GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

MEMOIR 404

QUATERNARY GEOLOGY OF SOMERSET ISLAND, DISTRICT OF FRANKLIN

ARTHUR S. DYKE

Canada

1983

CANADA
1842
GEOLOGICAL SURVEY - COMMISSION GÉOLOGIQUE

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Available in Canada through

authorized bookstore agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

and from

Geological Survey of Canada
601 Booth Street
Ottawa, Canada K1A 0E8

A deposit copy of this publication is also available
for reference in public libraries across Canada

Cat. No. M46-404E   Canada: $8.00
ISBN 0-660-11401-1   Other countries: $9.60

Price subject to change without notice

Critical Readers

W. Blake, Jr.

Original manuscript submitted: 11 - 03 - 1980
Approved for publication: 15 -05 - 1981

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Preface

Discovery of commercial hydrocarbon reserves and the opening of the first base metal mines in the Canadian Arctic Archipelago during the last decade have focused attention on the potential for economic development in the far North. Reconnaissance mapping of the bedrock geology of the Arctic by the Geological Survey of Canada in the 1950s and 1960s laid the foundation for resource exploration. As major commercial projects were proposed for the North, a need arose for an understanding of the surficial geology. In response to this need, the Geological Survey initiated several projects to map surficial materials over large areas of the Arctic.

This memoir is part of the reporting process for one of several projects started in the mid 1970s to map the terrain along a proposed gas pipeline route from the northwestern Arctic Islands to southern Canada. It describes the surficial material and geomorphic processes on Somerset Island and the potential impact of the surficial geology on future land use activities; it also details the Quaternary history of the island. Thus, the report reflects two main roles of Geological Survey of Canada – to provide geological information necessary in making rational land use decisions and to provide a framework for understanding the physical evolution of the Canadian landmass.

R.A. Price
Director General
Geological Survey of Canada

OTTAWA, June 1983

Préface

Le découverte de réserves d'hydrocarbures marchandes et l'ouverture des premières mines de métaux de base dans l'archipel de l'Arctique canadien au cours de la dernière décennie ont mis en lumière les possibilités de mise en valeur économique de l'Extrême-Nord. Les travaux de reconnaissance cartographique de la géologie de la roche en place, entrepris dans l'Arctique par la Commission géologique du Canada au cours de années 50 et 60, a posé les fondements des activités d'exploration des ressources. À mesure que d'importants projets de commercialisation des ressources du Nord étaient proposés, il devenait nécessaire d'acquérir une meilleure connaissance de la géologie de surface. Afin de répondre à ce besoin, la Commission géologique du Canada a mis en oeuvre quelques projets de cartographie des matériaux de surface couvrant de vastes régions de l'Arctique.

Le présent mémoire s'inscrit dans le cadre des activités qui ont pour but de rendre compte de l'état d'un des projets entrepris vers 1975 dans le but de dresser la carte du terrain occupant un corridor de gazoduc proposé, dont le parcours s'étirerait des îles du nord-ouest de l'Arctique jusqu'au sud du Canada. L'auteur du mémoire décrit les matériaux de surface et les processus géomorphiques de l'île Somerset, et l'effet possible que pourrait avoir la géologie de surface sur les activités éventuelles d'utilisation des terres; il raconte également en détail l'évolution de l'île au cours du Quaternaire. Ainsi, le document traduit deux des principaux rôles de la Commission géologique du Canada, soit de fournir l'information géologique nécessaire à la prise de décision logique en matière d'utilisation des terres, et de fournir un cadre qui contribuerait à la meilleure compréhension de l'évolution physique du territoire canadien.

R.A. Price
Directeur général
Commission géologique du Canada

OTTAWA, juin 1983

QUATERNARY GEOLOGY OF SOMERSET ISLAND, DISTRICT OF FRANKLIN

Abstract

Somerset Island was formed during a Late Cretaceous-Tertiary rifting episode associated with separation of Canada and Greenland. The Barrow Surface and anomalous canyons near the northeast coast are relict, prerifting landforms.

Surface materials are divided into eight genetic units. Rock and residuum cover 70 per cent of the island, till covers 20 per cent, and glaciofluvial, glaciolacustrine, fluvial, marine, and colluvial sediments cover the rest.

Gravel resources are small. Sand is more plentiful but is concentrated in a few large deposits. Riprap is widespread but thin.

Till and residual soils have low liquid limits and narrow ranges of plasticity. Massive ground ice is common in till more than 2 m thick. Thinner till and residual soils lack large bodies of massive ice, but natural moisture contents exceed liquid limits in the uppermost permafrost, especially at the till/rock interface. Marine and fluvial sediments have high ground ice contents in the upper 2 m or so of permafrost; natural moisture contents exceed the liquid limits of the silt and clay deposits. Slopes on till, residuum, colluvium, and on marine silt and clay are prone to instability during the spring snowmelt and active layer thaw period; instability could be induced later in the thaw season by wetting of slopes, thawing the upper ice-rich permafrost, or other active layer disturbances.

Prior to the last glacial episode, the island was covered by a regional ice sheet that left widely scattered erratics, and a lengthy period of bedrock weathering produced extensive colluvial and residual soils; however, the relative ages of these events is not known. "Old" driftwood in a glaciomarine delta above the Holocene marine limit indicates deglaciation and a high sea level stand prior to late Wisconsin time, and erratic shells of apparent middle Wisconsin age in till indicate that Peel Sound was free of glacier ice during the middle Wisconsin.

During the last glacial episode (late? Wisconsin), an eastward-flowing ice sheet inundated the southern and western parts of the island, while a local ice cap occupied the northeastern plateau; nunataks separated the ice masses in places. Recession from the north, east, and south coasts began about 9200 to 9300 radiocarbon years ago, and the west coast became ice free about 9100 to 9200 radiocarbon years ago. The pattern of coastal emergence during the Holocene reflects the isostatic dominance of the main eastward-flowing ice sheet; emergence continues today at rates of about 46 cm per century in the west and 28 cm per century in the east.

Neoglacial lowering of the snowline caused limited glacierization of areas 300 to 350 m a.s.l.

Résumé

L'île Somerset s'est formée pendant un épisode de formation de zones de fracture (rifts), au cours duquel se sont séparés le Groenland et le Canada. La surface de Barrow et les canyons anormaux que l'on rencontre près de la côte nord-est sont des formes topographiques résiduelles, antérieures à la période de formation des zones de fracture.

Les matériaux de surface sont divisés en huit unités génétiques. Les roches et débris recouvrent environ 70 pour cent de l'île, le till 20 pour cent, et les sédiments fluvioglaciaires, glaciolacustres, fluviatiles et marins le reste.

Les dépôts de graviers sont peu importants. Le sable est plus abondant, mais seulement en quelques endroits. La couverture pierreuse est étendue, mais peu épaisse.

Les tills et les sols résiduels ont une basse limite de liquidité et une étroite gamme de plasticité. Dans les dépôts de till de plus de 2 m d'épaisseur, il n'est pas rare de rencontrer de gros blocs de glace dans le sol. Les tills et sols résiduels plus fins ne contiennent pas d'importantes concentrations de glace massive, mais leur teneur naturelle en humidité dépasse les limites de liquidité au toit du pergélisol, surtout au contact entre le till et la roche. Les sédiments marins et fluviatiles ont une teneur élevée de glace dans le sol dans les 2 m supérieurs du pergélisol environ; et la teneur naturelle en humidité dépasse les limites de liquidité des dépôts de silt et d'argile. Les pentes formées sur les tills, les sols résiduels et les sols colluviaux, ainsi que sur les silts et argiles marins deviennent instables pendant la fonte des neiges au printemps et le dégel du mollisol; plus tard, pendant la saison de dégel, l'instabilité des pentes imprégnées d'eau augmente, à mesure que fond le pergélisol riche en glace, ou qu'apparaissent d'autres perturbations du mollisol.

Avant le dernier épisode glaciaire, l'île a été recouverte à l'échelle régionale par une nappe de glace qui a abandonné des matériaux erratiques sur une grande étendue; d'autre part, une période prolongée d'altération du soubassement a produit de vastes surfaces de sols colluviaux et résiduels; on ne connaît pas l'âge relatif de ces événements. Dans un delta glaciomarin, au-dessus de la limite marine holocène, la présence de bois de dérive "ancien" indique qu'avant la fin du Wisconsin, il y a eu déglaciation et que le niveau de la mer était élevé; d'autre part, des coquilles dispersées dans le till, qui apparemment datent du Wisconsin moyen, indiquent que le détroit de Peel était libre de glace de glacier au cours de cet épisode.

Pendant le dernier épisode glaciaire (Wisconsin supérieur?), une nappe glaciaire s'écoulant vers l'est a recouvert les parties sud et ouest de l'île, tandis qu'une calotte glaciaire locale a occupé le plateau nord-est; des nunataks séparaient par endroits les masses de glace. Il y a environ 9200 à 9300 ans, d'après la datation au radiocarbone, les glaces ont commencé à reculer sur les côtes nord, est et sud, et la côte ouest est devenue libre de glace il y a 9100 à 9200 ans. Pendant l'Holocène, l'émersion du littoral reflète l'effet isostatique dû à la présence de la nappe glaciaire s'écoulant vers l'est; aujourd'hui, le soulèvement du littoral se poursuit à la cadence de 46 cm par siècle à l'ouest et 28 cm par siècle à l'est.

L'abaissement néoglaciaire de la limite des neiges a provoqué une glaciation limitée des zones d'altitude supérieure à 300-350 m au-dessus du niveau de la mer.

INTRODUCTION

General

The impetus for this project, and several related projects, came from the need of the Canadian government for information on terrain conditions along a proposed gas pipeline route from the northwestern Arctic Islands to Ontario. The project area encompasses northeastern, District of Keewatin, Boothia Peninsula, and Somerset and Prince of Wales islands, but this report deals only with Somerset Island. The island lies between 71°57' and 74°11' N and 90°10' and 90°50' W (Fig. 1); its area is 24 700 km^2.

Two seasons of field work were done. The first, in 1975 was a helicopter reconnaissance survey of Quaternary sediments, landforms, and permafrost by Geological Survey of Canada personnel and simultaneous surveys of soils, plants, and streams by Canada Soil Survey[1], Canadian Forestry Service[2], and Glaciology Division[2] personnel. Preliminary maps of surficial materials and landforms (Netterville et al., 1976a) and reports on terrain types (Netterville et al., 1976b), weathered bedrock (Dyke, 1976), engineering characteristics of soils[3] (Veillette, 1976; Kurfurst and Veillette, 1977), plants and pedogenic soils[3] (Zoltai and Woo, 1976; Woo and Zoltai, 1977), and streams (Grey, 1976) were released soon after the field season. The author extended investigation of the glacial and sea level history and improved drift and permafrost sample coverage in 1977; some results are given in Dyke (1978a, b, 1979a).

The island was remapped by airphoto interpretation in 1979; that map (1555A) forms the core of this report. Eight broad genetic categories of surficial materials are recognized. Description of these along with laboratory data on texture and composition comprise the Surface Materials chapter. The Economic Geology chapter deals with geochemical analysis of drift samples for uranium and base metals as well as with land use considerations. The Quaternary History chapter deals with the history of glaciation and sea level.

Acknowledgments

The 1975 field party, led by the late J.A. Netterville, included R.D. Thomas, K.A. Drabinsky, J.J. Veillette, and myself. S.C. Zoltai, Canadian Forestry Service, and V. Woo, Canada-Manitoba Soil Survey, worked closely with us and helped in many ways. During the 1977 season I was assisted by R.G. Hélie and S.J. Black. Logistical support during both seasons was provided by Polar Continental Shelf Project, Energy, Mines and Resources Canada. Critical reading by Drs. W. Blake, Jr. and R.J. Fulton lead to substantial improvements in the text.

Topography

Most of the surface of Somerset Island is a plateau between 250 and 500 m a.s.l. The highest point on the island is little more than 500 m a.s.l. and large tracts of land fall between 250 and 300 m a.s.l. A spectacular cliff forms the east coast of the island north of Creswell Bay and canyons, more than 100 m deep, cross the central and northeast part of the island. Fiord-like valleys occur north of Bellot Strait, along the west coast.

Climate

Weather records were kept at Fort Ross, on the southeast tip of the island, during its period of operation between 1938 and 1950. The climate of the northern half of the island, however, is probably better described by the data from Resolute Bay on the south coast of adjacent Cornwallis Island. Both sets of data (Table 1) describe long, cold, dry winters and brief, cool, damp summers. Taylor (1977) provides more detailed information on the summer climate of Cunningham Inlet, on the north coast of Somerset Island.

Vegetation and Soils

Woo and Zoltai (1977) have divided Somerset Island into ecological regions and districts (Fig. 2). The High Arctic region has less vegetation and less soil profile development than the Mid-Arctic region. The carbonate bedrock areas in the High Arctic (H1a, H1b, Fig. 2) have polar desert vegetation that provides about 1 per cent ground cover and soils that exhibit little or no profile development (regosolic turbic cryosols). Areas underlain by gneiss (H2) have vegetation ground covers ranging from 10 to 90 per cent, with vegetation communities more or less evenly split between polar desert, crustose lichens, dwarf shrubs, and sedge meadows; little or no soil profile development has occurred under the first two vegetation types but brunisols and gleysols (brunisolic and gleysolic turbic cryosols) occur under the last two. A small area underlain by Eureka Sound sandstone (H3) supports an oasis of dwarf shrubs and sedge meadows growing on brunisols and gleysols, respectively.

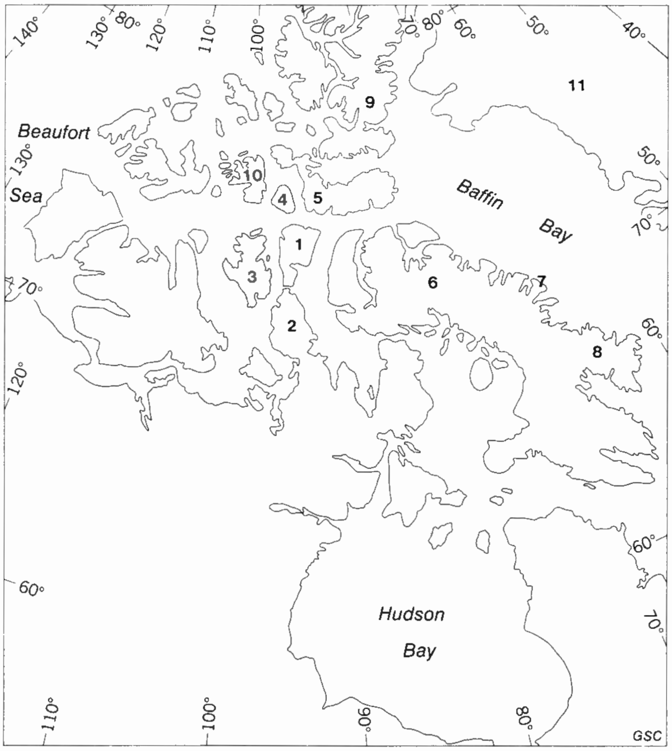

Figure 1. *Location of the study area and other places referred to in the text. (1) Somerset Island, (2) Boothia Peninsula, (3) Prince of Wales Island, (4) Cornwallis Island, (5) Devon Island, (6) Baffin Island, (7) Clyde Foreland, (8) Cumberland Peninsula, (9) Ellesmere Island, (10) Bathurst Island, (11) Greenland.*

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[1] Department of Agriculture

[2] Department of Environment

[3] In this report the term soil is used in both the pedological sense (Introduction) and the engineering sense (subsequent sections).

