Current Research (1990) Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 39-48

SURFICIAL GEOLOGY MAP OF INSULAR NEWFOUNDLAND

David Liverman and David Taylor
Terrain Sciences Section

ABSTRACT

A 1:500,000 scale surficial geology map of insular Newfoundland has been compiled, using existing 1:50,000, and 1:250,000 mapping, and original aerial photograph interpretation. A simple descriptive legend is used, denoting eleven units based mainly on material grain size, and geomorphology. The map is limited in that it only shows the dominant sediment type of what is usually a mixture of several types in a given area. A pronounced landform zonation is apparent on the completed map, which differs from other documented examples. The map will be of use to, amongst others, mineral exploration companies using drift prospecting techniques, in development of aggregate resources, land-use planning, and to hydrogeologists.

OBJECTIVES

Integrated surficial geology maps do not exist for the island of Newfoundland. Examination of existing map coverage suggested that, with some additional aerial photograph interpretation, compilation of a 1:500,000 scale map would be possible. Such a map is considered important because:

1) it would enable the Geological Survey Branch to accurately evaluate the quality and extent of existing coverage,
2) it would be used as a tool for planning future mapping,
3) the 1:500,000 scale allows recognition of broad patterns of sediment distribution, which could aid interpretation of glacial history of the island, and
4) a compiled map allows presentation and summary of much work, which at present has limited distribution.

LEGEND

The legend is intended to highlight the distribution of surficial sediment types and to accommodate all pre-existing mapping with minimum re-interpretation. Thus, a classification based initially on grain-size distribution was chosen; sediments were further subdivided based upon geomorphology, and sediment thickness criteria. In complex areas, or in areas with several sediment types, only the dominant sediment type was indicated on the map. Genetic interpretation was avoided, wherever possible, in designating units. The designated units are described below.

Exposed Rock (Unit 1)

This unit consists of exposed bedrock having little or no sediment or vegetation cover. It is recognized on aerial photographs by generally lighter tones, and distinct bedrock structure, usually in the form of lineations marking bedding or jointing. The composition of bedrock is variable, and is not specified on the map. Patches of till and other surficial sediment, less than 1.5-m thick, may be present, but are rare. Slopes are variable, from gentle to very steep. On gentle slopes, there is usually abundant evidence of glacial activity in the form of striae, roches moutonnés, and smoothed surfaces. Preservation of striations depends on the hardness, grain size, and resistance to weathering of the bedrock. The topography is bedrock controlled. Exposed rock is commonly associated with Units 2 (rock concealed by vegetation), and 3 (till veneer), and may have sporadic patches of Unit 11 (bog). In areas of steep slopes, it is associated with colluvium.

Large areas of exposed bedrock occur where there is little soil cover to allow plant growth, where climate is unsuitable, or where the geochemistry of bedrock is unfavourable. Absence of soil cover is due to lack of glacial deposition followed by little postglacial weathering.

Rock Concealed by Vegetation (Unit 2)

This unit consists of bedrock concealed by vegetation, with a significant discontinuous till cover (<50 percent by area). On aerial photographs it appears as dark toned areas, but with recognizable bedrock structure. Vegetation growth is sufficient to cover the surface. Patches of till and other surficial sediment having a thickness generally less than 1.5 m are common. Areas of exposed rock are also frequently found. Slopes are variable from gentle to steep. Topography is variable and bedrock controlled. Gradational boundaries commonly exist between Unit 2, and Units 1 (exposed rock) and 3 (till veneer). Unit 2 can also be associated with Unit 11 (bog), and, on steep slopes, Unit 10 (colluvium).

Till Veneer (Unit 3)

This unit is composed of a thin (<1.5 m) discontinuous sheet of till, which consists of diamicton (a sediment containing a wide mixture of grain sizes, usually ranging from clay to boulders). A veneer is defined as a sediment cover of 1.5 m or less (Rutter, 1977). On aerial photographs, Unit 3 is recognized by moderate to dark patchy tones, and where associated with bedrock structure, is partially obscured. The proportion of matrix (sand size or finer) depends on the source material for the diamicton and can vary from 20 to 90 percent. The coarse component (greater than sand size) normally consists of granules (0.2- to 0.4-cm diameter) and pebbles (0.4- to 6.4-cm diameter), but can contain up to 30 percent cobbles and boulders, with maximum clast diameter of between 1 to 2 m. Patches of Units 1 and 2 (exposed rock, and concealed rock) are common, but form less than 50 percent of areas mapped as Unit 3. Sporadic occurrences of small sand and gravel deposits (Unit 7) are also found. Normally, tree cover is extensive. Slopes are variable, as is topography, reflecting variation in the underlying bedrock. Gradational boundaries exist with Unit 2 (concealed rock), and units with thicker sediment cover.

