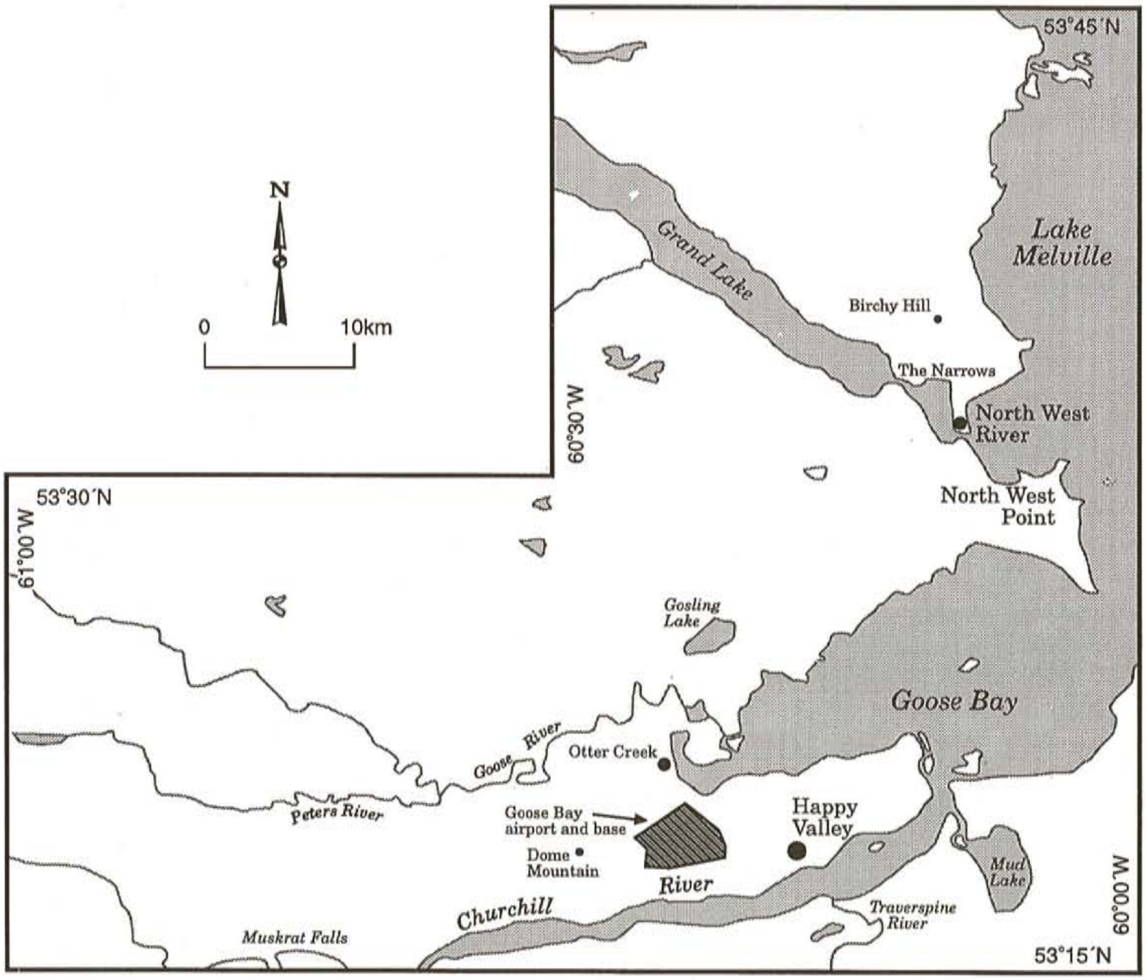

Figure 2. *Detailed location map showing areas discussed in text.*

ance in the planning of future development in the area, and mitigating the effects of past activities.

Happy Valley–Goose Bay is a developing community with a high demand for aggregate but the preponderance of sand in the area has resulted in difficulties obtaining suitable quantities of gravel. The main aggregate resource is currently situated north of North West River (Plate 1). As well as being some distance from Goose Bay, it is the subject of concern from local residents, both due to the volume of truck traffic, as well as for aesthetic considerations (Kirby, 1989). Recent completion and upgrading of the Trans-Labrador Highway has required large volumes of aggregate. This was supplied by the comparatively more expensive method of crushing bedrock, obtained from quarries on Dome Mountain, just west of Goose Bay.