Table 1. Climatic data for Resolute, Cornwallis Island, and Fort Ross, Somerset Island

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Range
Average monthly and annual daily mean temperatures (°C)															
Resolute[1]		-33	-34	-31	-23	-11	0	4	3	-5	-15	-24	-29	-16	38
Fort Ross[2]		-29	-32	-26	-22	- 9	0	4	2	-4	-12	-22	-26	-15	36
Average monthly and annual precipitation															
Resolute[1]	Rainfall (mm)	0.0	0.0	0.0	0.0	T	5.8	23.4	25.7	3.8	T	0.0	0.0	58.7	-
	Snowfall (cm)	2.8	3.3	3.3	5.8	8.9	6.6	3.0	4.8	14.2	15.5	5.6	4.8	78.6	-
Fort Ross[2]	Rainfall (mm)	0.0	0.0	0.0	0.0	2.6	12.5	21.8	35.0	0.0	0.0	0.0	0.0	69.0	-
	Snowfall (cm)	17.0	7.6	20.0	8.4	11.2	23.5	1.0	1.5	29.2	31.2	23.0	8.2	160.0	-

[1] Atmospheric Environment Service (1975)
[2] Rae (1951)

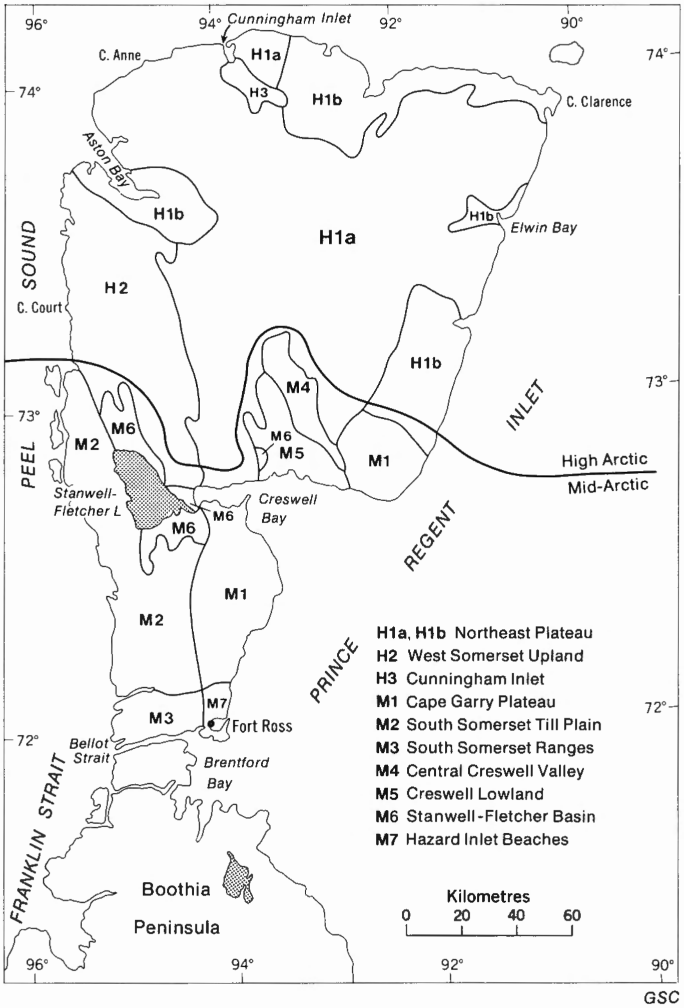


Figure 2. Ecological districts of Somerset Island and the location of the High Arctic/Mid-Arctic boundary (from Woo and Zoltai, 1977, p. 23).

In the Mid-Arctic ecoregion, vegetation ground cover ranges from 10 to 100 per cent. Crustose lichens provide about 30 per cent cover on granite and gneiss, dwarf shrubs cover 40 to 70 per cent of tills, and sedge meadows provide nearly complete cover on poorly drained sites such as seepage slopes on tills and marine silts in topographic depressions. Brunisols occur under the shrub communities and gleysols under the sedge meadows.

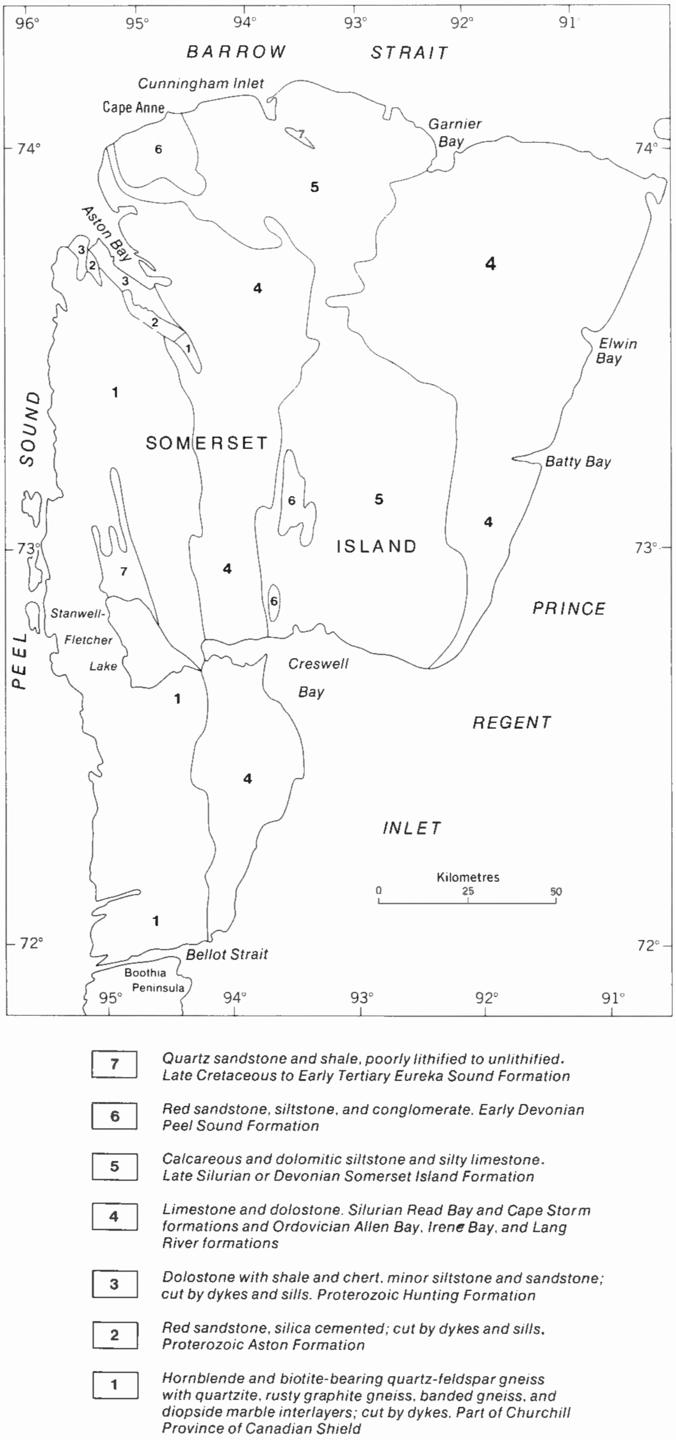
Bedrock Lithology

The bedrock of Somerset Island ranges in age from Precambrian to Early Tertiary (Fig. 3). Western Somerset Island is underlain by a northern projection of crystalline Canadian Shield and its composition is typical of vast stretches of the Shield. The northern tip of the crystalline rock is overlain by red quartzitic sandstone of the Aston Formation. The sandstone is conformably overlain by dolostone with shale, chert, siltsone, and sandstone of the Hunting Formation. The Hunting and Aston formations and older crystalline rocks are cut by numerous diabase dykes and sills of late Precambrian age. The Hunting Formation is overlain by limestone and dolostone of the Lang River, Irene Bay, Allen Bay, Cape Storm, and Read Bay formations, which are continental shelf deposits. The Somerset Island Formation is richer than older rocks in fine grained clastic material which was deposited in intertidal and supratidal environments during a major regression. These rocks pass successively upwards into deltaic siltstone, sandstone, alluvial sandstone, and conglomerate of the Peel Sound Formation. The conglomerate contains clasts of both the underlying carbonate and crystalline bedrock.

No rocks are known from the time interval Early Devonian to Late Cretaceous. A tiny faulted outlier of shale and limestone near Creswell Bay, correlative with the Kanguk Formation of more northerly and westerly islands, represents marine conditions during late Cretaceous time (Dixon et al., 1973). Latest Cretaceous or Early Tertiary fluvial quartz sands are preserved near Stanwell-Fletcher Lake (Dineley and Rust, 1968) and Cunningham Inlet (Hopkins, 1971).

Tectonic History

The tectonic history of Somerset Island is largely the story of the Boothia Uplift (Kerr, 1977). In the study area the Boothia Uplift consists of the Boothia Horst, which is the crystalline rock of the Shield, and the Cornwallis Fold Belt, represented by eastward-dipping strata flanking the crystalline rocks. East of the fold belt the Paleozoic strata of the Jones-Lancaster Basin are nearly horizontal. The Boothia Horst was uplifted, causing folding of the overlying strata in six phases between Precambrian and Upper Devonian time. The major uplift on Somerset Island caused the regression recorded in the Somerset Island Formation. Subsequent fluvial erosion of the emergent basement and flanking strata produced the detritus contained in the Peel Sound Formation. The area remained emergent until Late Cretaceous time.



Modified from Tuke et al. (1966), Blackadar (1967), Dineley and Rust (1968), Hopkins (1971), Miall et al. (1978). GSC

Figure 3. *Major bedrock lithologies of Somerset Island.*

Much of the topographic grain of the Shield and the Cornwallis Fold Belt is controlled by structures produced during uplift of the Boothia Horst. Most major geographic elements of the central Arctic Islands, however, were produced during the Late Cretaceous-Tertiary Eurekian Rifting Episode (Dinely and Rust, 1968; Brown et al., 1969; Daae and Rutgers, 1975; Kerr and deVries, 1977). Kerr and deVries (1977) proposed that Somerset Island is nearly surrounded by normal faults along which the island was uplifted during the Tertiary, particularly in middle to late Tertiary time (Kerr, 1980), and that the adjacent straits – Peel Sound, Barrow Strait (part of Parry Channel), and Prince Regent Inlet – are grabens (rift valleys). Formation of smaller grabens on land at this time preserved the Eureka Sound sediments near Cunningham Inlet and Stanwell-Fletcher Lake. The block faulting of the Eurekian Rifting Episode that produced the islands and straits was a consequence of the rifting of Canada from Greenland and subsequent seafloor spreading (Daae and Rutgers, 1975).

Pre-Quaternary Landforms

Most of the surface of Somerset Island is a fragment of the Barrow Surface, one of the major surfaces of erosional planation in Arctic Canada (Bird, 1959, 1967). It cuts across nearly flat-lying sediment of the Jones-Lancaster Basin, the

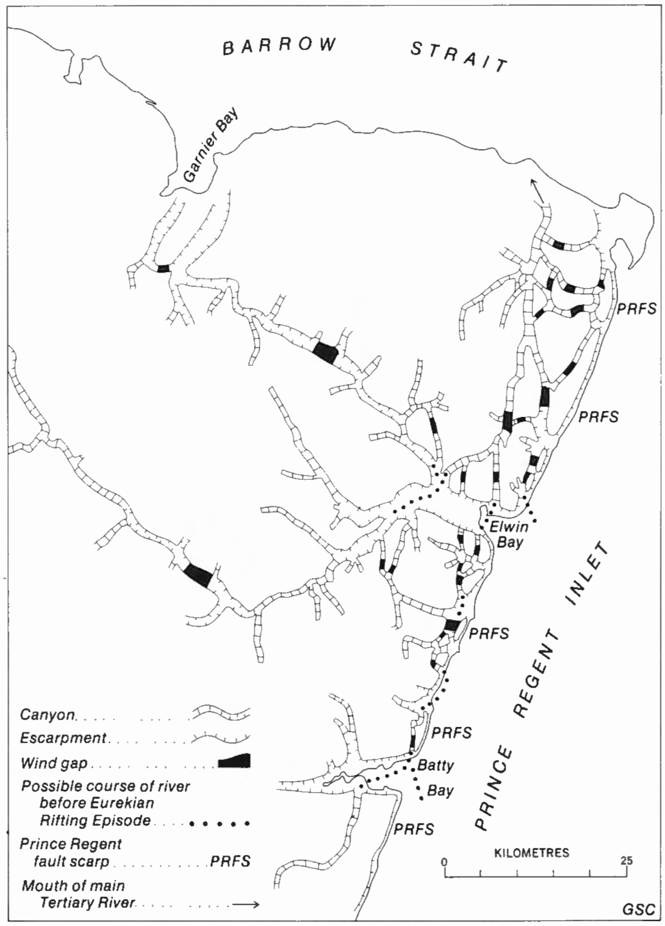


Figure 4. *Anomalous canyons on northeastern Somerset Island possibly representing a Tertiary drainage system beheaded by the Prince Regent fault scarp and the Elwin Bay side graben during the Eurekian Rifting Episode (Late Cretaceous to Late Tertiary).*

steeply dipping rocks of the Cornwallis Fold Belt, and the crystalline shield of the Boothia Horst without significant change in elevation. Parts of the same surface occur at roughly the same elevation in eastern Prince of Wales Island, Boothia Peninsula, northwestern Baffin Island, and Devon Island. This implies that the erosion surface was formed while these areas were part of a contiguous landmass prior to formation of the straits. Hence, the erosion surface predates the Eurekian Rifting Episode.

Smaller elements of the landscape probably also predate the Eurekian Rifting Episode. Northeastern Somerset Island is crossed by canyons incised more than 100 m into bedrock. Some canyons show classic symptoms of stream capture such as wind gaps and underfit streams (Fig. 4). Four short, but nevertheless deep canyons are truncated at both ends by the straight cliff bordering Prince Regent Inlet, almost certainly a fault scarp, and two canyons are apparently interrupted by the cliff-bound valley, possibly a small side graben, leading into Elwin Bay. Craig (1964) interpreted these anomalous canyons as subglacial meltwater channels, but it is also possible that they are part of a Tertiary drainage basin that was beheaded by downdropping of the Prince Regent graben. If so, it may be possible to find the upstream and eastern parts of this basin by detailed bathymetric mapping or acoustic profiling of nearby Prince Regent Inlet, assuming that the canyons have not been eroded by glacier ice. That the canyons are preserved seems likely in light of the finding of well preserved river valleys on the floor of Barrow Strait (Bornhold et al., 1976).

The presence of drowned fluvial features in the inter-island channels does not necessarily support the hypothesis of Fortier and Morley (1956) that the channels were formed by Tertiary fluvial erosion, as they can be accounted for by the tectonic history sketched above. The preservation of the ancient fluvial features in the channels, and possibly on the islands, testifies to the minor role played by the Quaternary glaciers in forming the larger elements of the present landscape

SURFACE MATERIALS

Map 1555A shows the distribution of eight genetic types of surface materials. They are discussed below in the order in which they appear in the legend, that is, in order of relative age. However, the significance of the materials to interpretation of Quaternary history is reserved for the Quaternary History chapter.

In most of the map area the geological boundaries can be recognized easily on airphotos, except for in a few areas where the quality of aerial photographs is poor.

With the exception of a thin active layer, all surface materials are perennially frozen. Active layer thickness was measured at about 200 sites, mostly in till and diamictic residuum. Measurements of thickness cluster around 50 to 60 cm and range from 35 to 90 cm. Although coarser grained materials tend to develop deeper active layers, depth of thaw is more closely related to site drainage conditions and vegetation cover than to type of material; shallow thaw occurs in wet meadows and deeper thaw in well drained bare soils.

Rock (Unit R)[1] and Residuum (Unit 1)[1]

Rock and weathered rock (residuum), which collectively cover about 70 per cent of the island, are distinguished from each other on the basis of extent of weathering and morphology and are subdivided on the basis of lithology. Large areas underlain by both crystalline Precambrian Shield and Paleozoic sedimentary bedrock show no signs of glacial erosion (units 1a, 1b); they have well integrated drainage systems with no lakes or ponds, but small patches of till and a few glacial erratic boulders occur among the weathered rock debris. Elsewhere bedrock everywhere showns signs of glacial scouring (units Ra, Rb, Rc). Each rock and weathered rock terrain has a distinctive suite of landforms and materials that distinguishes it from the others (Table 2).

In the weathered gneiss terrain, bedrock outcrops only in tors (Fig. 5,) and cryoplanation terrace escarpments (Fig. 6) – the dominant and diagnostic features of the area (Dyke, 1976). Many escarpments are aligned parallel to major joint systems, most obviously a north-south system that has developed along the foliation trend. Hence, they are structurally controlled landforms. Tors are left standing on the cryoplanation terrace treads as isolated rock knobs after upslope retreat of the escarpments. Both tors and escarpments are outlined by late lasting snowbanks, which suggests that nivation plays a prominent role in their formation (cf. Reger, 1975).