The likely origins of a diamicton veneer include glacial deposition by lodgment, basal melt out, or supraglacial melt-out processes. The majority of diamicton in Unit 3 is considered to have been deposited by glacial proccesses and is thus a till.

Till Blanket (Unit 4)

This unit consists of a blanket of glacially derived diamicton (till) greater than 1.5-m thick, with variable topography, that cannot be assigned to Units 5 (hummocky terrain) or 6 (ridged till). Two main types are classified together in this legend, but due to the legends being used in source mapping, cannot be separated on the final map.

The first type consists of a blanket of diamicton, with a channeled topography. On aerial photographs it is recognized by variable, lineated tones, a moderate vegetation cover, channeled topography, and no evidence of bedrock structure. Composition and grain-size distribution is similar to that of Unit 3 (till veneer), although within channels, sand and gravel are common at the surface, forming less than 30 percent of the unit. Slopes are moderate and relief is 1 to 5 m. Drainage is moderate to good. The unit is associated with units of thick sediment cover (Unit 5, hummocky till; Unit 6, ridged till; and Unit 7, glaciofluvial gravels), and shows gradational boundaries with Unit 3 (till veneer). It represents between 80 and 90 percent of Unit 4 as mapped.

Channeled areas occur where meltwater has eroded and modified the original topography during deglaciation. Thus, it is not possible to suggest a primary environment of deposition for the diamicton solely from aerial photograph interpretation.

The second sediment type consists of a blanket of diamicton having a smooth topography and forming a low-relief plain. It is recognized on aerial photographs by dark, even tones. Drainage is poor to moderate, slopes are gentle having a relief of 1 to 3 m. Composition and texture is similar to Unit 3 (till veneer).

The origin of this second type is polygenetic. On the uplands of the west coast, areas of subdued topography composed mainly of diamicton have been interpreted by Grant (1986a,b) to represent previously glaciated areas, which remained ice-free during the Late Wisconsinan. Weathering and periglacial activity have modified the original topography. Elsewhere on the island, till plains are probably deposited by lodgment or basal melt-out processes (although genetic studies are absent).

Hummocky Terrain (Unit 5)

This unit consists of a blanket of diamicton (<1.5-m thick) having an irregular, hummocky surface. Hummocks rarely form a linear pattern commonly oriented across valleys but are mostly random. On aerial photographs, Unit 5 is recognized by its hummocky topography and mottled dark tones. Its composition is similar to other units composed of diamicton, but is more variable in texture. In addition to diamicton hummocks, some can be formed of moderately sorted sand and gravel, with very low amounts of silt and clay present. Unit 11 (bog) is commonly found in the low areas between hummocks, and small areas of Unit 7 (glaciofluvial gravel and sand) are intermittently distributed. Slopes are gentle to moderate, and the hummocks generally have relief of 5 to 10 m. Drainage is poor. Hummocky terrain is commonly associated with other units composed of thick sediment accummulations, in particular glaciofluvial gravel (Unit 7), and with bog (Unit 11). It shows gradational boundaries into till veneer (Unit 3).

This unit incorporates landforms described as hummocky moraine, ribbed moraine, cross-valley moraine, and Rogen moraine. Most of the unit consists of hummocky moraine. The origin of hummocky moraine is controversial. The most commonly held and accepted view is that a hummocky topography is formed when ice stagnates, and hummocks formed by either remoulding of the existing diamicton, or by topographic inversion (Gravenor and Kupsch, 1959; Parisek, 1969; Stalker, 1960). It is likely that some of the area mapped as hummocky terrain in Newfoundland was deposited subglacially, either by active ice, or subglacial meltwater (Proudfoot, *et al., this volume*). In the absence of more detailed studies, it is suggested that most of this unit was deposited by glacial stagnation. Irregular ridges, formed by an alignment of hummocks (ribbed moraine, cross-valley moraine), also form during stagnation and are considered to be oriented transverse to ice flow (Embleton and King, 1975). Rogen moraine is thought to be deposited at the base of actively flowing ice (Sugden and John, 1976).

Ridged Till (Unit 6)

This unit is composed of diamicton greater than 1.5-m thick, having a streamlined, elongate, ridged surface. It is recognized on aerial photographs by its distinctive geomorphology, and dark lineated tonal pattern. It is mostly composed of diamicton, but similar ridges may also be formed of gravel and sand, or bedrock. Where diamicton forms the ridges, the grain-size distribution is similar to that of Unit

3 (till veneer). Bog (Unit 11) is found in the low areas between ridges. Slopes are moderate to gentle, and relief on the ridges varies from less than 3 m to more than 20 m. Drainage is poor to moderate. The unit is associated with till blankets (Unit 4), hummocky terrain (Unit 5), and glaciofluvial sand and gravel (Unit 7), and shows a gradational contact with till veneer areas (Unit 3).