Plate 1. *Gravels exposed in aggregate operations at Sunday Hill, near North West River.*

The development of the Lower Churchill River as a source of hydroelectric power development has been proposed and considered for a number of years. If such a development is to take place, understanding of the surficial geology of the area affected by the development would be critical, both in locating sources of construction material, and in predicting the effects of construction.

PHYSIOGRAPHY

The Goose Bay region lies at the western extremity of Lake Melville, an inlet of the Labrador Sea that runs over 100 km inland. Lake Melville is tidal with a range of up to 2 m, and is surrounded by a lowland, gently sloping down toward the lake, and with very low relief (Blake, 1956). This sharply contrasts with the bedrock-dominated highland plateaux that rise abruptly from this coastal plain. The plateaux are heavily wooded, and reach elevations of greater than 300 m. Three major valleys enter Lake Melville in the study area, the Churchill River, Goose River, and Grand Lake valleys (Figure 2).

The Churchill River (formerly known as the Grand River, and the Hamilton River) is the dominant feature of the southern part of the study area, and enters Lake Melville in Goose Bay (also known as Hamilton Inlet) near Happy Valley –Goose Bay. It has a sandy braided channel up to 3 km wide, and falls less than 15 m over the 45 km of its course that lies within the study area. The greatest drop is at Muskrat Falls, where the river narrows to less than 100 m and drops 12 m, but generally the gradient is very gentle, and high spring tides can reach as far as the falls (Blake, 1956). Only one tributary, of any size, enters the Churchill; i.e., the Traverspine River, on the southern side opposite Happy Valley.

The Goose River enters Terrington Basin of Lake Melville through a birds-foot delta. The lower part of the Goose River has low gradients and a meandering channel, but the steeper gradients of the upper reaches are demonstrated by a straight to braided channel pattern. The Goose River has an extensive terrace system associated with it, as does its main tributary, Peter's River.

North West River runs from Grand Lake to Lake Melville, and gives its name to the nearby community. The Grand Lake valley contrasts with those of the Goose and Churchill rivers in that it sits in a comparatively steep-sided bedrock-controlled trough. The lake itself is up to 2.5 km wide, over 40 km long, and at least 130 m deep (Blake, 1956). As North West River exits Grand Lake and flows through Little Lake into Lake Melville it cuts through two subparallel linear ridges up to 80 m high, oriented transverse to the valley axis.

BEDROCK GEOLOGY

The Lake Melville lowland is thought to be underlain by sandstones and conglomerate of the Neoproterzoic Double Mer Formation, but is mostly covered by a thick blanket of Quaternary sediments (Wardle, 1994). The Double Mer Formation is exposed south of the Churchill River. Wardle and Ash (1984) speculate that the Lake Melville lowland consists of a down-faulted block as part of a Precambrian graben system, and as such may be underlain at depth by Paleozoic sedimentary rocks. Most of the area is underlain by gniesses and intrusive rocks of the Grenville Province. The highland area between Grand Lake and Goose River is mainly underlain by rocks of the North West River anorthosite, a coarse-grained anorthosite with associated leucogabbroic rocks, and basal layered gabbro (Wardle and Ash, 1984; Wardle, 1994). The shores of Grand Lake show exposure of granitoid gneiss, and this rock type also crops out south of the North West River anorthosite to the Churchill River. The Dome Mountain Intrusive Suite forms a prominent hill west of Goose Bay and consists of monzonites, syenite and granite, along with enclaves of metagabbro and amphibolite. Numerous other minor granitoid intrusions are found throughout the area.

The area is thought to possess limited mineral potential, with indications of copper in the Dome Mountain area, and iron and titanium in the North West River anorthosite. Meyer (1990) and Emory-Moore and Meyer (1991) evaluated the potential for placer development and suggested that numerous black sand horizons in the area were potential sources of titanium. The river terraces in particular formed low-grade, high-volume deposits of illmentite–magnetite–haematite, but were not likely economically viable.

PREVIOUS WORK

Kindle (1924a, b) suggested that extensive terraces were formed mainly through tidal action in raised sea levels. Later, Tanner (1944) suggested that the major terrace at 45 m asl, at the mouth of the Churchill River, marked the marine limit in this area.

Blake (1953, 1956) described many of the main geomorphological features of the area, as observed during reconnaissance investigations of the Quaternary geology of the Goose Bay area. He suggested that ice flow, as interpreted from drumlins and flutings, was southeastward in the area of Grand Lake, but eastward in the Lake Melville basin. He interpreted this as showing that distinct coalescing ice lobes occupied the Lake Melville basin and Grand Lake. Linear ridges in the North West River area were interpreted as end moraines formed by ice exiting from Grand Lake.