The tors and escarpments are surrounded by blockfields and grus. The grus, formed by weathering, primarily by granular disintegration, of the blocks is a gravelly sand or gravelly muddy sand (Fig. 7A). Cryoturbation has arranged this mixture into sorted circles and nets (mudboils) even where fine grained material constitutes only 5 to 10 per cent of the surface, as is commonly the case. Despite the apparent mobility of the active layer materials, however, downslope movement has been insufficient to cause much mixing of blocks from adjacent compositional bands, for the composition and structure of the bedrock is repeated in the felsenmeer. Considerable downslope movevent of fine sediment must have occurred, however, because extensive sheets of colluvium mantle lower slopes and valley floors (unit 7a).

The weathered Peel Sound conglomerate and sandstone terrain north of Aston Bay also has tors and well developed nivation features (Fig. 8); however, here, nivation has produced nivation hollows and small cirques rather than cryoplanation terraces. This reveals an interesting difference in the response of different lithologies to the same process. The failure of nivation to produce cryoplanation terraces on the sandstone and conglomerate probably results from the lack of a well developed network of joints and fractures in these rocks.

Exposures of little-weathered Peel Sound conglomerate and sandstone are not extensive except in nivation hollows, cirques, and gully walls. Elsewhere, the conglomerate is mantled by gravel, produced by weathering out of the matrix, and the sandstone is mantled with platy felsenmeer and sand. Ice wedges have formed in the gravel.

Figure 5. *Tor surrounded by blockfield in the weathered gneiss terrain (unit 1a) near headwaters of Hunting River south of Aston Bay. Sides and top of tor are joint controlled. GSC 203014-E*

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[1] Unit designators on Map 1555A.

Table 2. Landforms and materials of the bedrock terrains

Map unit	Name	Landforms	Sediments	Drainage network
1a	Weathered gneiss	Smooth, low-angle slopes interrupted by 1 to 5m-high, joint controlled cyroplanation terrace escarpments and tors.	More than 95% cover of blocks (60-90%) with interstitial grus, about 1 m thick. Composition and structure of bedrock reproduced in felsenmeer.	Integrated
Ra	Glacially scoured gneiss	Rugged areas, up to 200 m local relief, with numerous bedrock basin lakes and ponds; fiord-like valleys, large escarpments and depressional lineaments along plains of structural weakness; crag-and tails; roches moutonnées, striae; subglacial and lateral meltwater channels.	Numerous patches of till in structurally controlled depressions, erratic boulders; otherwise bare rocks.	Deranged
1b	Weathered Paleozoic sedimentary bedrock	On Peel Sound Formation, north of Aston Bay: tors and nivation hollows; elsewhere: smooth, low angle, upper valleyside slopes and summits interrupted in few places by particularly resistant beds; numerous lateral meltwater channels.	Gravel over conglomerate; on other rocks, more than 95% cover of felsenmeer and silty, sandy rubble about 1 m thick. Colour, composition, and structure of bedrock reproduced in felsenmeer and rubble.	Integrated; many canyons
Rb	Glacially scoured sedimentary bedrock	Craggy to hummocky surface with numerous bedrock basin lakes and ponds; escarpments; large ice-moulded bedrock forms in few places, striae on recently exhumed surfaces; subglacial and lateral meltwater channels.	Numerous patches of till, but most bedrock covered by felsenemeer or silty sandy rubble, 1 m or less thick; commonly mixed wtih erratics and minor till.	Deranged
Rc	Glacially scoured Cretaceous Tertiary sandstone	Small rounded or gullied hills.	Few erratics or patches of marine sediment; elsewhere, quartz sand (unlithified bedrock).	N/A

Figure 6A. Oblique aerial view from about 100 m above ground of cryoplanation terraces in the weathered gneiss terrain (unit 1a) south of Aston Bay. One to two metre-high escarpments occur at the junction of light- and dark-toned areas. Dark-toned areas are higher and lichen-covered whereas light-toned areas are nearly lichen-free because of late lasting snow cover. Linear snowbanks line escarpments in the lower left and upper right in this late summer view. GSC 203507-F

Figure 6B. Ground view of cryoplanation terrace escarpments (lined by snowbanks), low tors (vertical arrows), and felsenmeer-covered cryoplanation terrace tread (oblique arrows) in the weathered gneiss terrain east of Fiona Lake. GSC 203014-J

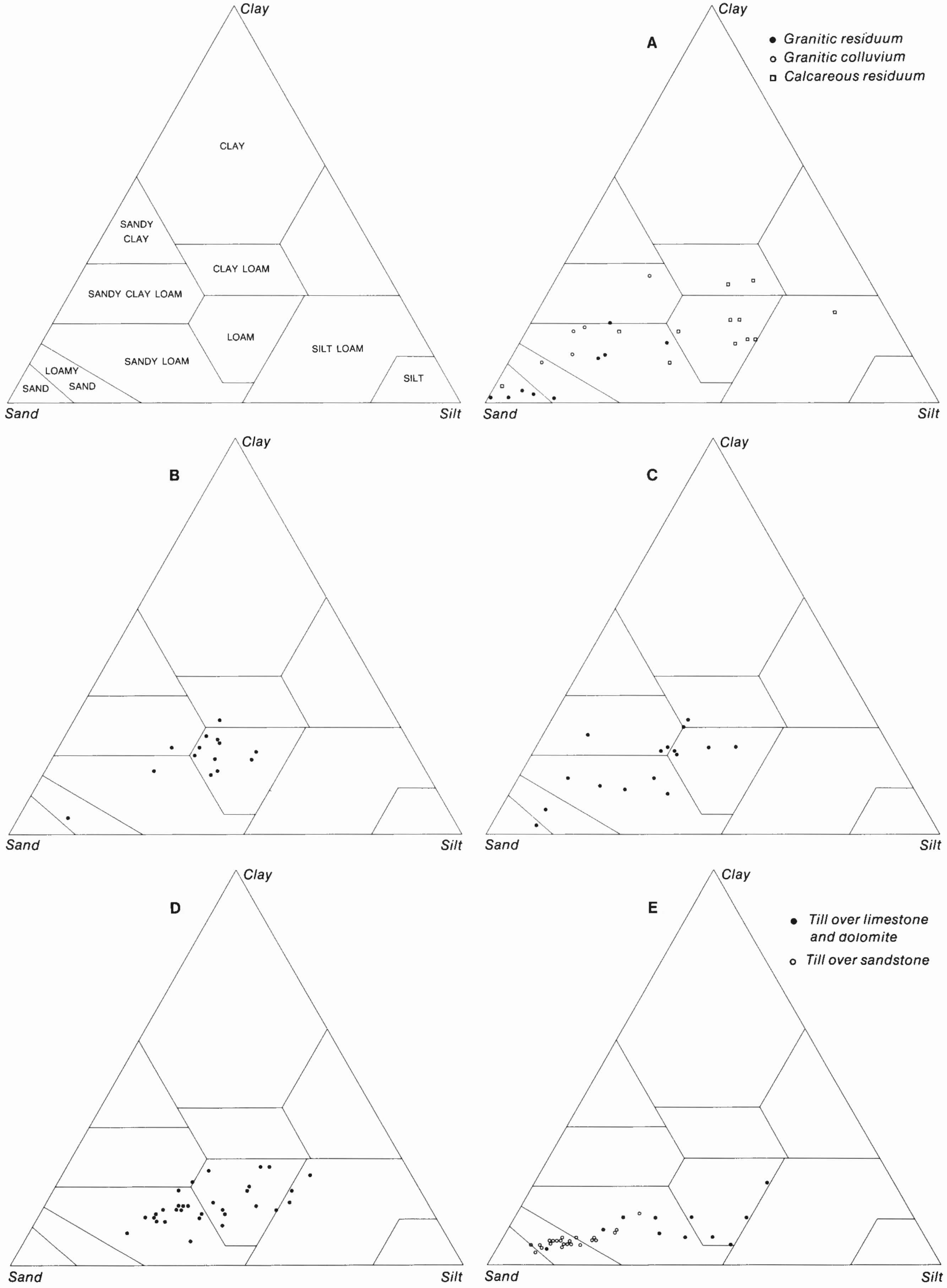

Figure 7. *Textural characteristics of diamictic residual soils and tills on Somerset Island. (A) granitic residuum, calcareous residuum, and colluvium derived from granitic residuum; (B) till blanket; (C) till veneer over crystalline shield rock; (D) well vegetated till veneer over sedimentary rock; (E) unvegetated or poorly vegetated till veneer over sedimentary bedrock.*

Figure 8. *Tors composed of crossbedded sandstone (foreground and middle ground) and nivation hollows with firn banks (background) eroded in conglomerate. Both rock types belong to Peel Sound Formation of northwestern Somerset Island. GSC 203508-E*

Figure 9. *Platy limestone felsenmeer near the middle reach of Cunningham River, north-central Somerset Island. GSC 203478-K*

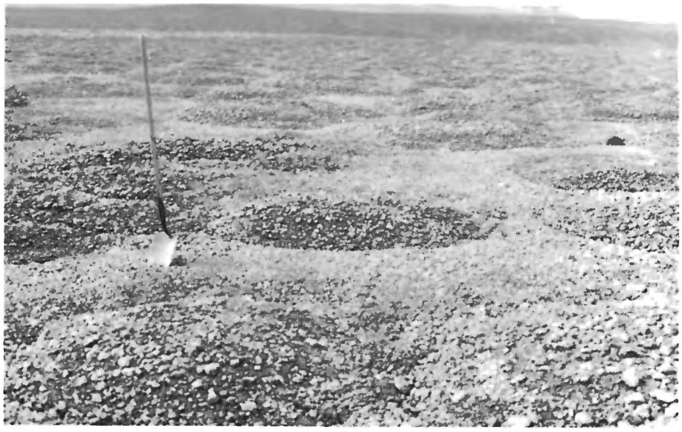

Figure 10. *Stony loam (calcareous residuum) near Cunningham River, north-central Somerset Island. Surface has been patterned into high-centre mudboils (nonsorted circles) by cryoturbation. GSC 203478-W*

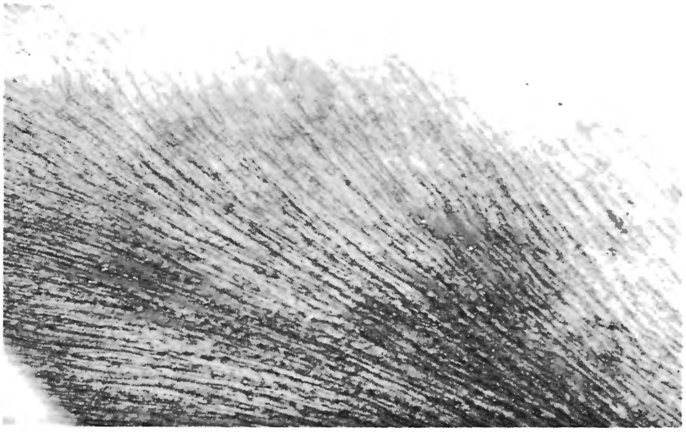

Figure 11. *Oblique aerial view of solifluction stripes outlined by vegetation (narrow dark stripes) on calcareous residuum mantling a gentle slope near Cunningham River, north-central Somerset Island. GSC 203508-K*

In the weathered carbonate bedrock terrain (unit 1b), which dominates the north-central and northeast part of the island, solid bedrock outcrops only in canyon walls and in small cuestas which interrupt otherwise smooth, gentle slopes. Elsewhere, the bedrock has weathered to platy felsenmeer (Fig. 9) or more commonly to a stony loam (Fig. 10), texturally similar to till on the same rock type (Fig. 7a, 7e).

Despite the textural similarity to till, the sediments have been mapped as residual soils formed by weathering because the colour, composition, and structure of the underlying bedrock is repeated in them in considerable detail. The surface of the diamictic residuum has been patterned by cryoturbation and solifluction into a dense, interlocking network of unsorted to poorly sorted circles and nets on level and nearly level ground (Fig. 10) and into stripes on slopes (Fig. 11). Large amounts of fine grained material have moved downslope to produce extensive sheets of colluvium on lower slopes and valley floors (unit 7b).

In contrast to these weathered bedrock terrains with their integrated drainage systems, smooth graded slopes, and nivation landforms, the glacially scoured bedrock terrains have deranged drainage systems with numerous lakes and ponds, rugged hilly to hummocky topography with numerous cliffs, and streamlined glacial erosional forms such as roches moutonnées, crag-and-tail hills, and striae. In the scoured crystalline shield most of the surface consists of nearly unweathered bedrock in contrast to the felsenmeer and grus of the weathered shield. The glacially scoured carbonate bedrock surface, however, is less easy to distinguish from the weathered carbonate bedrock surface because most of the former is mantled by a mixture of felsenmeer and minor till and the latter is mantled by till-like residuum. For that reason, the scoured carbonate bedrock is identified mainly on the basis of its hummocky and basined surface.

Till (Unit 2)

Thickness

Till, which covers about 20 per cent of the island, is mapped as two units: veneer and blanket. Till blankets are more than about 2 m thick (unit 2a); they completely obscure the form, composition, and structure of the underlying bedrock, but in most places the bedrock lithology can be seen in nearby outcrops. Till veneers are 1 to 2 m thick, in most places not thick enough to completely mask the form of the underlying bedrock surface. Hence, blankets and veneers are differentiated on the basis of the extent to which local bedrock relief is muted or obscured.

Vegetation Cover

Well vegetated tills (50 per cent or more ground cover) produce dark tones on airphotos, whereas poorly vegetated and unvegetated tills (less than about 5 per cent ground cover) produce light tones. Till blankets on all types of bedrock and till veneers on gneiss and granite are well vegetated, except in areas of particularly rapid solifluction and areas of recently melted snowbanks. However, both a well vegetated and a poorly vegetated variety of till veneer occurs on the Paleozoic sedimentary bedrock. The mutual boundaries of these two veneers are abrupt and generally easy to trace on airphotos, which suggests that the veneers were deposited at different times and that they have different provenances. The boundary between poorly vegetated till and glacially scoured Paleozoic bedrock (unit Rb), weathered Paleozoic bedrock (unit 1b), or colluvium derived from weathered Paleozoic bedrock (unit 7b) is more difficult to locate because the latter three materials are poorly vegetated or bare; hence, all four materials have the same tone on aerial photographs.

Texture

Tills overlying such diverse rock types and with such different abilities to support vegetation could be expected to differ substantially in texture; however, this is not borne out by textural analyses of the matrix (Fig. 7). Well vegetated till blankets (unit 2a) are loams or sandy loams as are vegetated till veneers on the Precambrian shield (unit 2b1) and vegetated till veneers on Paleozoic carbonate bedrock (unit 2b1). The latter till is apparently slightly more silty in some places than are the other vegetated tills, but the bulk of the samples are texturally identical to those from the other tills.

Poorly vegetated till veneers that overlie carbonate bedrock occupy the same textural class as vegetated tills on the same rock type, although some samples contained slightly less clay. The unvegetated till veneer that overlies the sandstone and conglomerate of the Peel Sound Formation near the northwest corner of the island is most distinctive texturally of the the various tills; its matrix is loamy sand to sand. More detailed textural analyses of the less than 4 mm fraction (Fig. 12) show that all tills have bimodal grain-size distributions with one mode in the granule class and the second mode in the fine sand or coarse silt class. The poorly vegetated till veneer over carbonate bedrock is more gravelly and stony than the others, but it is doubtful that the greater abundance of coarse material accounts for the paucity of vegetation.