This unit is composed of flutes, drumlins and crag-and-tail hills. The origin of these is controversial, although most researchers accept that they are formed subglacially, with the long axes paralleling ice flow. A number of hypotheses suggest that they form at the base of active ice, with ice flow producing a streamlined landform by lodgment of till onto a core, or by moulding of previously deposited till (Sugden and John, 1976). An alternative hypothesis suggests that their morphology is due to the action of large volumes of subglacial meltwater on the base of the ice, with subsequent filling of subglacial cavities by previously deposited till, or sand and gravel (Shaw, 1983; Shaw and Sharpe, 1987). In the absence of detailed studies, it is not possible to choose between these hypotheses when determining the genesis of these Newfoundland examples.

Glaciofluvial Gravel and Sand (Unit 7)

This unit consists of variable thicknesses of gravel and sand with diverse topographical expressions. It is distinguished on aerial photographs by its generally light tones, association with other units deposited by ice, and geomorphology. It consists mainly of poorly to moderately sorted gravel, having between 5 and 50 percent sand. The gravel clasts are mainly pebbles, but may contain up to 70 percent cobbles, and sporadic boulders. The unit is always well drained. The surface morphology is varied and shows the following types.

i) *Planar with Numerous Channels*. Relief is generally less than 2 m, and slopes are gentle. Type 'i' may contain isolated steep-sided depressions 2- to 5-m deep. These sediments were deposited in outwash plains (sandar) by proglacial braided streams, generally during ice retreat or stagnation.

ii) *Elongate Sinuous Ridges*. These can be up to 10-km long, with steep slopes and a relief of 3 to 15 m. The ridges can be multiple and complex, intermittently widening into mounds and hummocks. The ridges are interpreted as eskers or esker complexes and are probably deposited either subglacially or at ice margins during ice stagnation or retreat. Their alignment is generally perpendicular to ice margins.

iii) *Isolated Mounds or Hummocks with no Associated Ridges*. Relief is up to 20 m, and slopes are moderate to steep. These are interpreted as kames, formed at the ice margin where supraglacial or ice-marginal streams deposit their bedload in contact with ice.

iv) *Terraces along Valley Sides*. These have variable slopes with flat upper surfaces and steep sides and the relief can be up to 20 m. These are interpreted as kame terraces, deposited by meltwater flowing between a valley side, and ablating ice (Sugden and John, 1976).

v) *Arcuate (fan-shaped) Mounds*. These are either isolated topographic features, or occur at valley mouths. They are interpreted as fan deltas or deltas, formed where meltwater discharged directly from the ice margin into a body of water (ice contact deltas), or where outwash streams flowed into standing water. These features are related to marine or lacustrine environments. Many have been raised to their present position by postglacial isostatic rebound.

Marine Clay, Sand, Gravel, and Diamicton (Unit 8)

This unit varies in composition, and is recognized by its topographic position relative to the modern sea level, and geomorphology. Sediments located below the marine limit (the maximum sea-level stand following deglaciation) have been mainly deposited or reworked by marine processes. The distribution of this unit is controlled by the amount of isostatic rebound (postglacial uplift of land depressed by the weight of overlying ice). The elevation of the marine limit varies systematically over the island, from a maximum of 125 to 150 m on the Northern Peninsula to zero or net submergence on the Avalon Peninsula (Grant, 1980). This unit incorporates a wide range of deposit types, outlined below.

i) *Planar Terraces of Sand and Gravel*. These are composed of well to moderately sorted gravel and sand, and are common at altitudes ranging from 2 to 50 m above the modern sea level. Gravel is normally pebble sized or smaller, and forms between 20 and 100 percent of the deposit. This type was formed by the action of waves on surficial sediments at higher sea-level stands.

ii) *Silt and Clay Plains*. Isolated coarse clasts (dropstones) are commonly found within a silt–clay matrix, but comprise less than 5 percent of the sediment. This type was deposited by a combination of offshore marine processes including turbidity currents and suspension settling in an environment dominated by glaciofluvial sediment input. It is rarely exposed at the surface.

iii) *Diamicton Blanket*. This can be 1.5- to 15-m thick, and generally contains abundant lenses and beds of silt, sand, and gravel. Surfaces commonly contain little silt or clay, and have concentrations of coarse clasts. Type 'iii' was deposited in ice proximal glaciomarine settings, where diamicton was deposited by remobilization of till as debris flows, rain-out of sediment from floating ice margins, and reworking by marine current activity (Eyles and Miall, 1984; Powell, 1981). Winnowing by nearshore marine processes resulted in removal of fines as sea level fell.

iv) *Sand and Gravel Ridges*. These are composed of moderately to well sorted sand and gravel and are found mainly on the west coast. These ridges were deposited as beaches, formed by wave action, during still-stands at times of raised sea level.

v) *Sand and Gravel at or near Modern Sea Level.* These are found on the coast around the island and are related to modern marine processes. Beach ridge complexes, bayhead and baymouth bars, and spits can be recognized by their geomorphology. Type 'v' is mainly composed of well sorted pebble to cobble gravel. In some low lying areas, fine grained sediment is found, deposited in coastal lagoons impounded behind these landforms.