Blake (1956) identified a major terrace at the mouth of the Churchill River at 45 to 47 m asl and described it as a former delta of the Churchill River. He indicated that this terrace rose to approximately 62 m asl at Muskrat Falls, and suggested that prominent lower terraces were found at 4, 8, 12.5, 19, 26 and 31 m asl. He described terraces on the Goose River at 19 m asl (the highest in the lower reaches), and at 6 to 8 m asl, and 9.5 to 12.5 m asl.

Fulton and Hodgson (1979) described the results of reconnaissance mapping in southern Labrador, and identified a dominant eastward ice flow in the area, with some draw-down effects into the Lake Melville basin. Preliminary maps at 1:50 000 scale were prepared (Fulton and Hodgson 1969), and compiled into a 1:500 000 scale map (Fulton, 1986).

Fitzhugh (1972, 1973) and Clark and Fitzhugh (1991) discussed the sea-level history in the Goose Bay and North West River areas. Detailed work in the North West River area resulted in the identification of sets of terraces between 3.2 and 24.4 m asl, and integration with archaeological data allowed reconstruction of a sea-level curve that showed a steady fall in sea level from 30 m asl at 5000 BP to present. They presented a regional curve that shows marine limit at 135 m asl, with a minimum age of 7550 BP.

A number of radiocarbon dates have been obtained from the region (Batterson *et al.*, 1992). Marine shells from near Muskrat Falls were dated at 7490 ± 150 BP (GSC-1254). These were recovered from 4 m asl, but Fulton and Hodgson (1979) interpreted these as being deposited in association with a sea-level stand of at least 85 m asl. A number of dates are available from North West River including barnacles (*Balanus hamerii*) dated at 7600 ± 100 BP (GSC-2970) from 27 m asl, and marine shells at 33 m asl (5330 ± 170 BP, GSC-1135). Wood dated to 5640 ± 60 BP (GSC-2896) was found near Mud Lake at 3 to 4 m asl. The collector suggested that the wood may be reworked, or deposited well below sea level (Vanderveer *in* Lowdon and Blake, 1979), as the presence of wood close to modern sea level is hard to reconcile with dates on marine fossils of similar age found well above sea level elsewhere.

ACCESS AND FIELD METHODS

The developed nature of the study area means that access is better than in many other parts of Labrador. A paved highway runs from Happy Valley–Goose Bay to North West River, and gravel roads, including the Trans-Labrador Highway provide moderate access to the Goose Bay map area, and parts of the Goose River and North West River map areas. Further access is possible via boat, using the Churchill River, the Goose River (easily navigable for only the lower 15 km), and Grand Lake. Much of the area is inaccessible other than by helicopter. This includes most of the northern half of the North West River map area (NTS 13F/9), and the northwest part of the Goose River map area (NTS 13F/7).

GEOMORPHOLOGY AND SURFICIAL GEOLOGY

ICE FLOW

Striations are common in the higher altitude parts of the study area. Rock outcrop is rare at lower elevations, masked by the thick blanket of marine and fluvial sediment. Where seen, striations suggest a comparatively simple ice-flow history with few examples of crossing striae recorded. Most striae indicate eastward to east-southeast ice flow, apart from in the Grand Lake valley, where southeast flow is indicated.

As discussed later, the genesis of drumlins is debatable, and makes their use as an ice-flow indicator speculative. However, in this area, these large-scale features generally seem to indicate a similar flow history to that interpreted from striations (Figure 3).

The dominant easterly to east-southeasterly flow was eastward from an ice divide located in the vicinity of the Smallwood Reservoir (Klassen and Thompson, 1993). Striations along the Grand Lake Valley are oriented parallel to the valley, suggesting that in the later stages of deglaciation, a drawdown effect occurred, controlled by local topography.

DIAMICTONS

Diamictons are best exposed in cuts through drumlinoid features. Diamictons tend to have a sandy matrix and generally less than 10 percent silt and clay. Clasts volumes are between 30 and 60 percent. Clast sizes range from granules to boulders, but pebbles and cobbles are the most common. The absence of good exposures makes it impossible to generalize about diamicton genesis, but it is likely that diamictons found below the marine limit are glaciomarine in origin rather than basal tills.

Drumlinoids

The higher ground in the west and northwest parts of the study area contains wide areas that show drumlinoid and fluted topography (Figure 3). These have variable shapes, tending to form sharp-crested elongate narrow ridges up to 1.5 km long. These are oriented generally east–west, and have their highest points on the western ends, with a "tail" dropping to the east. Their distribution appears to be strongly controlled by topography, being well developed in lower ground to the west of areas of higher ground.