Carbonate Content

The carbonate contents of the >2 mm fractions of samples from all types of till vary considerably (Fig. 13). The thicker tills have 10 to 50 per cent of their matrix as carbonate, compared to 0 to 50 per cent for till veneers over Precambrian Shield, 10 to 70 per cent for vegetated till

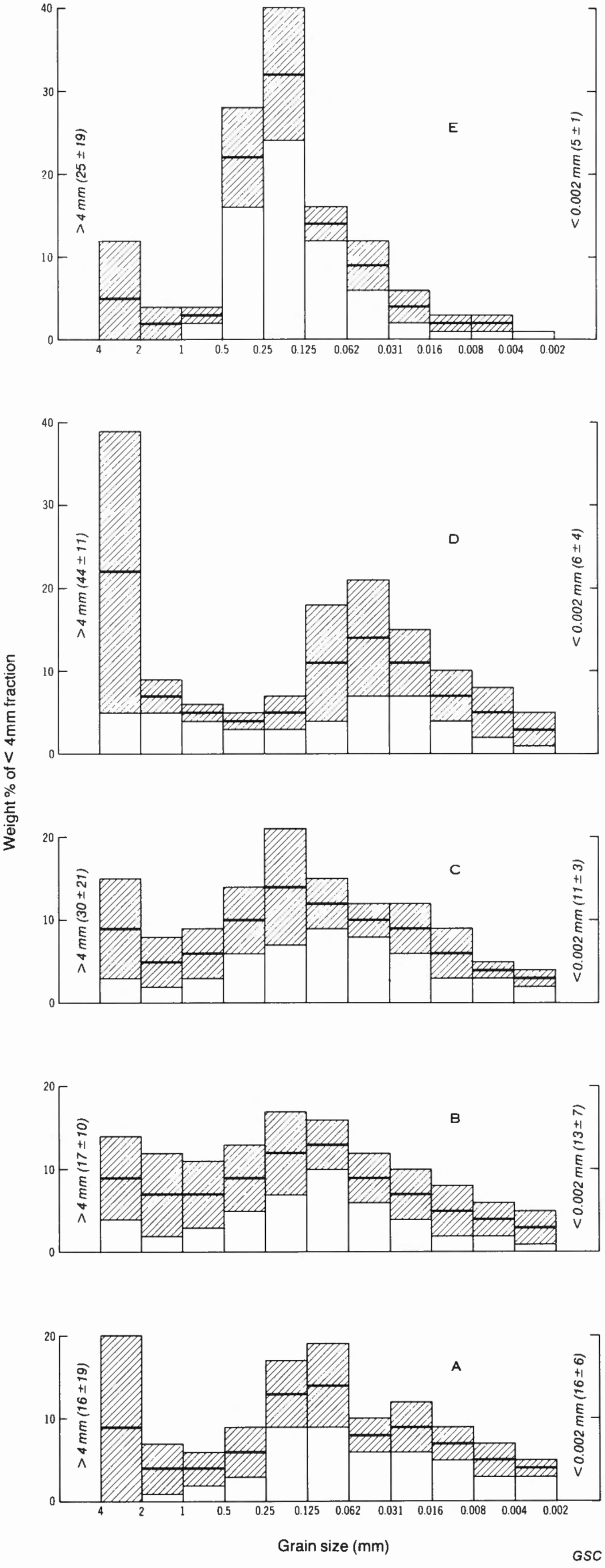

Figure 12

Detailed grain size distribution in tills on Somerset Island. Variability of samples for each till type is indicated by the mean (heavy horizontal line) and standard deviation (diagonally ruled areas) for each grain size class. (A) till blanket, 15 samples; (B) till veneer over crystalline shield rock, 13 samples; (C) well vegetated till veneer over sedimentary bedrock, 25 samples; (D) unvegetated or poorly vegetated till veneer over carbonate bedrock, 5 samples; (E) unvegetated or poorly vegetated till veneer over sandstone bedrock, 28 samples.

veneers over Paleozoic carbonate bedrock, and 0 to 90 per cent for poorly vegetated till veneers over Paleozoic bedrock. It does not, therefore, seem to be just the high carbonate content of the soil that prevents a more substantial vegetation growth on the poorly vegetated till veneer.

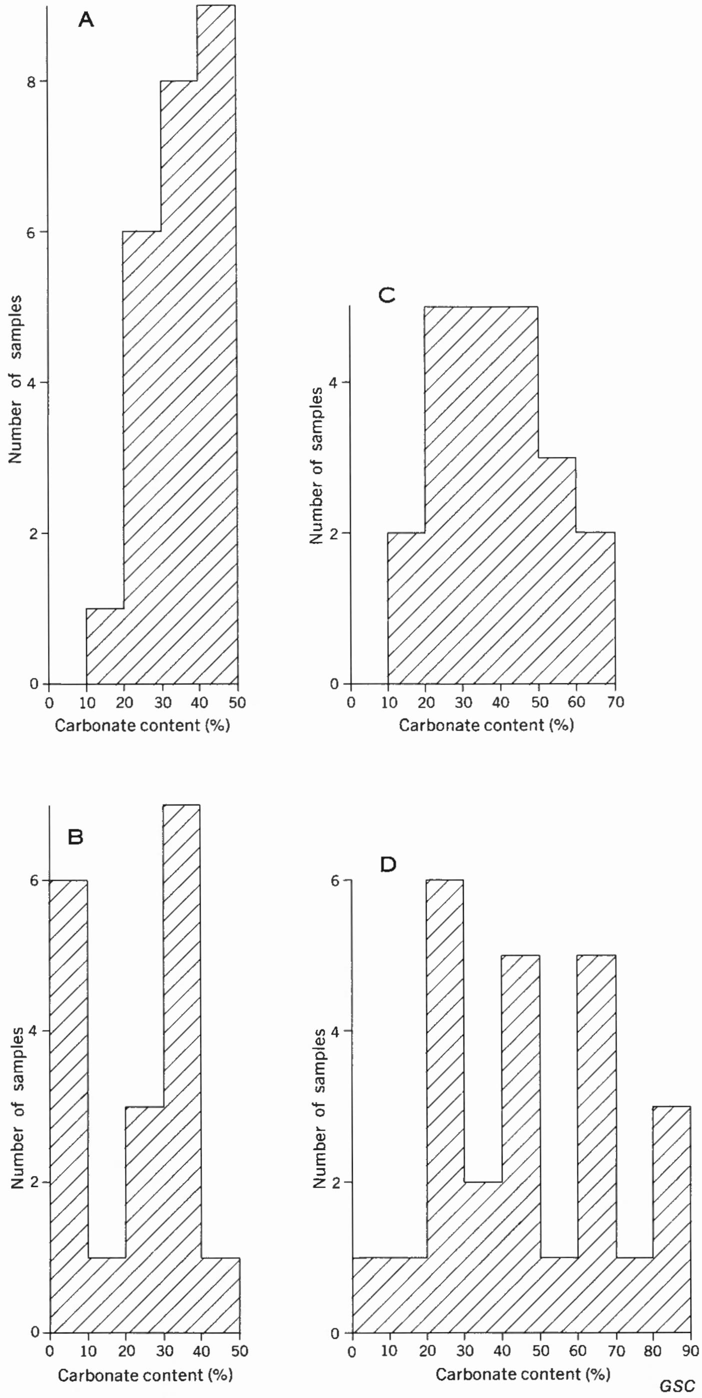

Figure 13. *Total carbonate contents of matrix of various tills on Somerset Island. (A) till blanket; (B) till veneer over crystalline shield rock; (C) well vegetated till veneer over sedimentary rock; (D) unvegetated or poorly vegetated till veneer over sedimentary rock.*

Explanation of Vegetation Contrasts

Where ice flowed from the crystalline shield onto carbonate bedrock, as it did south of Creswell Bay (Dyke, 1978a), the till veneer that overlies the carbonate bedrock is well vegetated. This suggests that the nutrients that support plant growth are provided by shield-derived materials, potassium produced by weathering of feldspar, for example. Conversely, the poorly vegetated till veneers have little or no shield-derived material.

Patterned Ground

Both till veneers have the same suite of patterned ground features: unsorted to poorly sorted mudboils on gentle slopes and level ground and solifluction stripes and lobes on slopes. The till blanket has a nearly continuous network of large, rectangular, high-centre ice-wedge polygons as well as nearly ubiquitous mudboils (Fig. 14). In fact, the polygons are helpful in delineating the extent of the thicker till. The widespread distribution of ice-wedge polygons on thick till and scarcity on thin till indicates that ice wedges are unable to form in this area in sediments less than about 2 m thick.

Glaciofluvial Sediments (Unit 3)

Three types of glaciofluvial sediments, composed of gravel and sand, cover areas large enough to depict on the surficial geology map (Map 1555A). Two kame moraines occur on the southern peninsula of the island; the largest, near the eastern end of Bellot Strait, is about 100 m high, and the other, south of Lang River (Fig. 15), is about 30 m high. Several small conical moulin kames, about 5 m high, occur within 10 km of the southern shore of Stanwell-Fletcher Lake, between Stanwell-Fletcher Lake and Fiona Lake, just north of Fiona Lake, midway between Fiona Lake and Aston Bay, and 10 km north of the head of Creswell Bay.

Small eskers, about 5 m high and 1 to 2 km long, occur west of Stanwell-Fletcher Lake, west of Fiona Lake, near the south shore of Aston Bay (Fig. 16), south of Cunningham Inlet, and west of Garnier Bay.

Proglacial outwash occurs in association with meltwater channels in several small pockets south of Stanwell-Fletcher Lake and in larger sheets, about 2 to 3 m thick, northeast of Stanwell-Fletcher Lake (Fig. 17) and north of the head of Creswell Bay. These deposits are composed mostly of coarse gravel, commonly boulder gravel.

The surfaces of almost all gravel and sand deposits exhibit high-centre ice-wedge polygons, which aids in their identification.

Glaciolacustrine Sediments (Unit 4)

Three small areas on north-central Somerset Island are thought to have been covered by ice-dammed lakes but none was visited in the field. The surrounding terrain is weathered bedrock or colluvium, both poorly vegetated. The probable lacustrine sediments are relatively well vegetated veneers whose upper topographic limits appear to delineate former water planes. The sediments likely were derived from the weathered rock and colluvium by wave action and probably are dominantly silt.

Raised Marine Sediments (Unit 5)

Raised marine sediments have been divided into deltaic (unit 5a), nearshore (unit 5b), and beach (unit 5c) facies. Together they form the third largest terrain unit on the island.

Figure 14. High-centre rectangular ice-wedge polygons and mudboils on thick till, southern Somerset Island. (Photo by Stephen Zoltai)

Figure 15. A 30 m-high kame moraine (right skyline) south of Lang River, southern Somerset Island. GSC 203507-Z

Numerous small raised deltas occur along the west coast and near the large bays of the north and east coasts. Large deltaic accumulations, 20 to 100 km^2 in area, occur south of Cunningham Inlet and along the southeast coast. The maximum thickness of these deposits probably exceeds 100 m, and most sediment is well sorted foreset sand and bottomset silt and clay. Where the original depositional surface is preserved, it is underlain by 1 to 5 m of topset gravel and sand. In many places, however, the topset deposits have been removed by fluvial erosion during emergence, so the surface can be directly underlain by any of the three facies.

Nearshore silt and fine sand occur mostly in depressions surrounded by raised beaches or on plains seaward of raised deltas. The latter are prodeltaic sediments and the former are either lagoonal sediments or foreshore sediments that were not buried by beach sediments during regression. These materials stand out as dark-toned areas on aerial photographs because their fine texture and topographic situation combine to produce poor drainage and, hence, wet meadow vegetation.

Raised beaches line those coasts underlain by sedimentary bedrock, except for the cliffed coast along Prince Regent Inlet, and they occur here and there along the granitic west coast. In areas underlain by carbonate bedrock, the beaches are composed of subangular plates of limestone and dolomite, most 5 to 30 cm across, with interstitial mud and sand. Beaches that overlie the Peel Sound sandstone north of Aston Bay and the Eureka Sound sandstone along the north shore of Stanwell-Fletcher Lake are composed of medium to coarse sand. Those along the west coast were derived from granitic till, so they have a sandy to bouldery gravel texture. Beach deposits are 2 to 3 m thick in most places and individual beach ridges are about 0.3 to 1 m high.

The most common patterned ground forms on the gravel and sand deposits are high-centre ice-wedge polygons. The silt and fine sand are patterned by both high- and low-centre ice-wedge polygons and by earth hummocks.

Fluvial Sediments (Unit 6)

Fluvial gravel and sand are divided into two types: deposits that are flooded every year or two and those that are not. The former have channel-scarred surfaces and are flooded and actively modified by water during spring snowmelt. The latter are perched above the present flood

Figure 16. Small esker, about 5 m high and 1 km long, near the south shore of Aston Bay, northwestern Somerset Island. Six small conical kames occur on the far side of the esker. GSC 203507-Q

Figure 17. Outwash gravels and associated lateral meltwater channels northeast of Stanwell-Fletcher Lake, Somerset Island. GSC 203508

zone and in most places are separated from it by a distinct bluff 1 m or more high. Some of the inactive alluvium, particularly the deposits in the valley leading from Cunningham Inlet to Garneir Bay, is probably proglacial outwash. High-centre ice-wedge polygons are common on the inactive deposits.

Colluvial Sediments (Unit 7)

Large areas in the weathered bedrock (residuum) terrains (units 1a, 1b), particularly in the weathered carbonate terrain, are mantled by sheets of colluvium which cover almost all lower valley slopes and floors. They are traversed by small streams that are incapable of removing the sediment being brought to their courses by solifluction, sheetwash, and rillwash. Consequently, the stream beds are aggrading and braided. Most channels, however are dry except during snowmelt.

The colluvium is derived from the finer grained constituents of the residuum that lies directly upslope. Hence, the calcareous colluvium, derived from silty, sandy rubble, is dominantly a loam or silt loam whereas the granitic colluvium, derived from grus, is mostly gravelly sand and sandy loam.

Solifluction stripes are dominant on colluvial slopes and large distinct solifluction lobes (Fig. 18) are common in the granitic colluvium. Circles and nets occur on the more level areas.

Neoglacial Terrains

Small areas near the northeastern tip of the island were covered by ice fields in the recent past (Dyke, 1978b). These icefields covered weathered bedrock and modified it during meltout, so that the terrains are distinguished from the adjacent area by the presence of small eskers and meltwater channels. Remnants of these icefields persist as stagnant ice plugs, some more than 30 m thick, in canyons.

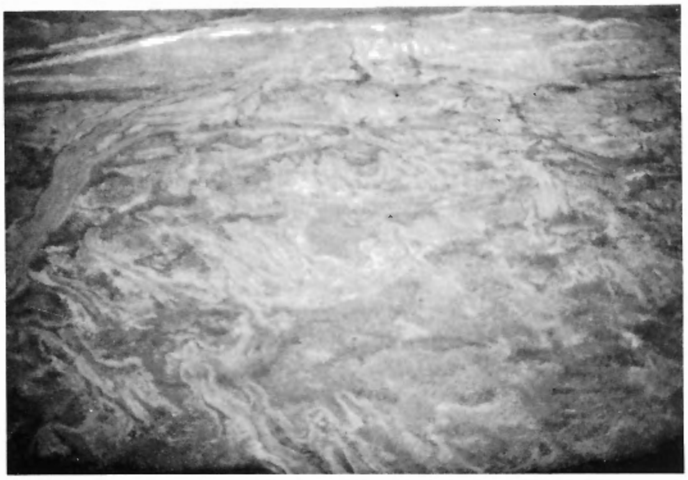

Figure 18. *Oblique aerial view of large solifluction lobes (lighter-tones areas) in granitic colluvium in the weathered bedrock terrain northeast of Fiona Lake, Somerset Island. GSC 203507-I*

ECONOMIC GEOLOGY

Map 1555A describes the character and composition of the terrain. This is turn determines distribution, density, and composition of the vegetation cover. The map, therefore, can be a useful document in deciding, assessing, or regulating land use policy and in predicting or assessing environmental impacts. One of its most obvious uses is as an inventory of granular resources.

Specific decisions, such as those involved in selecting best locations for roads, pipelines, or compressor stations, in designing these utilities, or in deciding construction schedules, require data on soil[1] behaviour and on properties of the perennially frozen soils, particularly their temperatures and ice contents. Such data and an understanding of the geomorphic processes peculiar to the area are necessary for assessment of slope stability and trafficability. These land use concerns are addressed in the first part of this chapter.

The second part of the chapter deals with the use of till and weathered bedrock as a medium for mineral prospecting.

Land Use Concerns

Granular Resources

The gravel resources of Somerset Island are not large. Kames and eskers (unit 3a) occur in several areas of the island, but only two deposits contain significant quantities of materials. Proglacial outwash deposits (unit 3b) are small, thin, and bouldery and the uppermost 1 m or so or deltaic sediments (unit 5a) represents only small gravel resources. The largest gravel resources, by far, are the raised beaches (unit 5c). In many places, however, this gravel is muddy, either because it has been mixed by cryoturbation with underlying marine silts and clays or with till or because fines have been produced by postemergence weathering of the carbonate clasts. In other places the beaches consist entirely of 10 to 30 cm-diameter limestone plates, more closely resembling felsenmeer than gravel. Fluvial sediments (unit 6) are mostly gravel but are not extensive; active alluvial plains make up about half of the unit. A final small source of gravel is the weathered conglomerate of the Peel Sound Formation north of Aston Bay.