Alluvium (Unit 9)

This unit consists of moderate to well sorted gravel, sand, silt and clay, associated with modern rivers. It is recognized on aerial photographs by its relationship to active river channels, and its channeled or flat topography. It consists of a mixture of sand and gravel along stream channels, and silt and clay on overbank or flood plain areas. A few examples of alluvial fans have been mapped and are included in this unit. On flood plains, the unit is commonly associated with Unit 11 (bog), and in coastal areas it shows a gradational boundary with Unit 8 (marine sediments).

Colluvium (Unit 10)

This unit consists of a mixture of grain sizes from boulders to clay, and is identified by its association with steep slopes. On aerial photographs, it forms an apron at the base of steep slopes, and obscures bedrock structure. Its composition is variable, but in many cases is dominantly cobble- to boulder-size angular rock debris, with a variable amount of fine grained matrix. It is formed through mass movement processes. It is usually associated with exposed and covered rock (Units 1 and 2).

Bog (Unit 11)

This unit consists of aggraded and degraded organic matter. It is 1- to 10-m thick, and preserved by a reducing and acid environment in low-lying, water-saturated, poorly drained areas. It is recognized on aerial photographs by an absence of tree cover, moderate to light even tones, and low relief. Bog is interspersed with most of the other units. It forms either by growth of wetland vegetation in place, or by progressive filling of lakes and ponds.

SOURCES

A full list of sources will be appended to the first draft of the map, but most of the map has been compiled from existing mapping undertaken by the Terrain Sciences Section, Geological Survey Branch, Newfoundland Department of Mines and Energy, and the Geological Survey of Canada. Terrain Sciences Section mapping is of two types.

1) The bulk of available mapping consists of reconnaissance aerial photograph interpretation, with the primary objective of locating aggregates (Kirby *et al.*, 1989; Sparkes, 1987; Vanderveer, 1976, 1977a, b, 1987a, b, c, d; Vanderveer and Cornish, 1977; Vanderveer *et al.*, 1987). A terrain classification legend was used in these maps, enabling easy adaptation into that used for the compiled map.
2) More detailed maps, based on aerial photograph interpretation but with substantial field checking cover a small part of the island (e.g., Sparkes, 1984a, b; Proudfoot and St. Croix, *in prepration*).

Geological Survey of Canada mapping mostly uses a legend that is in part interpretive, but was adaptable to the system with some additional aerial photographic interpretation (Grant, 1973, 1974a, b, 1975, 1986a, b, c, 1989, *in press*; Henderson, 1972). In areas of overlapping coverage, reliance was placed on Geological Survey Branch mapping, because the original aerial photograph interpretation and the interpreters were usually available for consultation.

After collation of available mapping, large areas remained unmapped (Figure 1). Department of Mines and Energy geologists co-operated to map these areas using aerial photograph interpretation. Martin Batterson and Dave Proudfoot mapped large areas of NTS sheet 2D; Dave Liverman mapped parts of 12A, 2D, 11P and 1M; and Lloyd St. Croix mapped some areas of 2E and 2F.

METHODS

Existing maps are mainly at 1:50,000 and 1:250,000 scale. These were coloured according to the final legend, disregarding any unit smaller than 1 by 1 km. In the case of terrain classification legends, the dominant terrain type was used in cases where a unit was composed of more than one sediment type. 1:50,000 maps were then transferred to 1:250,000 bases, and boundaries between map areas checked, in some cases with the aid of further aerial photograph interpretation. 1:250,000 maps were coloured, and boundaries checked prior to transference to the 1:500,000 base.

Limitations of Mapping

Users of this map should be aware of a number of limitations.

1) The quality and accuracy of the map is dependent on the original larger scale mapping. In most cases, and in particular the areas mapped specifically for this project, there has been little or no ground checking of the aerial photographic interpretation. Experience has shown that such interpretation is fairly accurate, but ground checking can yield extensive modification of the interpretation.
2) Many boundaries are gradational, and precise positions are subject to the judgment of individual interpreters. In compilation, differences in interpretation were obvious at boundaries between mapping by different authors. Such differences were