Access to these areas is generally poor, but one well-exposed road-cut was examined in this study. The road-cut, located west of Dome Mountain, is up to 5 m thick, and forms a north–south-oriented exposure through the crest of a 500-m-long east–west-oriented ridge. The exposed material is boulder-rich diamicton, having clasts up to 1-m-long axis, and the clasts forming up to 50 percent of the sediment. The matrix consists of medium to coarse sand having less than 10 percent silt and clay. Clasts show concentrations of silt on their upper surfaces, and layers of fine sand beneath them. The matrix contains numerous laminae of fine to medium

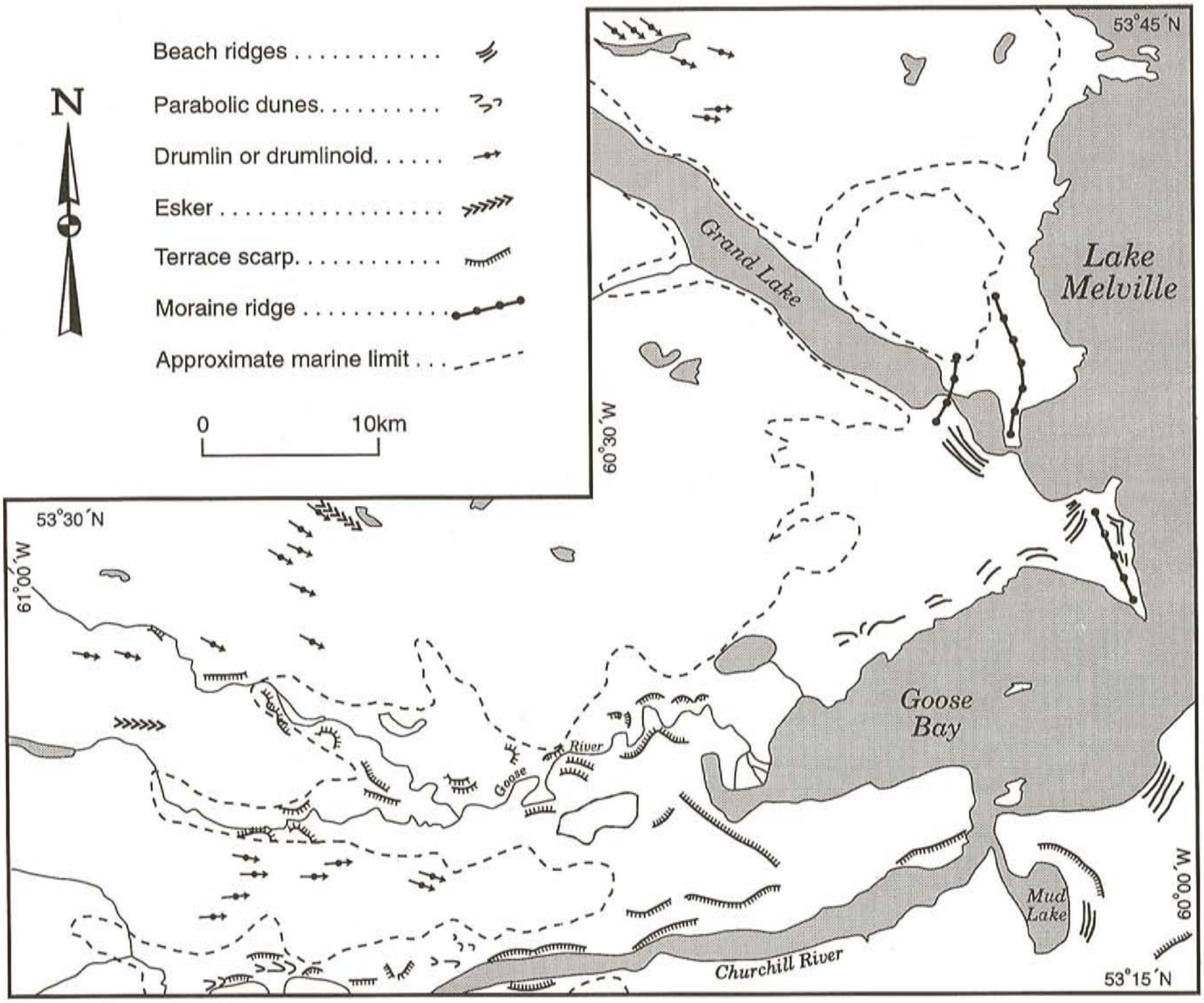

Figure 3. *Sketch map of the surficial geology of the Goose Bay area.*

sand, from 0.3 to 3 cm thick, laterally continuous and lying horizontally. Two clast fabrics were obtained from similar stratigraphic positions, 1 to 1.5 m below the surface. Both fabrics are unimodal, and moderately to well oriented (S1= 0.68, K= 0.89, mean orientation 87° dipping at 5°; S1=0.63, K=1.44, mean orientation 252° dipping at 3°). The mean orientations parallel the long axis of the ridge.

The origin of drumlins and flutings is subject to considerable debate. The conventional view is that they form subglacially through the action of ice flow on a till substrate (*see* Menzies, 1989). This model was challenged by Shaw (1983), Shaw and Ashley (1988) and others who believed that drumlins are formed by major subglacial meltwater flows. The diamicton exposed in the example appears to be deposited basally, with the moderately oriented fabrics and the numerous sorted laminae indicating a basal melt-out origin (*cf.*, Lawson, 1979; Shaw, 1982; Rappol, 1985). Basal melt-out tills are common components of drumlins and as such yield little information on drumlin genesis. The clast fabrics do however indicate ice flow at some point parallel to the drumlin axis.

MORAINE RIDGES

Several large sediment ridges are aligned northeast–southwest; transverse to the Grand Lake Valley. These are up to 80 m high, 1 to 2 km wide and 10 km long (Figure 3). The most prominent extends 9 km north from North West River, and can be traced south of North West River for a farther kilometre. At North West River, the ridge is known as Sunday Hill, and the northward extension, Birchy Hill. A second much smaller ridge is found at the narrows at the end of Grand Lake, and a third large ridge runs south from North West Point.