Sand occurs in association with gravel in units 3 and 6, but the largest sources are the foreset and topset facies of raised deltas (unit 5a), the unlithified Cretaceous-Tertiary "sandstone" (unit Rc), and raised beaches (unit 5c). Most of the deltaic sands are 10 to 30 m thick, fine to medium grained, and poorly graded; some beds contain fine grained detrital plant debris. The Cretaceous-Tertiary rocks near Stanwell-Fletcher Lake are up to 300 m thick and underlie an area of about 200 km^2. They are mostly fine to medium grained, angular to subangular quartz sands (Fig. 19); beds of gravel and silt occur throughout the sequence, as do carbonized plant fragments (Dineley and Rust, 1968). The unlithified sandstone southwest of Cunningham Inlet outcrops over about 8 km^2 and is at least 30 m thick; it continues southwestward beneath Quaternary sediments for an unknown distance. Texturally and mineralogically the sands resemble those near Stanwell-Fletcher Lake except that they contain lignite-rich zones at least 1 m thick. Raised sand beaches occur near the north shore of Stanwell-Fletcher Lake, where they were derived from sandy till and quartz sandstone, and between Cape Anne and Limestone Island, where they were derived from red sandy till.

The most widespread granular resource is riprap in the form of limestone felsenmeer (unit 1b; Fig. 9). Because this is only 1 m thick or less in most places, however, it would probably be more economical and less damaging environmentally to produce riprap from blasted and crushed bedrock if large quantities are required.

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[1] In this and subsequent sections, the term 'soil' is used in the engineering sense.

Atterberg Limits

Atterberg limits are parameters of soil that provide valuable information on how the soil will behave as an engineering material (Lambe and Whitman, 1969). Soils can exist in solid, plastic, or liquid states depending upon their texture, mineralogy, and moisture content. The plastic and liquid limits of a soil are the moisture contents that mark the boundaries between the solid and plastic and between the plastic and liquid states of soil; the plasticity index is the numerical difference between the plastic and liquid limits. These parameters, the Atterberg limits, are used to classify soils according to the Unified Soil Classification System.*

Atterberg limits were determined for 67 samples of diamictic soils (unit 1a, 1b, 2a, 2b, and 7a). All tills and most weathered bedrock samples are CL*, CL-ML, or ML soils (Fig. 20) – gravelly, sandy, silty clays (CL) and gravelly, sandy clay silts (ML) of low plasticity. Liquid limits average 20 per cent and range from 15 to 36 per cent; plasticity indices average 5 per cent and range from 1.5 to 12 per cent. A further 33 samples of diamictic soils, mostly till derived from sandstone north of Aston Bay (part of unit 2b) and weathered gneiss (lunit 1a) were too coarse for testing. These are SC and SM soils, poorly graded gravelly sand clay and sand-silt mixtures.

Fine grained marine sediments (unit 5a, 5b) are mostly CI, CL, and ML soils, inorganic silty clays of medium to low plasticity (Fig. 20) with minor OL soils, organic silt clays of low plasticity. Liquid limits average 31 per cent and range from 23 to 37 per cent; plasticity indices average 9 per cent and range from 2.5 to 15.7 per cent.

Permafrost Thickness and Ground Temperatures

All of Somerset Island is underlain by permafrost. Only one measurement of the thickness of the permafrost layer (zone in which ground temperature is continuously at or below 0°C) of the earth's crust has been made on the island;

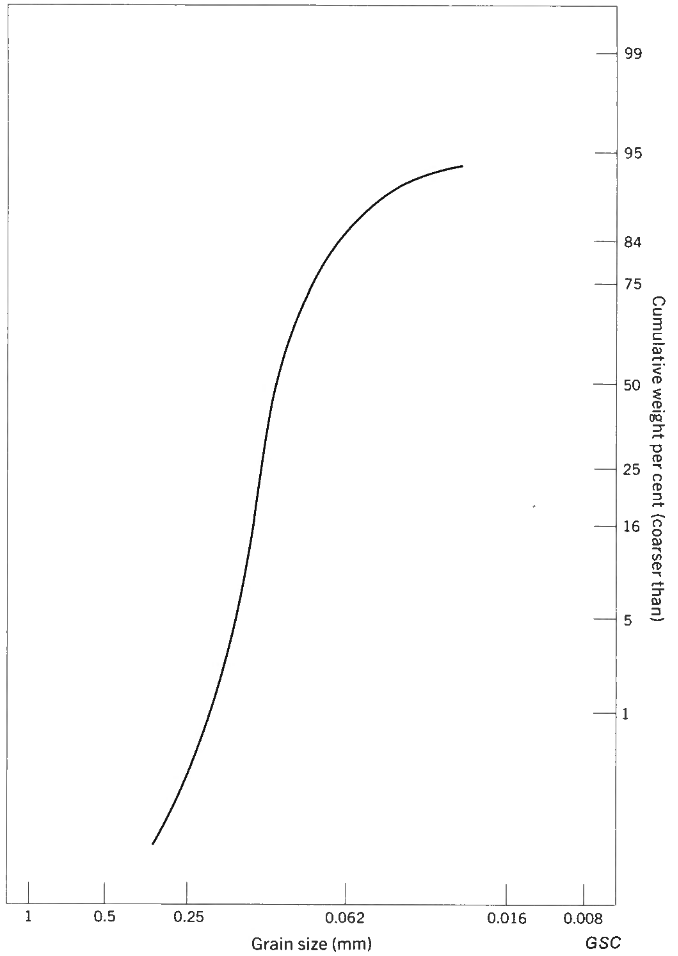

Figure 19. *Representative grain size curve for Cretaceous-Tertiary quartz sands near Stanwell-Fletcher Lake, Somerset Island (from Kurfurst and Veillette, 1977).*

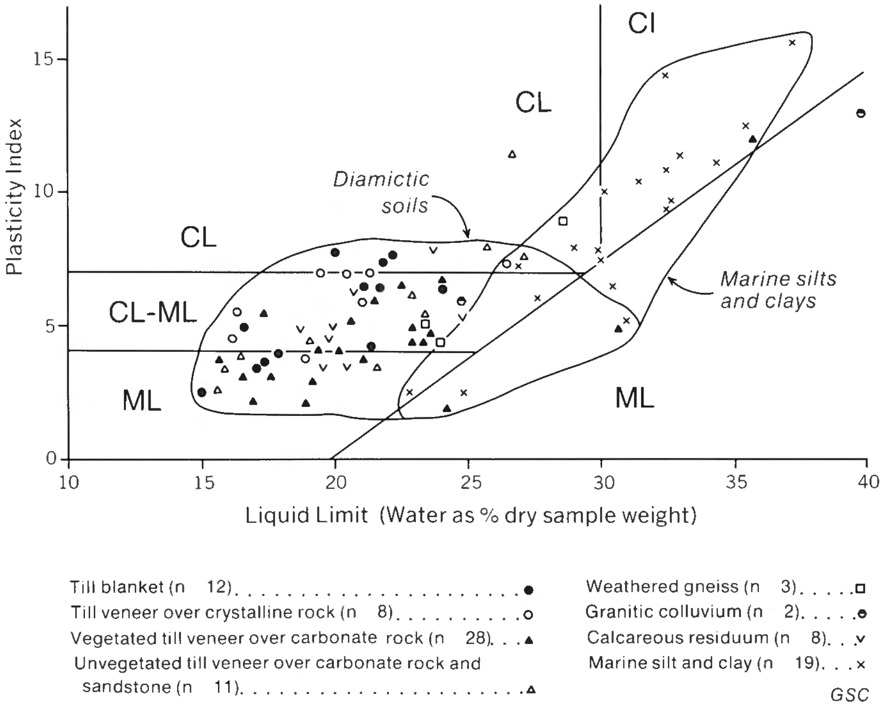

Figure 20

Classification of diamictic soils (till and residuum) and fine grained marine sediments of Somerset Island according to the Unified Soil Classification System.

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*Unified Soil Classification terminology (Lambe and Whitman, 1969).

at the Panarctic Garnier well near the northeast coast Taylor and Judge (1974) determined a permafrost thickness of about 500 m. At Resolute Bay on nearby Cornwallis Island the permafrost extends to a depth of 396 m (1300 feet, Brown, 1967). The extent of permafrost beneath the straits that surround the island is not known but subzero seabottom temperatures have been recorded in Barrow Strait (Collier and Judge, 1977). Properties and extent of permafrost beneath the straits should be considered in the construction and operation of any project involving the area under these straits.

The temperature of the frozen ground and active layer is an important engineering design criterion because it is an index of the extent to which ground temperature can be artificially altered without causing permafrost aggradation or degradation and consequent terrain disturbance or structural damage. Below a certain depth, known as the level of zero amplitude, the temperature gradient is nearly constant and above that depth, temperature fluctuates seasonally. At Resolute Bay the level of zero amplitude, presumably in bedrock, is about 30 m below the surface, but at 17 m depth the seasonal temperature fluctuation engendered by an annual air temperature range of 42°C is only 0.4°C (Cook, 1958). Thus, large temperature fluctuations are restricted to the uppermost permafrost and the active layer.

Summer ground temperature profiles to depths of 3 m below frost table in marine clay silts on Somerset Island were recorded in 1975 by Veillette (in Kurfurst and Veillette, 1977). The data show an average thermal gradient of 4.3°C per metre (0.043°C per cm) (Fig. 21) and a roughly constant warming trend at all depths.

A variety of conditions and properties such as ambient air temperature, degree of saturation, rate of groundwater flow, and vegetation cover influence temperature fluctuations and thermal gradients in the active layer. No attempt was made to investigate the details of these complex interrelationships, but single ground temperature profiles were measured in nine pits in till, one in marine silt, one in marine sand, one in marine gravel, one in grus, and multiple profiles were measured in a single pit in alluvial gravel (Fig. 22). The strongest influence on the thermal gradient is probably ambient air temperature (Fig. 22); a rough measure of active layer thermal gradient is simply air temperature divided by frost table depth.

Ground Ice

Information on the distribution and type of ground ice on Somerset Island comes from two sources: the distribution of ice-wedge polygons and retrogressive-thaw flowslides and subsurface investigations by means of coring and jack-hammering. Subsurface investigations conducted in 1975 were described in detail by Veillette (in Kurfurst and Veillette, 1977). These investigations were extended in 1977, and the two sets of data are combined in the discussion below, which proceeds according to map unit. Moisture content is given as a percentage of weight of dry sediment; however, many samples of known volume were taken so moisture as a per cent of volume versus moisture as a per cent of weight can be compared (Fig. 23). Volumetric moisture contents are useful in calculating thaw settlement.

Glacially scoured gneiss (Ra). Most of this terrain is bare, unweathered bedrock where ground ice occurs only as small joint fillings. Even these small ice lenses, however, have displaced some joint blocks from their original positions by as much as 1 m.

Glacially scoured Paleozoic bedrock (Rb). Two pits through veneers of till mixed with frost shattered bedrock on well drained sites in this terrain revealed calcareous sandstone with ice lenses up to 20 cm thick along bedding planes just below the frost table. The strata had been bent and fractured by the growth of segregated ice, which had distinct foliation normal to the bedding planes. Features resembling ice-wedge troughs occur in carbonate bedrock at a few sites (Fig. 24). Ice wedges and lenses are probably most common in poorly drained areas and on seepage slopes (Fig. 25).

Unlithified Cretaceous-Tertiary sandstone (Rc). Three boreholes in this material north of Stanwell-Fletcher Lake revealed no massive ice and decreasing moisture content with depth (Fig. 26). All three holes, however, were in well drained sites, and moisture contents in the upper sandstone are probably higher where it is overlain by poorly drained till or organic soils.

Weathered gneiss (1a). The permafrost of this terrain was not investigated but the extent of the ground ice is limited by shallowness of the unconsolidated veneer and its well drained nature. A few centimetres to decimetres of segregated ice probably occurs at the weathered rock/solid rock interface and massive ice probably fills open joints in bedrock.

Weathered Paleozoic bedrock (1b). One borehole in this terrain averaged a moisture content of 14 per cent (Polargas, 1978). As with the weathered gneiss, extent of ground ice is limited by shallowness of the unconsolidated veneer and by its well drained nature. Ice wedges occur in the weathered conglomerate north of Aston Bay and small ice lenses probably occur at the weathered rock/solid rock interface throughout this terrain.

Till blanket (2a). This material probably has more ground ice than any other on the island. Almost everywhere, the till is patterned by ice-wedge polygons (Fig. 14) and some 30 active retrogressive-thaw flowslides (Fig. 27) appear on aerial photographs of the island. Both features, which are rare on

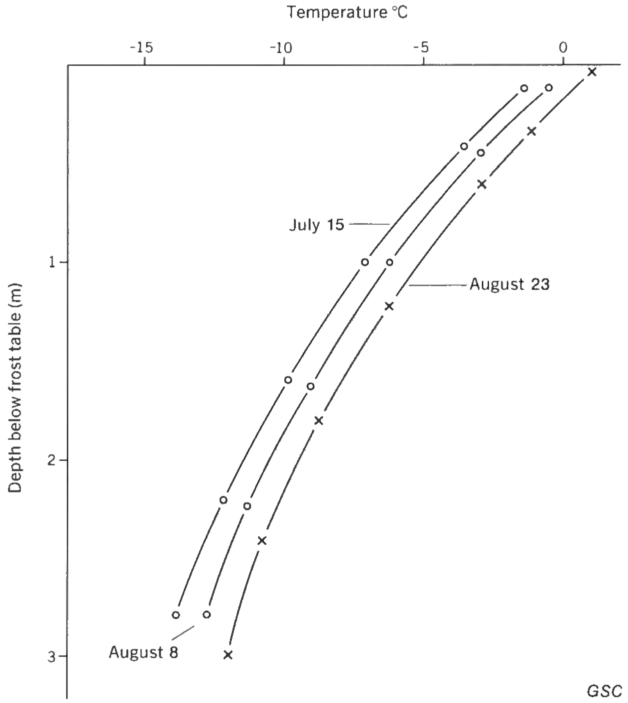
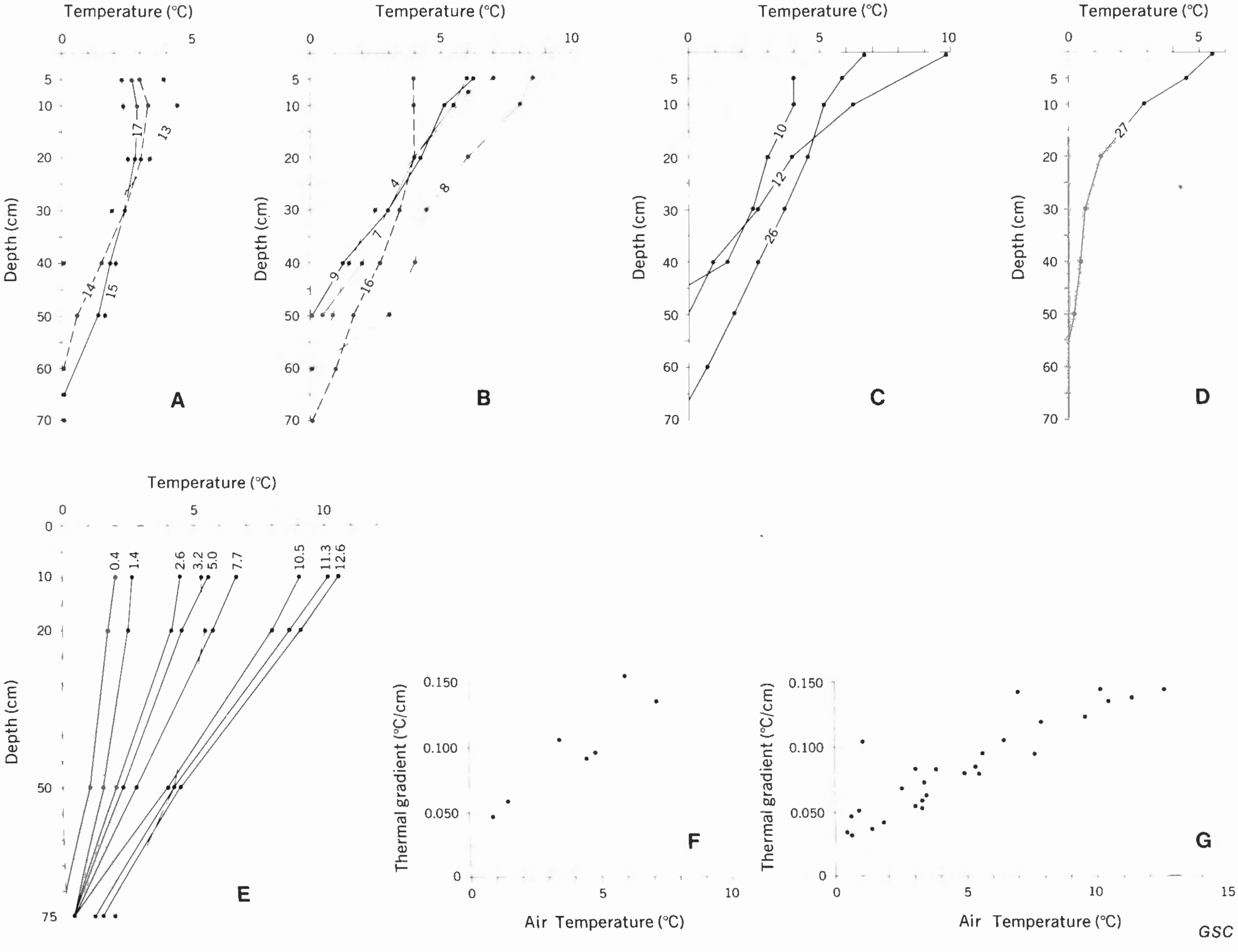


Figure 21. *Ground temperature profiles, July and August 1975, in marine clay silts on Somerset Island (from Kurfurst and Veillette, 1977).*

the till veneers, indicate that massive ice occurs extensively just below the permafrost table. Two pits in this terrain (one by Polargas, 1978) encountered 88 and 140 cm of till over more than 2 m and more than 5 m of bubbly, vertically foliated massive ice.