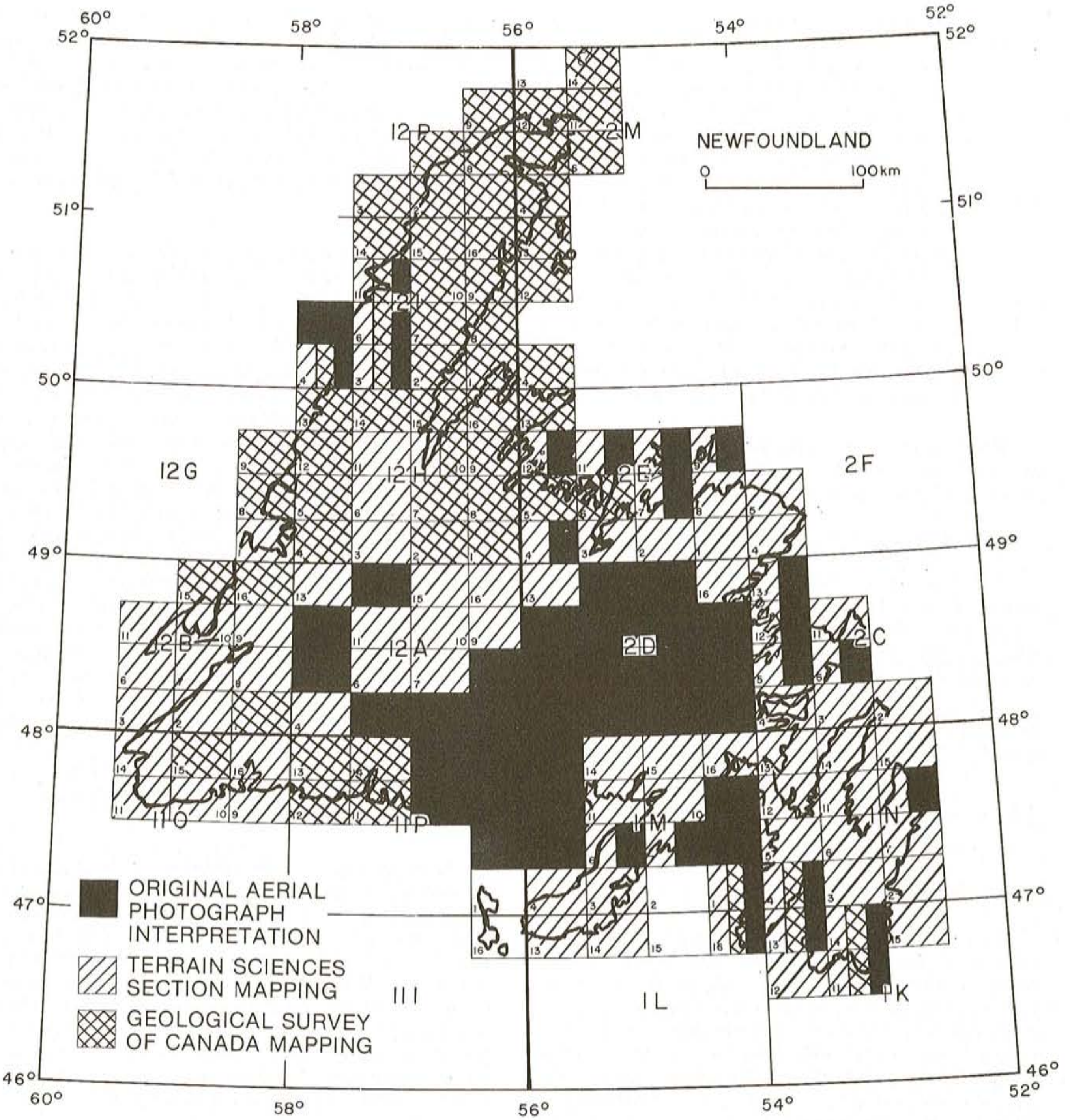

Figure 1. *Sources of information used to compile the surficial geological map of insular Newfoundland.*

generally minor, but result in the original unit fitting into different categories of the legend adopted for the compilation map. For example, a unit might be mapped as till veneer having areas of concealed rock by one author; and dominantly concealed rock having patches of till veneer by another. Major differences in interpretation were rarely encountered. To accommodate such examples without resorting to re-examination of aerial photographs, boundaries have been placed that may not reflect actual differences in surficial sediment.

3) The scale of the map results in the omission of many deposits of small area but of major importance, economically and otherwise. For example, many ice-contact sand and gravel deposits are too small to be shown on a 1:500,000 scale map, but are important sources of aggregate. Similarly, many small areas of bog are found throughout the island, but usually

will not form a large enough area to be displayed.

4) The glacial and postglacial sedimentary environments are complex, and have resulted in a complicated distribution of surficial sediment, with considerable lateral and vertical variation over short distances. Any surficial mapping, results in simplification of this distribution, but this is particularly marked on such a small-scale map as that presented here. Terrain classification legends can accommodate units composed of a mixture of terrain types, but the decision to only show the dominant sediment type for a given area on the compiled map may mislead casual users. It must be emphasized that each map unit of the compiled map shows only the dominant sediment type found in the area, with associated sediment types or minor, but important areal extent, not represented.