There is excellent exposure of the sediments that compose one such ridge in large gravel pits on the north side of Sunday Hill (Plate 1). These show mostly gravel and sand. Gravels vary from well sorted to poorly sorted, with moderate sorting dominant. Gravels are mostly planar bedded and gently dipping with beds traceable laterally over tens of metres. Pebble–cobble gravels constitute the majority of the exposed sections, along with minor boulders and granules. Sands are found mostly toward the top of the sequence and formed well sorted planar beds. Sand interbeds are common throughout.

Kirby (1989) conducted a program of shallow back-hoe test pitting on Birchy Hill, and encountered well sorted sand and silts, in some cases containing marine fossils (at elevations up to 76 m asl).

These ridges have previously been interpreted as end moraines (Blake, 1956; Fulton and Hodgson, 1979). End moraines frequently contain diamicton as a major component of the sediments, yet none was observed in exposures in this area. The presence of marine fossils close to the ridge crest, in sediments overlying gravels, strongly suggests that these ridges were deposited below marine limit, likely as ice-contact subaqueous outwash. The breaks in the ridge system indicate that deposition was likely as a series of subaqueous outwash fans. As such, the ridges do indicate former ice marginal positions, and that the Grand Lake Valley was a major conduit for subglacial meltwater during deglaciation. The formation of ridges as opposed to flat topped deltas suggests that the ice margin did not remain static long enough for a sufficient volume of material to be deposited to build up to marine limit. It is likely that these ridges were built up when the ice front stabilized for brief periods of time on bedrock ridges, possibly fiord sills.

A small exposure near Otter Creek shows interbedded granule gravels, diamictons and sand, suggesting an ice contact glaciofluvial origin. Most surface sediments in this area are terrace sands, and it is possible that a moraine ridge similar to those at North West River was completely buried by later glaciomarine and fluvial sedimentation, with this exposure cutting into the crest.

GLACIOMARINE MUDS

Glaciomarine muds are intermittently exposed in roadcuts, and well exposed in the Goose and Churchill river valleys. The thickest sequences are seen in excellent exposures along the banks of the Churchill River below Muskrat Falls (Plate 2). At least 20 m of mud form a sequence that