Till veneer (2b). No deep excavations were made in the till veneer overlying the Precambrian Shield but 12 pits were made in till veneers overlying sedimentary bedrock. Ice occurs most commonly as pore fillings, coatings up to 5 cm thick around pebbles and boulders (Fig. 28), and roughly horizontal massive ice lenses up to 10 cm thick just above bedrock. Moisture (ice) content increases downwards (Fig. 26B) and far exceeds the liquid limit of the soil in the bottom metre.

Kames (3a). Kames are well drained and coarse textured and so probably have little excess ice except as small ice wedges. Three Polargas (1978) boreholes in the kame moraine on the north side of Bellot Strait show an average moisture content of about 8 per cent to depths of 2 to 3 m. A fourth hole revealed an average of 25 per cent moisture between 2 and 10 m depth (Fig. 26C).



A – well vegetated till veneer (unit 2b1)

B – unvegetated and poorly vegetated till veneer (unit 2b2)

C – marine sediments (10 = silt, 12 = sand, 26 = gravel; unit 5)

D – granitic colluvium (grus, unit 7a)

E – selected profiles for various air temperatures (given at top of lines) in a single pit in inactive fluvial gravels (unit 6a)

F – average thermal gradient vs. air temperature for pits shown in A, B, C, and D

G – average thermal gradient vs. air temperature for a single pit in fluvial gravel (29 measurements, July 29 to August 19, 1975). Numbers on profiles in A, B, C, and D refer to pit numbers.

Figure 22. *Temperature profiles in active layer sediments on Somerset Island, summer 1975, and the relation of the thermal gradient to air temperature.*

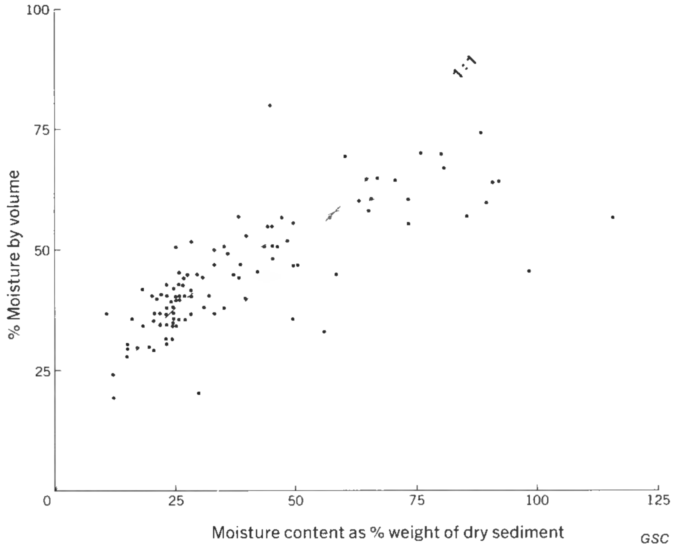
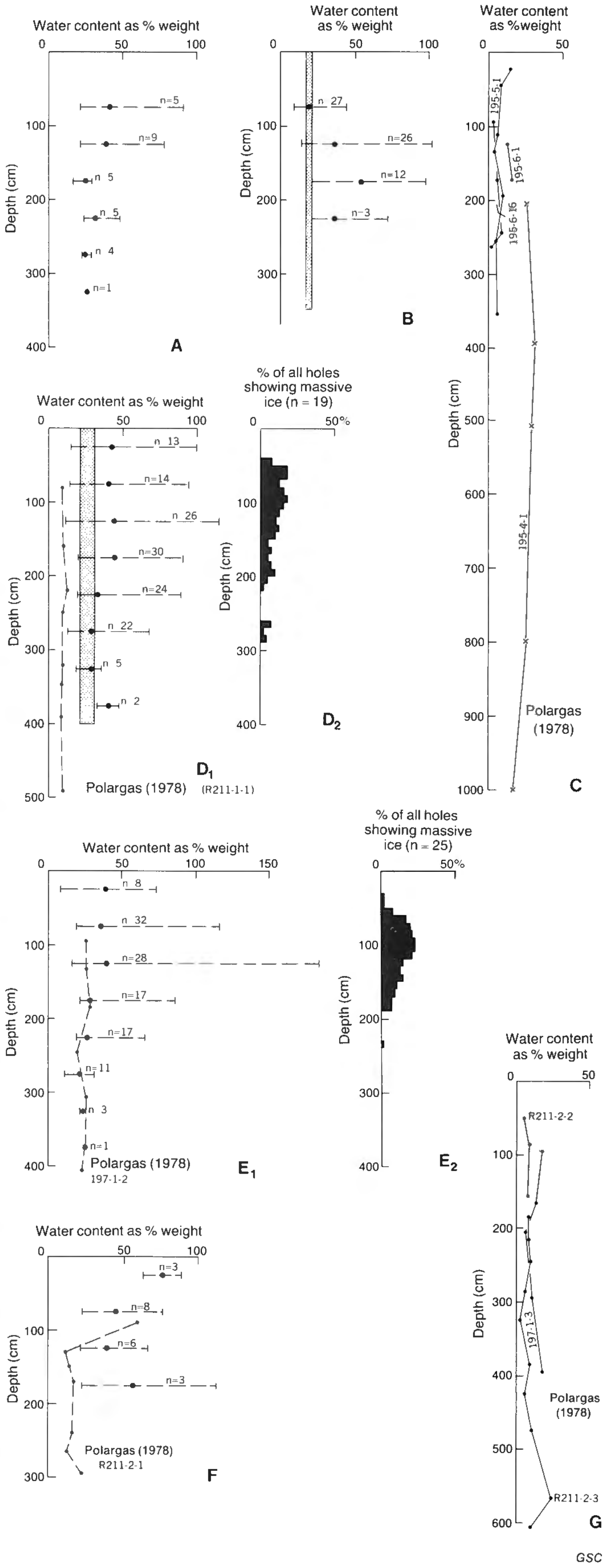


Figure 23. *Comparison of moisture contents by volume and moisture contents by weight in samples of sand, silt, and till from Somerset Island.*

Figure 24. *Trench resembling an ice-wedge trough in frost-shattered limestone south of Creswell Bay, Somerset Island. GSC 203478-R*

Figure 25. *Limestone bedrock deformed by growth of a ground-ice lens on a seepage slope north of Creswell Bay, Somerset Island. Original dip of strata was to lower left, parallel to surface slope. Strata have been displaced upward 2 to 3 m near the crest of the dome. GSC 203478-B*



Proglacial outwash (3b). No subsurface information is available for this unit, but most deposits are coarse textured and thin, and therefore probably have little excess ice.

Fine grained marine sediments (5a, 5b). Silt and clay comprise most of the bottomset deltaic and nearshore facies of marine sediments. Nineteen boreholes, most located in eroded bottomset deltaic sediments south of Cunningham Inlet (Kurfurst and Veillette, 1977), revealed a concentration of massive ice between the frost table and 2 m depth (Fig. 26D2). Moisture contents of samples without massive ice decrease with depth, especially near the 2 m level (Fig. 26D1). Average moisture contents of these samples exceed the average liquid limit in the upper 2.5 m. If the massive ice lenses were thawed the moisture content of the upper 2.5 m would far exceed the liquid limit. An additional borehole by Polargas (1978) in silty clay beneath a thin beach gravel veneer showed moisture contents lower than the lowest encountered in this study (Fig. 26D1).

Marine sand (5a). Ground ice in marine sand of deltaic foreset and topset facies was investigated in 25 boreholes, most located in the large delta north of Creswell Bay. Ground ice profiles are similar to those in marine silt and clay in that massive ice occurs in many places within 2 m of the surface (Fig. 26E2) and the average moisture content of samples without massive ice decreases with depth (Fig. 26E1). The sands, however, contain about 5 to 10 per cent less moisture than the finer sediments at all levels. Ice-wedge polygons, and hence ice wedges, are common in marine sand; wedge ice is probably the most common type of massive ice.

Marine gravel (5c). No subsurface information is available from the raised beach terrain; however, ice-wedge polygons occur almost everywhere so ice wedges are common. The sediments are coarse textured and well drained so other types of excess ice probably are not common.

Inactive, terraced fluvial sediments (6a). Inactive fluvial sands and gravels are patterned almost everywhere by ice-wedge polygons, so ice wedges are common. Moisture contents obtained from seven boreholes in gravelly sand show considerably more ice than occurs in marine sand (Fig. 26F). An additional borehole by Polargas (1978), however, yielded very low values, averaging only 15 per cent moisture below a depth of 1 m.

Active fluvial sediments (6b). Boreholes to depths of up to 6 m were sunk in active alluvial plains at three sites by Polargas (1978). Average water contents are surprisingly low, averaging only about 10 per cent (Fig. 26G).

Colluvial sediments (7a, 7b). No subsurface information is available for colluvial terrains. The colluvium occupies wet lower slopes and valley floors that are aggrading due to the more rapid supply than removal of colluvium. Hence, the permafrost table is aggrading in saturated sediment and this has likely given rise to growth of segregated ice.

Slope Stability and Cryoturbation

Slopes on exposed competent bedrock are stable except for cliffs where scree accumulations indicate considerable rock fall activity. Rock glaciers (Fig. 29) occur on scree slopes in many places; this indicates that the scree is subject to slow flow by deformation of interstitial ground ice. These areas, however, can be easily identified and avoided.

***Figure 26** (opposite)*

Moisture (ground ice) content profiles and occurrences of massive ground ice in sediments on Somerset Island. Moisture contents were determined only on samples with no massive segregated ice. All samples, except those from Polargas (1978) boreholes, were grouped into 50 cm-depth intervals; for each interval, mean moisture content (dots),range of moisture contents (horizontal bars), and number of samples used (n=5) are given; shaded vertical bars in B and D1 show mean plastic and liquid limits and plasticity ranges. Individual profiles in C, D1, E1, F, and G are from Polargas (1978) with borehole numbers given beside the curves. Massive ice occurrences are shown as histograms (D2 and E2) using 10 cm depth intervals.

A – unlithified Tertiary-Cretaceous sandstone (unit Rc)
B – till veneer (unit 2b)
C – kame gravel (unit 3a)
D – marine silt and clay (unit 5)
E – marine sand and gravelly sand (unit 5)
F – terraced alluvium (unit 6a)
G – active (seasonally flooded) alluvium (unit 6b)

***Figure 27.** Oblique aerial view of a retrogressive-thaw flowslide (centre) in till south of Creswell Bay, Somerset Island. Massive ice is exposed in the backwall of the feature. GSC 203507-Y*

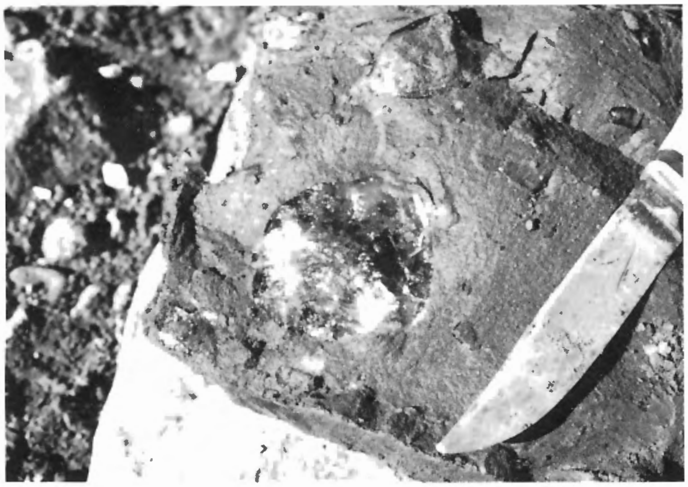


***Figure 28.** Ice coating around a stone in red sandy till (unit 2b2) near Cape Anne, Somerset Island. Most stones in this till are coated with ice, but most ground ice occurs as pore fillings. GSC 203507-O*

Figure 29. *Oblique aerial view of a rock glacier (talus glacier) with multiple transverse ridges near the south shore of Aston Bay. The feature is formed by slow flow caused by deformation of ground ice under the weight of the coarse scree. The active frontal lobe of the rock glacier (light-toned area abutting the small stream) is 8 to 10 m high. GSC 203508-N*

Diamictic materials everywhere show signs of movement in the form of patterned ground features, primarily mudboils, which indicate cryoturbation, and stripes and lobes, which indicate solifluction. Both processes commonly are active at the same site. Long-term average rates of cryoturbation under natural conditions, determined by radiocarbon dates on subducted soil organics at the edges of mudboils, appear to be very slow, less than 1 mm per year (Woo and Zoltai, 1977; Dyke and Zoltai, 1980). Because of the low liquid limits of the diamictic soils (Fig. 20), however, artificial processes such as vibration, differential loading, or ground ice thawing could speed cryoturbation or solifluction and cause slope failure. The retrogressive-thaw flowslides associated with massive ice in thick till show that sudden slope failure occurs there naturally but also that failure could be triggered easily by artificially loading a slope, saturating the active layer, or thawing the uppermost ice-rich permafrost. Slope instability increases during spring snowmelt and frost table lowering.

Coarse grained sorted sediments are not subject to cryoturbation and because of their high permeability likely would not be destabilized by thawing ground ice, except along terrace bluffs. However, natural slope instability is caused by undercutting of terrace bluffs and thermal erosion by streams.

Fine grained sorted sediments, mostly deltaic silt and clay, are subject to cryoturbation, giving rise to mudboils and earth hummocks. Most widespread natural slope instability in these sediments, however, is caused by gully and rill erosion. Because moisture content in the uppermost permafrost considerably exceeds the liquid limit of the sediment, these processes could be artificially accelerated causing rapid slope failure.

Trafficability

Trafficability is the suitability of a soil or terrain for offroad vehicle movement or the ability of the soil to support the vehicle. In the Arctic almost any large-scale industrial, commercial, or military activity (e.g., mining, pipeline construction, oil spill cleanup, vehicle testing) will involve use of offroad vehicles.

Traffficability varies seasonally. It is highest when the active layer is completely frozen, when lakes and ponds are frozen, and when snow smooths out small surface obstacles such as boulders, mudboils, and ice-wedge troughs; it is lowest when the active layer is saturated and this occurs almost everywhere during spring snowmelt.

Trafficability also varies with type of vehicle. For example, ice-wedge troughs pose little or no problem for large tracked or large wheeled vehicles but could ground air-cushioned vehicles. The aspects of each terrain that affect trafficability are summarized in Table 3.

Metal Content of Soils

Most samples of till collected by Geological Survey of Canada are analyzed for uranium and base metal content in the clay fraction by atomic absorption techniques. Results of such analyses are given in several papers on the District of Keewatin (e.g., Shilts, 1972, 1973, 1974, 1977; Shilts and Klassen, 1976; Shilts and Cunningham, 1977), where detailed sampling was carried out with the specific objective of developing drift prospecting techniques. Because drift prospecting was not a main objective of the Somerset Island project, sample density is too low to provide more than a general picture of the distribution of metals in the soils of the island.