If these limitations are understood, the map will be useful on a broad scale. Users may wish to consult more detailed mapping, if more appropriate for their requirements.

DISTRIBUTION OF UNITS

Although it is not practical to present a version of the map in this format a number of comments may be made regarding the distribution of zones. A distinct zonation is apparent. From the centre of the island to the coast, a concentric zonation is seen from:

Zone 1—mainly Unit 5 (hummocky terrain)
Zone 2—a mixture of Units 4 (till blanket), 5 (hummocky terrain), 6 (ridged till) and 7 (glaciofluvial gravel and sand; mainly kames and eskers);
Zone 3—Unit 3 (till veneer), Unit 7 (glaciofluvial gravel and sand, mainly outwash) and Units 1 and 2 (bedrock); and
Zone 4—Units 1 (exposed bedrock) and 8 (marine).

This zonation is clearly seen in central Newfoundland, and is also recognized on a smaller scale on the Northern Peninsula and the Avalon Peninsula (Figure 2). On a broad scale, this zonation was noted by Jenness (1960) who defined an inner and outer drift zone, whose boundary matches that between Zones 3 and 4 defined here. Jenness interpreted this zonation as marking a still-stand in ice retreat, with the boundary represented by a poorly defined end moraine, although this interpretation has not been supported by subsequent work (e.g., Tucker, 1976). Grant (1977) suggested that a line close to the boundary between Zones 3 and 4 designated here, might represent the Late Wisconsinan glacial limit, although this interpretation has not been supported by more recent radiocarbon dates (Dyke and Prest, 1987; J. Macpherson, personal communication, 1988, Department of Geography, Memorial University).

Eyles *et al.* (1983) described concentric zonation of land systems on a larger scale, observed in relation to the Laurentide ice sheet. Their model, however, showed thick drift at the margins, and mainly bedrock toward the centre. They demonstrated that the primary control on this zonation is bedrock geology, with the inner zone of little drift cover related to resistant crystalline bedrock of the Canadian Shield, and areal scouring by ice. Sugden and John (1976) outlined a zonation from scoured bedrock to streamlined landforms to disintegration and end moraines, based on examples from Ireland, North America, and Finland. Thus, the zonation seen in Newfoundland differs from the general models of landform distribution.

The distribution seen can be explained by a modification of the ideas of Jenness (1960), and is probably due to the superimposition of a later pattern onto one formed earlier. The general models of Sugden and John (1976) are based on deglaciation by progressive retreat of a single terrestrial ice margin. The pattern of erosion at the centre of the ice mass, and deposition at the margins may have existed at the maximum extent of the last glacial event, although it would have been modified by the presence of sea water at the margins of the ice sheet. It is likely that most sediment eroded by the ice sheet was deposited at the grounding line (the point at which the ice sheet is floated from its bed), as in the case in Greenland and Antarctica at present. In each area, the position of the grounding line varied through time, but generally would be seaward of the present coast, apart from on the Northern Peninsula. The extensive areas of Unit 8 (marine sediment) mapped on the northwest coast are mainly diamicton deposited in an ice-proximal glaciomarine environment, and have been exposed following major isostatic rebound. It is likely that similar thick deposits are presently submerged offshore of the remainder of the island. This hypothesis explains the absence of thick drift in Zone 4. If the ice sheet progressively retreated to the boundary between Zones 2 and 3, and then stagnated in place, the distribution of landforms can be explained.

Aerial photographic interpretation led Grant (1974c) to propose the existence of numerous independent ice caps during deglaciation. Striation mapping has to some extent supported this hypothesis (Vanderveer *et al.*, 1987; Brookes, 1989). It is clear that the final ice centres in Newfoundland stagnated in place, resulting in the formation of hummocky terrain. The source of this thick sediment cover is difficult to explain if these areas were solely zones of erosion. If the deposits seen, represented the marginal areas of several minor ice caps in existence during the final stages of deglaciation, then thick drift sequences might accumulate.

These hypotheses are highly speculative and await a greater knowledge of the offshore surficial geology, and deglaciation chronology.

IMPLICATIONS FOR USERS

Mineral Exploration and Drift Prospecting

Units 1 and 2 (exposed and concealed rock) generally have little sediment cover. This implies that results of soil sampling should reflect the bedrock directly underlying the site. Caution should be exercised when sampling in patches