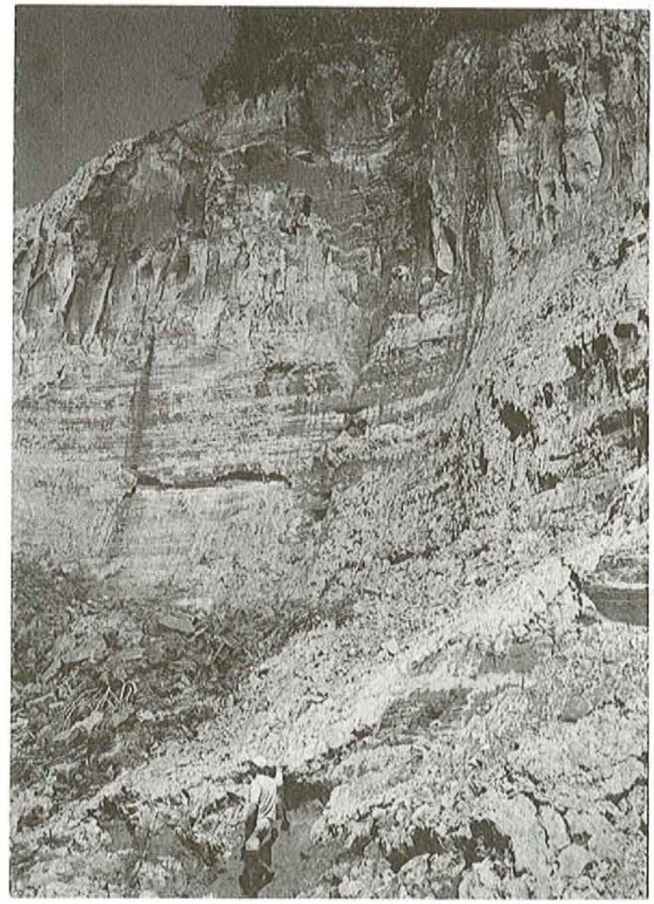

Plate 2. *Glaciomarine clay exposed downstream of Muskrat Falls.*

generally fines upward. The base of the section shows mostly planar bedded and rippled sand that progressively fines upward over 5 m into planar laminated silty clay, silt and fine sand. Sands are commonly normally graded, with some rip-up clasts. Rhythmic lamination dominates the lower part of the sequence, but becomes less clear in the upper parts, and grain size contrasts decrease. Normal grading is less well defined, and rip-up clasts absent. Dropstones are rare and occur intermittently at distinct stratigraphic levels within the sequence, prominently about 15 m above river level. A boulder at this level has a number of fossil barnacles (*Balanus hamerii*?) adhering to its surface.

A preliminary interpretation of this sequence suggests a transition from sedimentation dominated by underflow and turbidity currents to that by suspension settling from overflows and interflows (*cf.*, Mackiewicz *et al.*, 1984). The presence of dropstones indicates that glacial ice was calving in the basin at this time, with distinct calving events forming concentrations of clasts. The general fining up may represent a progressive deglaciation of the valley, resulting in the sediment source becoming increasingly remote with time. The bedrock ridge that crosses the valley at Muskrat Falls was probably able to prevent the passage of underflows down the basin, and in effect trapped coarser sediment west of this site.

An adjacent exposure shows large-scale deformation in the muds, with recumbent folds restricted to approximately 5-m-thick zones at the base of the section. Such folds are likely syn-sedimentary, caused by large-scale slumping of saturated sediments during deposition.

Muds are less well exposed elsewhere in the study area, being often covered by colluvium. These sediments are very prone to slope movement, both small and large scale. Several large rotational slumps have occurred along the Churchill River in the last 30 years, the largest being at Muskrat Falls itself, where over a square kilometre of terrace sediments have slumped into the river. Numerous other smaller landslides are found along the Churchill and Goose rivers, with their number increasing upstream as the glaciomarine muds compose a greater proportion of the cut-banks.

SEA-LEVEL FEATURES

Numerous raised beaches occur along the shores of Lake Melville. These are indistinct on the ground but are splendidly displayed on aerial photographs, notably on the east shore of Mud Lake (Figure 3), where over 30 closely spaced beaches occur up to 30 m asl (*see* Batterson and Liverman, 1995, pages 60 and 61). A similar sequence occurs near North West River and has been well described by Fitzhugh (1972, 1973), who suggested, based on archaeological evidence, that this sequence represents continuously falling sea level over the last 5000 years. Strandlines are less well defined at higher elevations, and no deltaic features are present, probably because glaciofluvial sedimentation from the major fluvial sources took place outside of the study area. In many places, the marine limit is best defined by the highest occurrence of glaciomarine clays (up to 75 m asl near North West River and over 100 m asl along the Churchill River Valley).