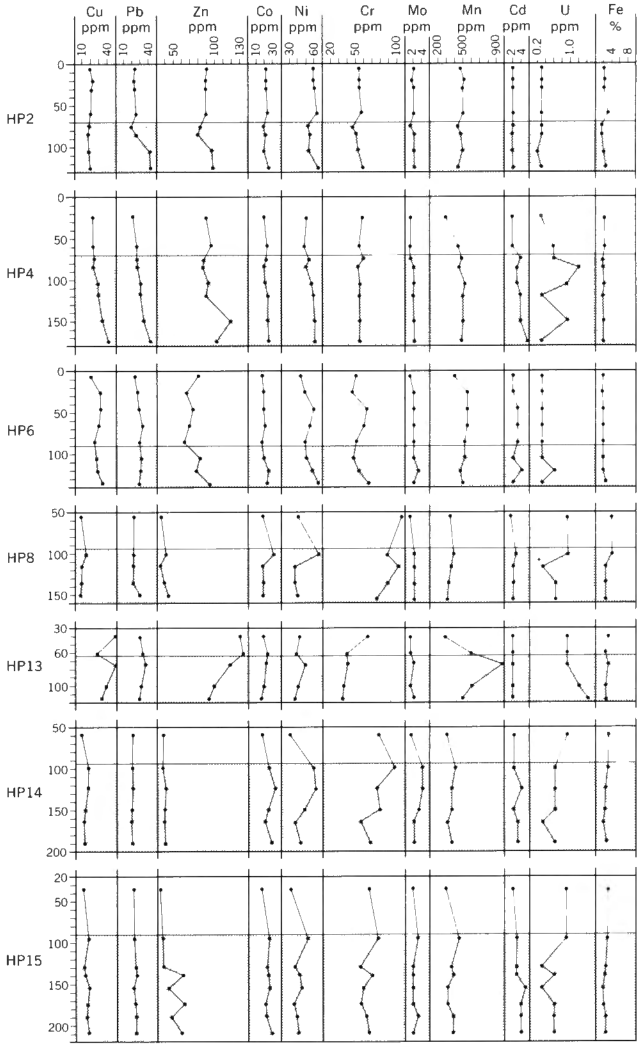


Figure 30. *Metal content profiles in the active layer and upper permafrost in till. Shaded areas represent frozen ground at time of collection.*

Table 3. Trafficability of terrain units, Somerset Island

Map unit	General restrictions to accessibility	Surface roughness problems	Traction problems
1a		1 to 2m-high bedrock escarpments; 60-90% block (1-2 m across) cover on entire area	Fine grained soil in mudboils saturated beyond liquid limit in early thaw season
Ra	Rugged terrain, up to 200 m local relief, numerous cliffs	Numerous boulders and frost-heaved joint blocks	
1b, Rb, Rc	Canyons in 1b and Rb, gullies in Rc	Up to 50 cm relief on mudboils	Fine grained soil saturated beyond liquid limit in early thaw season
2, 4		Surface bouldery between Stanwell-Fletcher Lake and Aston Bay	Soil saturated beyond liquid limit in early thaw season throughout area and on seepage slopes throughout summer
3		Boulders and ice-wedge polygon troughs (commonly up to 50 cm deep)	
5a	Gullies in silt and clay; terrace bluffs up to 10 m high	Ice-wedge polygon troughs (commonly up to 50 cm deep)	Few boggy areas with low-centre ice-wedge polygons; silt and clay saturated in early thaw season
5b			Most areas saturated throughout thaw season; boggy
5c		Ice-wedge polygon troughs (commonly up to 50 cm deep)	
6		Bouldery in places; 1 to 2 m-high terrace bluffs; ice-wedge polygon troughs	6b flooded during snowmelt
7			Natural water content beyond liquid limit much of thaw season, particularly in 7a

Most of the samples from Somerset Island came from the active layer and have been subjected to weathering. To test the representativeness of the active layer samples, multiple samples were collected from the active layer and upper permafrost in seven pits in till (Fig. 30). The data show that in most cases elements do not vary much with depth and that variance within the perennially frozen till is a large as in the active layer; therefore, near surface samples adequately represent the sediments. There does, however, seem to be a slight enrichment in the base of the active layer in molybdenum, copper, cobalt, nickel, and manganese.

The data can be used to establish background values for the various metals and to identify some areas where metal concentrations exceed background levels. High values are separated from background simply by visual inspection of histograms of frequency (number of samples) versus concentration for each metal (Fig. 31). Sample sites with values falling in the high tails of the histograms are targets for further exploration. The boundary between background and higher levels is about 100 ppm for copper, lead, cobalt, nickel, and chromium; 150 ppm for zinc; 1000 ppm for manganese; and 10 per cent for iron. Histograms for cadmium and molybdenum show only background values. Background uranium values are between 0 and 1.6 ppm; only two samples had concentrations higher than that.

All samples that yielded measurements falling in the high tails of the histograms and their locations are listed in Table 4. Half of these samples are clustered in two areas: (1) the weathered gneiss terrain east of Fiona Lake and (2) the unvegetated till over sedimentary bedrock northeast of Aston Bay (Fig. 32). The other half occur as isolated samples.

Weathered Gneiss East of Fiona Lake

The geology of the weathered gneiss terrain in the sampling area is shown in Figure 33. The dominant rock type is biotite-quartz-feldspar gneiss and garnetiferous quartz-feldspar gneiss. The gneisses are steeply dipping to vertical as a result of tight folding; an eroded syncline and anticline occur northeast of samples 77-W16 and 77-W17. The gneisses are intruded by diabase dykes, and those dykes that are wide enough to map from 1:60 000 scale airphotos form a swarm southeast of the sample points. Small dykes were noted in the field midway between the sites of samples 77-W8 and W10 and at the site of sample 77-W19, which consists of weathered dyke rock.

Table 4. Till and weathered bedrock samples with anomalous base metal contents

Sample	Cu	Pb	Zn	Co	Ni ppm	Cr	Mn	U	Fe %	UTM Grid (NTS)
15 km east of Fiona Lake										
77-W2						153				VM475200 (58 C)
77-W3	150		225		110	190				VM475200 (58 C)
77-W4	176		205		117	185				VM475190 (58 C)
77-W5	123		174			170				VM475190 (58 C)
77-W6	118		199		106	218				VM475170 (58 C)
77-W8					123	170				VM460177 (58 C)
77-W10			250		203	323	1335			VM450180 (58 C)
77-W11			161		118	227				VM445180 (58 C)
77-W12			169		105	209				VM440180 (58 C)
77-W16	252		165	140	138	105	1635			VM490215 (58 C)
77-W17	135									VM490215 (58 C)
77-W19	580				105				11	VM485215 (58 C)
77-W21	127		152			160		2.1		VM485215 (58 C)
Near north shore of Aston Bay										
77-W22			360		226		1390			VN350060 (58 C)
77-W23			580		268					VN350065 (58 C)
77-W29			355		125		1555			VN320110 (58 C)
77-W31			162							VM630770 (58 C)
77-T44	140		280				2000			VM430855 (58 C)
77-T45			210				1370			VM530760 (58 C)
Isolated samples										
75-28			158							VM386969 (58 D)
75-68	267						1540			VM529575 (58 C)
75-79a							2100			VM565569 (58 C)
75-88					114		1180			VM402624 (58 C)
75-89	222	420	433						14	WM312493 (58 C)
75-100	200									VM462098 (58 C)
75-109	103		152		117					VL546205 (58 B)
75-116			295							VM646947 (58 B)
75-117	125		275					3.7		VM251599 (58 C)
75-119	145		199				1515			VM332097 (58 C)
75-121							3425			VM555431 (58 C)
75-231							1375			VL378860 (58 B)
77-T4	112		170		111	118				VL495350 (58 B)
77-T19	176		200		156	122	2040			VL590780 (58 B)
77-T26	123		209		115	112				VL280860 (58 B)
77-T27			183				1030			VL685505 (58 B)
77-T32	128		165		155					VL560560 (58 B)
77-H24a			168							VL805860 (58 B)
77-H75						105				VL455180 (58 F)

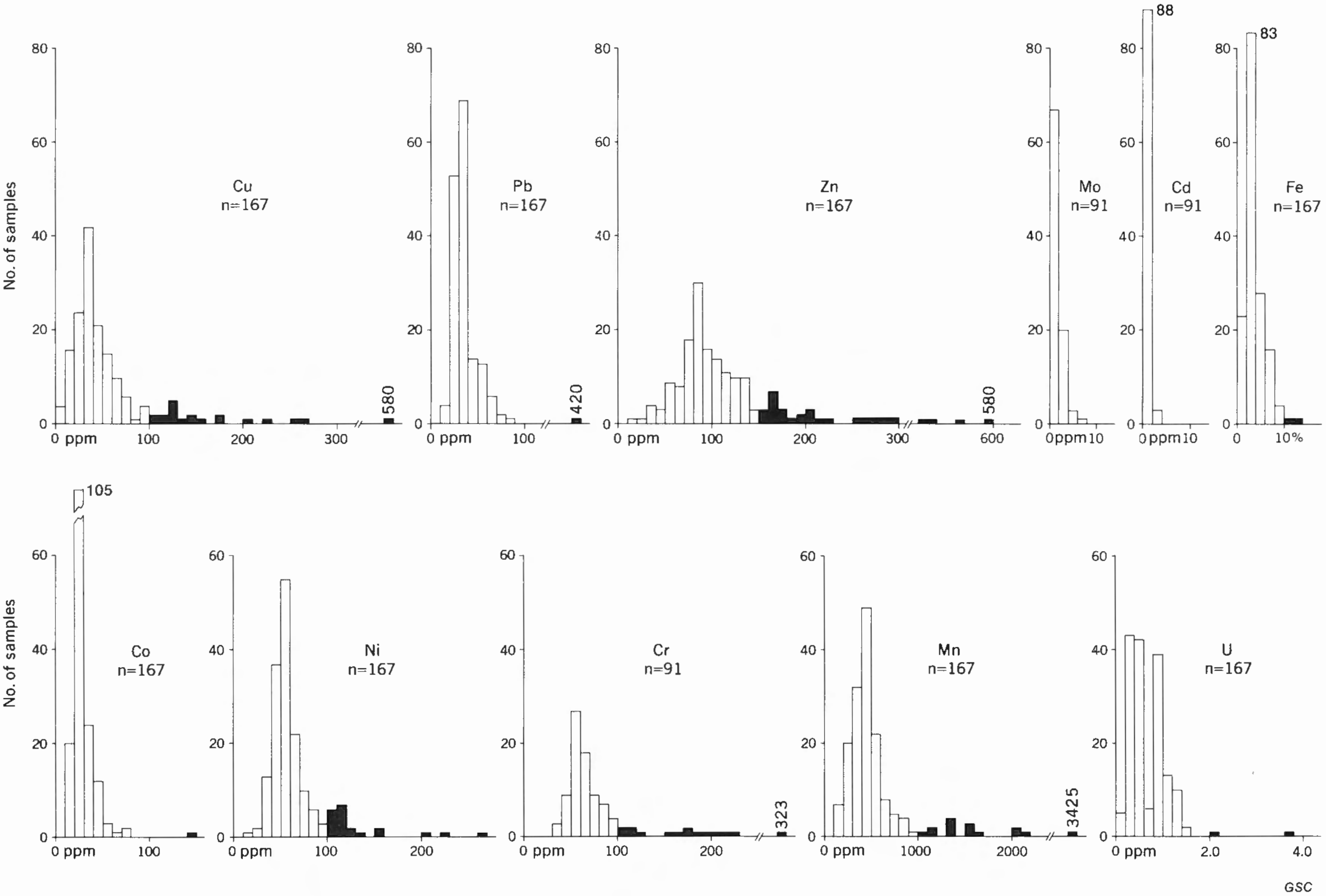


Figure 31. Histograms of metal concentrations in the <2µm fraction of till and residuum samples from Somerset Island. Black bars represent the tails of high concentrations (locations of these samples are shown in Fig. 32).

Except for sample 77-W6, which is till, all samples are sediments produced by in situ weathering of the bedrock or colluvium derived from the weathered bedrock directly upslope. No samples were obtained from other parts of the weathered gneiss terrain so it is not possible to say whether the metal contents of the samples are anomalous with respect to soils elsewhere in the terrain. They are, however, higher than in most samples of shield-derived till on the island.

The samples have high concentration of copper, zinc, nickel, and chromium. By far the highest copper concentration and one of the two iron anomalies occurred in the weathered dyke rock. Furthermore, the common relationship of chromium with ultrabasic rocks suggests that the high metal contents are probably associated with the dykes.

Till near Aston Bay

Samples from the unvegetated till veneer over sedimentary bedrock northeast of Aston Bay show high zinc, nickel, and mangenese contents. The northernmost samples (77-W22, -W23, -W29, Fig. 32) came from an area where ice flow was from the west or the southwest. Although the sites are only a few kilometres down-ice from major bedrock lithological contacts, the till is composed mostly of local bedrock fragments – Peel Sound conglomerate in the case of samples 77-W22 and 77-W23 and Read Bay carbonate in the case of 77-W29. This suggests short distances of glacial transport. Samples 77-W31, -T44, and -T45 could have been derived from either the Allen Bay, Cape Storm, or Read Bay carbonates since all three outcrop in the immediate area and ice flowed across the contacts.

Isolated Samples

Of the isolated samples that have high base metal contents, nine (75-88, -89, -100, -109, -117; 77-T4, -T19, -T26, -T32) are from till veneers overlying gneiss. Large dykes occur near samples 75-88 and 75-117, and the high chromium contents of samples 77-T4, -T19, and -T26 indicate ultrabasic source rocks. Four samples (75-116, -119, -231, 77-T27) are from vegetated till veneers overlying carbonate bedrock (unit 2b1) components of which, particularly in the case of samples 75-119 and 77-T27, likely were derived from the Shield. Samples 75-28 and -79a are locally derived tills (unit 2b2) overlying carbonate bedrock. Sample 77-H75, having a high chromium content, is from till veneer mostly derived from local Peel Sound sandstone and conglomerate.

The remaining three samples are from weathered bedrock. Sample 75-68 is from frost-shattered gneiss under 20 cm of till. The clays on which the analyses were performed, however, could have been washed down from the till. Sample 75-121, which has the highest manganese content of all samples, is from weathered carbonates of the Allen Bay Formation. Finally, sample 77-H24a is from frost-ruptured calcareous sandstone of the Somerset Island Formation under a till veneer which is derived mostly from the same bedrock.

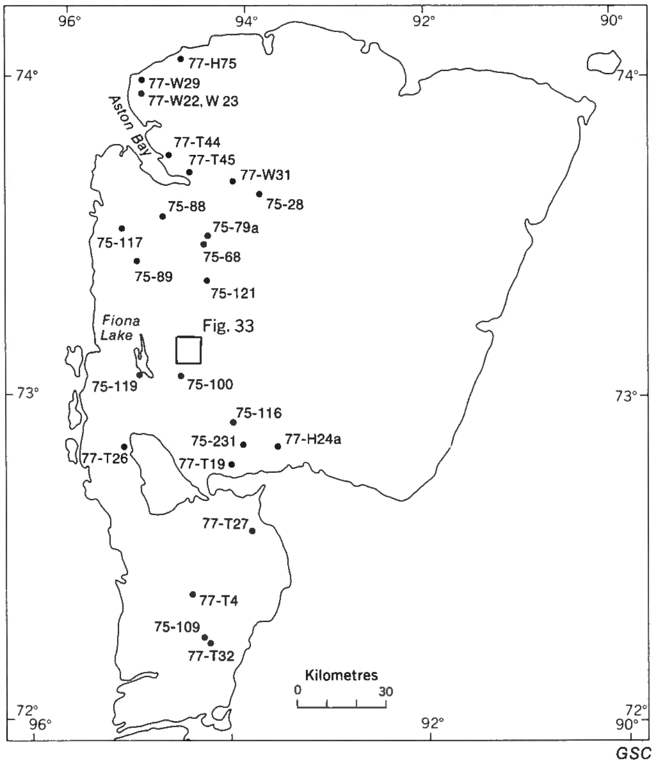


Figure 32. *Location of samples with high metal contents (cf. Table 4).*

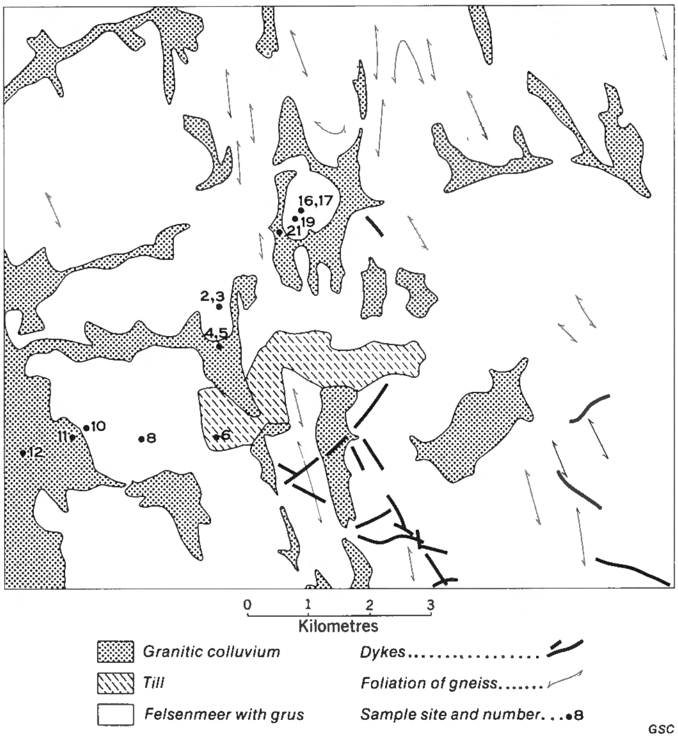


Figure 33. *Surficial geology of the weathered gneiss terrain east of Fiona Lake (cf. Fig. 32) in the area of samples that show high base metal contents (traced from airphoto A-16079-115). Sample numbers correspond to numbers in Table 4 prefaced by 77-W.*

QUATERNARY HISTORY

Most glacial and marine sediments and landforms on the island were produced during the last glacial episode. This episode, which terminated in the earliest Holocene, is probably the correlative of the late Wisconsin substage of the Wisconsin Glaciation of the southern Laurentide Ice Sheet. Other glacial and marine sediments, and periglacial residual soils and landforms were produced during glacial and nonglacial intervals before the last glacial episode. The excellent preservation and widespread distribution of late Wisconsin and Holocene features allow reconstruction of the main events of these times in considerable detail. The details of older events as well as their age assignments are necessarily more vague and uncertain.