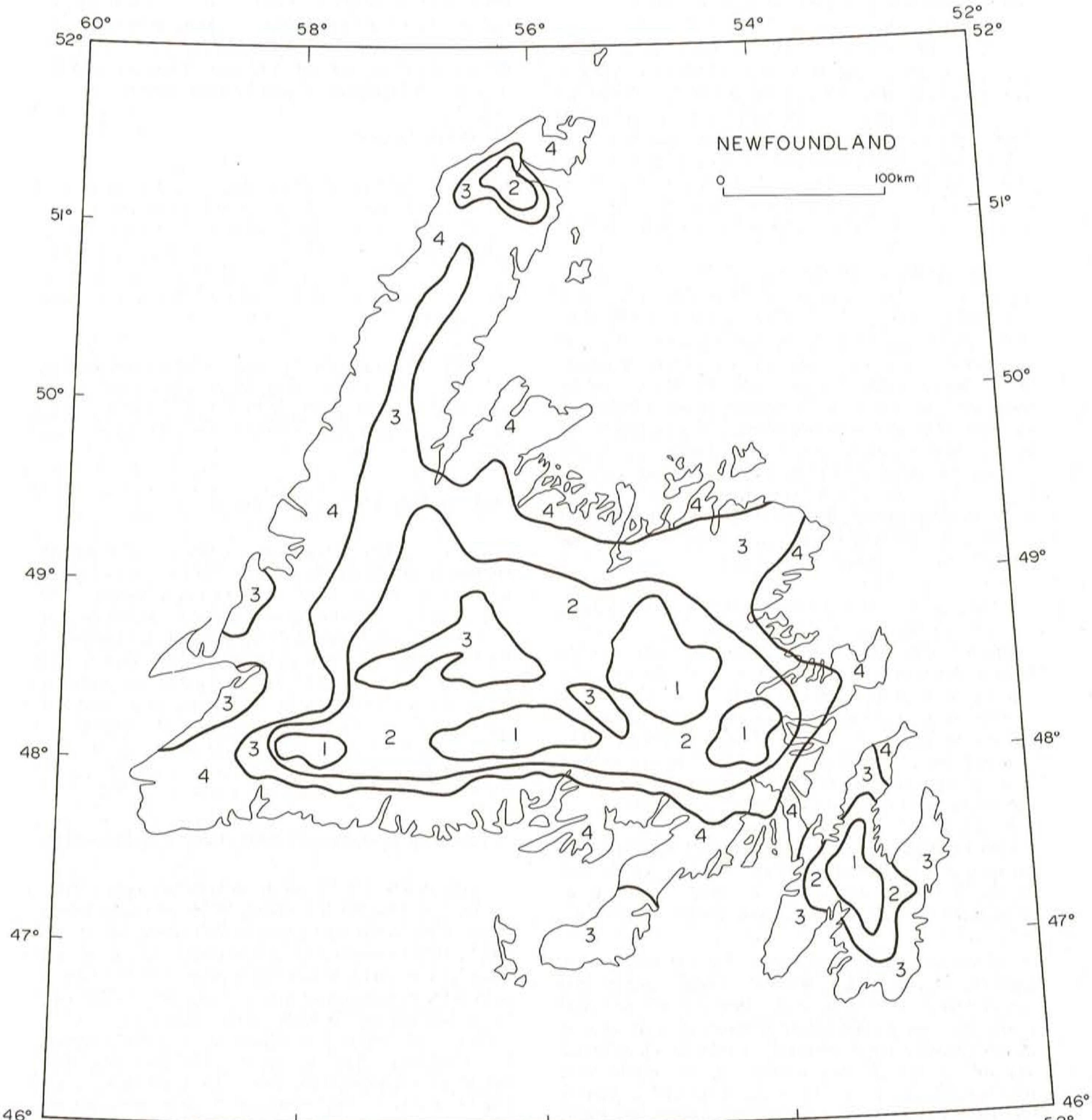

Figure 2. *Landform zonation apparent from surficial geology map of insular Newfoundland. Zone 1 consists mainly of Unit 5 (hummocky terrain); Zone 2 is a mixture of Units 4 (till blanket), 5 (hummocky terrain), 6 (ridged till) and 7 (glaciofluvial gravel and sand; mainly kames and eskers); Zone 3 consists of Unit 3 (till veneer), Unit 7 (glaciofluvial gravel and sand, mainly outwash) and Units 1 and 2 (bedrock); and Zone 4 is mainly Units 1 (exposed bedrock) and 8 (marine).*

of thicker drift cover, where the genesis of the sediment, and thus the associated dispersal pattern is variable.

Unit 3 (till veneer) should generally form a reliable sampling medium, and knowledge of regional ice-flow direction will be useful in interpreting results. It is not possible to generalize on transport distances for clasts given the few detailed studies in Newfoundland. The modification of Unit 4 by meltwater may complicate glacial dispersal by reworking of material downslope, particularly in channeled areas. In such cases, sediment dispersal will initially be by ice flow, but secondary dispersal downslope will occur by current flow.

The usefulness of Unit 5 (hummocky terrain) is dependent on the genesis of the individual sampled landform. If formed by topographic inversion (Gravenor and Kupsch, 1959), the source of sediment may be mainly material transported in englacial and supraglacial positions in the ice. Such material is generally not local, and reflects greater transport distances. If the landform is formed through moulding of basally deposited material as suggested by the ice-pressed drift hypothesis of Stalker (1960), or as Rogen moraine, then sediment will be dominantly locally derived. In some cases, detailed aerial photograph interpretation may suggest a likely genesis, but otherwise results from this unit should be treated with caution, and a number of possible dispersal models applied.