FLUVIAL TERRACES

Terraces of the Churchill and Goose rivers are striking features of the low elevation parts of the study area (Figure 3). They occur at a variety of altitudes, and are well exposed in cut-banks along the river valleys, as well as in roadcuts along the Trans-Labrador Highway. The sediments exposed show little variability in grain size or sedimentary structures, with well sorted fine to medium sand composing the bulk of the sequence. The sand is mostly planar bedded, cross-laminated, planar-tabular, cross stratified, and trough cross-bedded. Interbeds of silty sand and sandy silt are common. On good exposures, large-scale master bedding surfaces are observed, dipping at less than 5°, and forming planar or trough-shaped structures that can be traced laterally upward of 100 m. Along the rivers, cut-banks show that terrace sands are commonly underlain by marine clays. The elevation of the clay–sand contact relative to the river increases upstream, from below the river level near the current mouth, to more than 20 m above river level at, for example, Muskrat Falls. The contact between the underlying clays and terrace sands is generally sharp. In one section, the bed marking the contact consists of numerous clay clasts in a sand matrix, forming an intraclast gravel. The clasts are up to 5 cm diameter, and well rounded.

The exposures suggest deposition in a sand-dominated fluvial system. Examination of channel patterns on aerial photographs shows a braided pattern on the Churchill River terraces, and a meandering pattern with point bars well displayed in the Goose River valley. The sediment exposed in cut-banks generally support this interpretation. The sediment of the Churchill River terraces resemble the facies models developed for a sandy braided pattern by Walker and Cant (1984). The Goose River exposures generally lack overbank sediments and as such differ from the deposits of classical meandering systems. It is possible that the Goose River had a braided course in the earlier stages of terrace development, and the transition to meandering took place later. More detailed sedimentological description and interpretation are required to test this hypothesis.

In the lower part of the Goose River, cut-bank exposures through paleo-channels on the terrace surface are found. The base of one such channel is approximately 10 to 12 m asl, and the channel is 3 to 5 m deep and 30 m wide. The channel is formed in planar and trough crossbedded well-sorted sand, and is filled by interbedded sand, silt and clay, topped by peat. The channel fill contains numerous pieces of wood, up to 2 m or more long, and 30 cm diameter (Plate 3). The pattern of channels shown on aerial photographs indicates that at one time the Goose River passed through this channel system into Lake Melville via Gosling Lake to the north, rather than its current entry point. Wood samples collected during the present field season will be radiocarbon dated to determine when the change in drainage patterns took place.

Aerial photographs show a complex sequence of terraces in many places modified by large-scale slumping. Clearly developed paired terraces cannot be identified with certainty. Wood samples were collected in several locations along the Churchill and Goose rivers, and radiocarbon dating will assist in developing a chronology of terrace development.

SAND DUNES

Parabolic dunes are found on the higher terraces of the Churchill River (Figure 3). They form well-defined, arcuate, sharp-crested ridges, up to 0.5 km long and 3 to 7 m high. They are oriented with the nose of the dune ridge to the east,

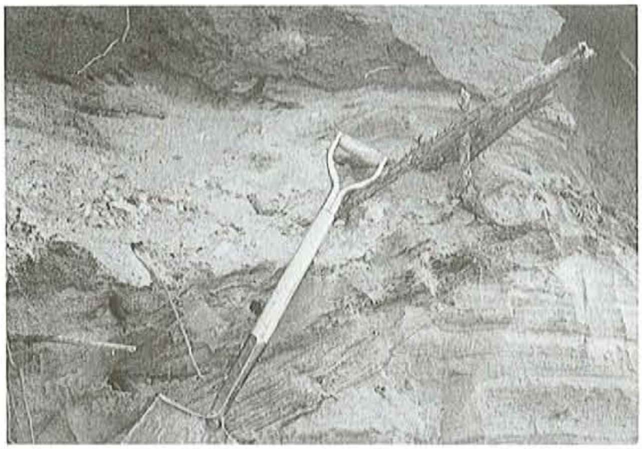

Plate 3. *Numerous wood pieces within a former channel of the Goose River.*

and the horns extending to the west or southwest, generally parallel to the valley axis. Small exposures show them to be composed of well-sorted fine to medium sand, mostly crossbedded, with some ripple crosslamination. The surfaces of the dune ridges are well vegetated, and the dunes seem stable.

Parabolic dunes form where there is an ample supply of sediment and strong winds. The orientation of these dunes indicates paleo-winds similar to the prevailing modern wind directions. Dunes do not appear on the lower terraces of the Churchill River, and development of a terrace chronology may assist in understanding the history of dune development.

GEOLOGICAL HISTORY

The area was glaciated by the Labrador sector of the Laurentide Ice Sheet during the last glaciation. Ice flow was eastward from an ice divide located in the vicinity of the Smallwood Reservoir (Klassen and Thompson, 1993). Flow directions were consistent, apart from a late diversion of ice into the Grand Lake valley as deglaciation progressed. The time of deglaciation is uncertain, constrained only by dates on marine fossils as being prior to 7550 BP. As the Lake Melville basin opened to the sea, the marine limit was at least 135 m asl in the western extreme of the study area, and although it is likely that the marine limit declines toward the outer coast (75 m asl in Groswater Bay; Clark and Fitzhugh, 1991), the rate of decline is not well defined in the field area. Marine limit is likely over 100 m throughout the field area, as shown by marine fossils at 76 m asl near North West River. Glaciomarine sedimentation was extensive, and dominated by fine-grained sediments. There is little evidence of ice-contact or ice-proximal sediments, apart from the moraine ridges at North West River and a single exposure near Otter Creek. It is likely that such material has been buried beneath the thick blanket of glaciomarine muds that cover the region below marine limit. The absence of deltaic sediments is due in part to the lack of major tributaries to the Churchill River, and thus there are few places where glaciofluvial meltwater would have entered the raised postglacial sea. The Churchill River valley would have formed a long inlet or estuary with the head lying outside the study area. Thus, glaciofluvial sedimentation was mostly restricted to outside of the field area.

Since deglaciation, sea level has apparently fallen steadily with numerous strandlines formed in the last 5000 BP. Most of the sea-level fall was in the initial stages of deglaciation, with sea level reaching 33 m asl about 4800 BP (Fitzhugh, 1972, 1973). As sea level fell, the Churchill and Goose rivers cut through their own flood plains, resulting in terrace development. The terraces and modern river systems are uniformly sandy. The current source of sediment for the rivers in the lower parts of their modern course is either sand from older terraces, or glaciomarine clays. Although diamictons are common in the areas above marine limit, and contain considerable volumes of gravel-sized clasts, such material is not available for fluvial erosion. Thus, gravel can only be incorporated into the system from well upstream, where the river valley lies above marine limit. In the case of the Churchill River, this is at least 100 km from the mouth, and still water above Muskrat Falls and Gull Island prevents bedload transport of gravels downstream. It is likely that the modern river system closely resembles the ancient river system that deposited the terrace sediment seen today, thus explaining the paucity of gravel in terrace sediments.

CONCLUSIONS

AGGREGATE GEOLOGY

The existing source of granular aggregate, Sunday Hill near North West River, contains ample reserves and is connected to Goose Bay via a paved road. Kirby (1989) was unable to locate gravel in Birchy Hill, but it seems likely that such material may exist at depth below a drape of distal glaciomarine sands and silts. Alternate sources exist in the immediate region but will require development or improvement of roads before they can be economically exploited. The upper Peter's River area in particular, contains fluvial terrace gravels, and an esker that may contain reasonable quality aggregate. This source is no farther from Goose Bay than the existing sources at North West River, but access is via a poorly maintained gravel road. Closer to Goose Bay, it appears that gravel may exist in the terraces as pockets, but this will prove hard to locate without geophysical methods. Ice-contact glaciofluvial sediment is likely present at depth, but the thickness of overlying sediment makes it impractical to exploit. A consultant's report (Klohn-Crippen Ltd., 1995) identifies gravel beds up to 3 m thick in drillholes at Otter Creek in the vicinity of the waste disposal site; these may be related to buried moraine ridges.

ENVIRONMENTAL GEOLOGY

The presence of a large military base in Goose Bay for over 50 years has resulted in environmental concerns in relation to fuel-storage facilities and landfills. Remedial work is underway to deal with subsurface contamination. The terrace of the Churchill River on which the base is sited consists of porous and permeable sand that does little to mitigate any leakage or spillage of fuel, or contamination from landfill. The excellent drainage of the terrace sediments also results in preservation of buried material in landfills. Plume migrations are generally in the order of 1 m per year (J. Lammey, personal communication, Wing Environmental Officer, 5 Wing, Goose Bay, 1996) and it is possible that silty sand interbeds seen within exposures are inhibiting migration.

Slope stability must be considered in any area of development underlain by glaciomarine muds. Large rotational slumps are common along the Churchill and Goose rivers, and cut-bank stability is generally poor. The effect of fluctuating river levels on erosion, and thus stability, must also be considered in any possible development.

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