The genesis of Unit 6 (ridged till) is subject to debate, and this complicates interpretation of results. If these landforms originated by direct deposition from actively flowing ice, then provenance will be local, although it is possible to drape the landform surface with a veneer of supraglacially transported (and thus non-local) sediment. If formed through the action of subglacial meltwater, then dispersal patterns will vary according to the internal composition of the landform. If composed of diamicton, then it likely formed through remoulding of basal sediment, and will reflect local bedrock, and ice flow will be the main control on dispersal. If composed mainly of sand, then transport distances of sediment may be considerable, and current flow-direction, controls dispersal. In this case, sedimentary structures can be used as paleoflow indicators.

Dispersal in Unit 7 (glaciofluvial gravel and sand) is controlled by current flow, and will generally show greater transport distances than sediment dispersed by ice. Sediment composition will be based more on resistance to abrasion in transport than proximity to bedrock source. Results from this unit will be generally hard to interpret, but knowledge of paleoflow directions can be useful. Dispersal in Unit 8 (marine sediments) is controlled by marine processes, although the influence of marine reworking may be minor in some cases. Thus, knowledge of the local marine limit is important when sampling in coastal areas, as is the direction of longshore drift.

Direction of dispersal in Unit 9 (alluvium) is usually apparent, given that it is part of an active geomorphic system. The models developed in interpretation of stream and overbank sampling should be applied (Levinson, 1974; Ottensen *et al.*, 1989). Units 10 and 11 (colluvium and bog) will generally not be targets for sampling, although efforts can be made to penetrate bog in grid sampling. In such cases, the genesis of sampled sediment is unknown, and a variety of dispersal hypotheses should be considered.

Aggregate Resources

Unconsolidated aggregate can be found in Units 7 (glaciofluvial gravel and sand), 8 (marine sediments), and 9 (alluvium). The grain-size distribution is dependent on the environment of deposition. Ice-contact deposits are generally poorly sorted, whereas those sedimentary systems able to transport sediment further, will produce better sorted material.

Other significant surficial sediment resources are found in Unit 8 (marine sediments), where marine clays may provide material for brick-making; and Unit 11 (bog), which contains peat that can be used for fuel and agricultural purposes, and diatomaceous earth.

Hydrogeology and Waste Disposal

Units 7, 8 and 9, which contain mainly sand and gravel are porous and permeable. They are thus optimal sources of groundwater, and poor substrates for waste disposal of any sort. Units composed mainly of a blanket of diamicton (Units 4, 5, and 6) are less permeable, but generally contain enough sand to permit passage of groundwater. Thus, they are also poor sites for waste disposal, and moderate sources of groundwater. Unit 11 (bog) is a poor source of groundwater, but forms the source area for many surface streams, and should also be avoided when placing waste disposal sites. Other units are of variable suitablity for waste disposal (in bedrock), depending on jointing and fracture patterns.

Engineering Geology and Natural Hazards Prediction

Any area with a thick surficial sediment cover requires careful evaluation when designing slopes, but areas mainly composed of marine clays are particularly susceptible to slope failure. Unit 10 (colluvium) consists of debris resulting from slope failures, and thus areas on or adjacent to this unit are susceptible to mass movement. Areas of Unit 9 (alluvium) are periodically inundated by floods, and are poor sites for development. Parts of Unit 8 (marine) are actively forming (beach ridge complexes, bars, spits), and thus are potentially hazardous in extreme conditions. Such landforms are also important in protecting inland areas from storm conditions, and modification or removal of them could be hazardous.

FUTURE PLANS

1. Following review of the first draft, a final coloured map will be produced by Spring, 1990,
2. this map will be followed by further similar scale maps of geomorphological features, and ice-flow direction indicators, and

3. in the course of compilation, 1:250,000 maps were produced as an intermediate stage, and it is planned to issue these as open file releases in areas where no map of comparable scale exists.

ACKNOWLEDGMENTS

A project of this scope requires co-operation and assistance from many people. It would not have been possible without the excellent and extensive mapping of many individuals. In particular, the mapping of Doug Grant of the Geological Survey of Canada was used for almost the entire west coast, and we are grateful for his provision of pre-print copies of some maps. The mapping of Doug Vanderveer, Randy Ricketts, Jerry Ricketts, Byron Sparkes, and Fred Kirby of the Geological Survey Branch covered a major part of the island. Sharon Scott and Christine Blackwood are thanked for their cartography, and uncomplaining colouring beyond the call of duty. Martin Batterson and Norm Catto are thanked for their reviews of this manuscript.

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