To provide a focus in this chapter, a summary interpretation of the Quaternary geology of Somerset Island is presented in Figure 34. On this map the island is divided into four types of terrain. (1) One terrain is thought to have been covered by warm-based, highly erosive ice during the last glacial episode. It consists of glacially scoured bedrock with ice-moulded forms and of till with ice flow lineaments; subglacial and ice marginal meltwater channels in both till and bedrock are common. (2) A second terrain type is thought to have been covered by cold-based, protective ice in the central zone of a local ice cap during the last glacial episode. It consists of weathered bedrock and colluvium derived from the weathered mantle. No basal glacial erosional features, ice flow features, or subglacial meltwater features occur, but ice marginal meltwater channels cut into the weathered mantle are abundant. Erratic boulders of gneiss and small patches of till occur there but they date from glaciation(s) prior to the last glacial episode. (3) Nunataks are thought to have remained free of glacier ice during the last glacial episode. Like the terrain covered by cold-based ice, it consists of weathered bedrock and colluvium, but differs in that it has no ice marginal channels. Also like the second terrain type, it has a few small patches of till, but these are also thought to predate the last glacial episode. (4) The fourth terrain type consists of areas of postglacial marine sediments.

Pre-late Wisconsin Events

Glaciation and Weathering

The oldest Quaternary events currently recognized on Somerset Island are (1) bedrock weathering and denudation, which produced the extensive residual and colluvial soils of the weathered bedrock terrains, and (2) glaciation(s), which left scattered erratics and small patches of till in these terrains. The erratics, although sparse, are widely distributed. If they represent a single glacial event, they could have been deposited only by an ice sheet that covered the entire island. The shield erratics that occur on the northeastern carbonate plateau could have come from the western part of the island; however, the erratics do not seem to be any more abundant near the Shield than farther from it. This distribution possibly indicates that the erratics came from other parts of the Canadian Shield or possibly even from crystalline rocks on Greenland. Similar erratics occur on Cornwallis, Bathurst, and adjacent smaller islands, where they are considered to date from a pre- "classical" Wisconsin glaciation (Barnett et al., 1976).

Whether the "old" glaciation occurred before or after the bedrock weathering interval that produced the extensive colluvial and residual soils is not known and will prove difficult to discover. If the colluvial and residual soils were formed before the old glaciation, the ice that left the erratics must have been noneroding, probably cold based, because it did not remove or even noticeably disturb the weathered rock mantle. In this case, the weathered rock mantle is the oldest Quaternary material on the island. If the weathering occurred after the "old" glaciation, the weathered rock mantle represents a lengthy nonglacial interval following the old glaciation but preceding the last glaciation[1]. At one site in the weathered gneiss terrain a slightly calcareous till was found beneath a 75 cm-thick veneer of colluviated grus (Dyke, 1978c; Woo and Zoltai, 1977). Obviously, colluviation of the grus occurred after till deposition, but whether the weathering that produced the grus also occurred after till deposition is not known.

Because there is some reason to suggest ice recession and marine incursion (see below) in this area after the start of the period normally referred to as the Wisconsin Stage, the "old" glaciation could have occurred during early Wisconsin time. This proposition of an extensive early Wisconsin ice cover is consistent with similar porposals of extensive early Wisconsin ice covers on Baffin Island (e.g., Miller et al., 1977; Dyke, 1979b).

Marine Episode

The possibility that a glacial recession accompanied by a marine incursion occurred prior to the last glaciation is indicated by two lines of evidence: (1) the occurrence of driftwood that yielded a nonfinite radiocarbon age and (2) the occurrence of shells, both in beach sediment and in the late Wisconsin till above the Holocene marine limit, that are thought to be older than late Wisconsin on the basis of their amino acid ratios.

The driftwood came from the north side of Creswell Bay and is more than 38 000 radiocarbon years old (GSC-2542); this fixes its age as pre-late Wisconsin. It was found at 160 m a.s.l. on the surface of bare, eroding sand that forms the side of a raised delta (Fig. 7 in Dyke, 1978a). The topset gravels of the delta form a terrace at 180 m a.s.l; this marks relative sea level position during deposition of the delta, and the wood could have been deposited originally at that level. The delta is anomalous in that it occurs landward of and 35 m higher than sediments that are otherwise the highest marine deposits in its vicinity. It is considered to be an ice marginal (glaciomarine) deposit because it sits at the headwaters of the present drainage system (hence was not deposited by a normal stream) and because its topset gravels contain many erratic boulders. The considerable elevation of the delta indicates that the sea transgressed a land that had been isostatically depressed by a large ice load, possibly that which deposited the erratics in the weathered rock terrains discussed above.

The highest beach ridge in the vicinity of the "old" delta lies 145 m a.s.l. At one site on the foreslope of this ridge, shells, including many well preserved whole valves of **Hiatella arctica**, were abundant. The amino acid ratios of these shells (77-S11) indicate that they are older than the last glaciation (Table 5).

The pre-late Wisconsin nonglacial interval and marine episode is also represented by shells that occur as erratics in the late Wisconsin till (Table 5). Erratic shells are common in the Somerset Island tills, particularly on the southern peninsula. Because the ice that emplaced the till in the latter area flowed eastward, the shells must have come either from the western fringe of the island or more likely from Peel Sound. This means that the area where the shells originated was ice free prior to the last glacial advance. Many of these erratic shells have similar amino acid ratios, both in the free and total fractions, to shells of the same species from the Kogalu Member of the Clyde Foreland Formation, Baffin Island (Miller et al., 1977) and from deposits assigned to the Quajon and Cape Broughton interstades of Cumberland Peninsula, Baffin Island (Dyke et al., 1982). Some of the ratios in the Somerset Island erratic shells, however, are considerably lower than the ratios in shells from these Baffin Island stratigraphic units. The youngest erratic shells are most significant because they date closest to the time of the last glacial advance and the end of the marine event that predated the advance.

The rate of racemization of amino acids is a function of both time and temperature (Rutter et al., 1979). Ignoring the influence of temperature for the moment, the youngest erratic shells in the late Wisconsin till of Somerset Island are younger than shells from the Kogalu Member or from deposits assigned to the Quajon Interstade or the Cape Broughton Interstade of Baffin Island. Most recent estimates of the age of the Quajon Interstade are 50 000 to 60 000 years B.P. (Nelson, 1980); most recent estimates of the age of the Kogalu Member are about 60 000 years B.P. (Miller et al., 1977; Szabo in Brigham, 1980, p. 111), about 80 000 years B.P. (Miller in Brigham, 1980, p. 111), and about 125 000 years B.P. (Feyling-Hanssen in Brigham, 1980, p. 111); and most recent estimates of the age of the Cape Broughton Interstade are about 70 000 years B.P. (Miller et al., 1977), 100 000 years B.P. (Szabo in Brigham, 1980, p. 111), about 130 000 years B.P. (Miller, in Brigham, 1980, p. 111), and about 500 000 years B.P. (Feyling-Hanssen in Brigham, 1980, p. 111). Given the great uncertainty in the age assignments of the Baffin Island stratigraphic units, particularly that of the Cape Broughton Interstade, it is difficult to suggest an age for the erratic shells on Somerset Island. If the young age estimates are correct, the erratic shells on Somerset Island are of middle Wisconsin age; if the oldest age estimate for the Cape Broughton Interstade is correct, the Somerset Island shells could be pre-Wisconsin.

The thermal history of the Somerset Island shells, however, has been quite different from that of the Baffin Island shells. The Baffin Island shells are from sites that have remained just beyond the limits of the ice sheets during middle and late Wisconsin time and for most of that time have remained above sea level (Miller et al., 1977; Nelson, 1980, Brigham, 1980; Dyke et al., 1982). Hence they probably have experienced extremely cold conditions in a narrow unglaciated fringe of land adjacent to the continental ice sheet. The Somerset Island erratic shells, on the other hand, were near the base of the late Wisconsin ice sheet until deglaciation during the early Holocene, and prior to being picked up by the ice sheet they probably resided in Peel Sound. The late Wisconsin Laurentide Ice Sheet on southern Somerset Island was almost certainly at pressure melting point at its base, because it was both highly erosive and debris laden, and the temperatures at the bottom of Peel Sound could not have been much below 0°C. Hence, the Somerset Island shells have occupied much warmer environments than have the Baffin Island shells during pre-Holocene time. Because the rate of racemization is proportional to mean annual temperature, a given amount of racemization represents a lesser age for the Somerset Island shells than for the Baffin Island shells. In other words the erratic shells on Somerset Island are probably considerably younger than the shells on Baffin Island with comparable ratios. If the extremely old age estimate of Feyling-Hanssen (in Brigham, 1980, p. 111) for the Cape Broughton Interstade is rejected the youngest Somerset Island erratic shells fall well within the time interval normally ascribed to the Wisconsin Glaciation, and document the first recognized

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[1] The phrase "last glaciation" is used in a strictly local sense to mean the last glacial episode on Somerset Island. It should not be equated with the entire Wisconsin Glaciation.

Table 5. Ratios of the amino acids D-alloisoleucine to L-isoleucine in the free and total (free+peptide bound) fractions in **Hiatella arctica**

Sample (Field/Lab No.)	Amino Acid Free	Ratio Total	Units on Baffin Island with comparable ratios	Comments
75-142 (AAL-162)	N.D. N.D.	0.020 0.018	Cumberland Peninsula Holocene: 0.026 (Total)	75-142 ^{14}C dated at 9310 ± 90 (GSC-2272)
77-S13 (AAL-411)	N.D. N.D.	0.031 0.040	Clyde Foreland Formation, Holocene Eglinton Member: 0.02 (Total)	77-S13 ^{14}C dated at 9270 ± 90 (GSC-2596)
75-97a(I) (AAL-367)	N.D.	0.019		From beach surface 104 m a.s.l.
75-97a(II) (AAL-366)	N.D. N.D.	0.033 0.043		From beach surface 104 m a.s.l. same sample as 75-97a(I) indicating shells of mixed ages.
75-251b (AAl-1051)	0.354 0.232 0.173	0.0420 0.0296 N.D.	Cumberland Peninsula; Quajon Interstade: 0.30-0.38 (Free) and 0.031-0.068 (Total); Cape Broughton Interstade: 0.26-0.51 (Free) and 0.054-0.10 (Total). Clyde Foreland Formation, Kogalu Member: 0.29 (Free) and 0.045 (Total).	From till surface 389 m a.s.l. 72°35'20"N, 94°48'50"W
75-254 (AAl-1049)	0.272 0.188 0.362	0.075 0.024		From till surface 214m a.s.l. 72°24'50"N, 94°57'50"W
77-S11 (AAl-410)	0.13 0.17	0.048 0.050		Shells from beach 145 m a.s.l.
77-S1 (AAl-537)	0.21 0.36 0.32	0.10 0.066 0.047		From till surface 365 m a.s.l.
75-170 (AAl-1050)	0.724 0.699 0.675	0.0834 0.0927 0.0710		From till surface 226 m a.s.l. 72°30'30"N, 93°36'W.
75-136 (AAL-161)	0.53	0.080		From till surface 217 m a.s.l. 73°03'N, 92°44'W.
75-178 (AAL-1052)	0.815 0.723 0.721	0.182 0.120 0.106	Cumberland Peninsula, last interglaciation: 0.55-0.74 (Free) and 0.13-0.18 (Total). Clyde Foreland Formation, Cape Christian Member: 0.66 (Free) and 0.15 (Total)	From till surface 254 m a.s.l. 73°44'10"N, 93°56'W.
75-171b (AAL-364)	N.D. N.D. N.D.	0.33 0.20 0.23	Cumberland Peninsula pre-last glaciation: 0.398-0.51 (Total). Clyde Foreland Formation, Pre-Cape Christian interglaciation: 0.25 (Total) (Nonion tallahattensis zone)	From till surface 184 m a.s.l. 72°23, 49"N, 93°54'W.

Cumberland Peninsula data from Dyke et al., 1982.
Clyde Foreland Formation data from Miller et al., 1977.

mid-Wisconsin nonglacial interval in the central Canadian Arctic. Blake (1980) also has proposed a mid-Wisconsin nonglacial interval on southern Ellesmere Island based on finite radiocarbon dates and comparable amino acid ratios.

Late Wisconsin Glaciation

Late Wisconsin Advance

No radiometric dates are available on the youngest known shells in the late Wisconsin till so the timing of the last ice advance on Somerset Island remains unknown. However, if it was roughly contemporaneous with the last major advance of southern Cordilleran and southern Laurentide Ice, it probably occurred 20 000 to 30 000 years ago (Dreimanis and Karrow, 1972; Fulton and Smith, 1978).

Glacial Limits

The highest ground between the head of Creswell Bay and Aston Bay and near the northwest corner of the island probably stood above the limit of late Wisconsin ice (Fig. 34). These are areas of weathered bedrock mantled by residuum; tors, cryoplanation terraces, and nivation hollows are the dominant landforms. The contact of this weathered rock terrain with the obviously glaciated terrain is distinct in most places. It marks the edge of glacially scoured bedrock, the edge of a till sheet, or both. In many places the contact is also defined by the uppermost of series of nested sidehill meltwater channels. Because of the nature of the contact and its coincidence with the uppermost ice marginal features, it is taken to represent an altitudinal glacial limit. The limit lies about 240 m a.s.l. near the northwest corner of the island and about 330 m a.s.l. just south of Aston Bay and just north of Creswell Bay. South of Creswell Bay, land more than 460 m a.s.l. was overridden by vigorously flowing ice. Hence, the ice over western Somerset Island was much thicker in the south than in the north.

Ice Flow Patterns

Two main patterns of ice flow features occur on Somerset Island (Fig. 34). The entire southern peninsula and the western coastal zone between Stanwell-Fletcher Lake and Aston Bay bear evidence of overriding by an eastward-flowing ice sheet. The rest of the island, with the exception of the nunataks discussed above, bears evidence of a roughly radially flowing local ice cap. These two ice masses coalesced in the lowlands partly occupied by the head of Creswell Bay and Aston Bay.

The eastward-flowing ice sheet produced striae, fluted till, crag-and-tail hills with till tails, and large ice-moulded, streamlined bedrock forms, also mostly crag-and-tails. These large streamlined bedrock forms occur in a few places near Stanwell-Fletcher Lake but are common between Fitzroy Inlet and Bellot Strait on the southern tip of the island. The same field of eastward-oriented ice-molded bedrock forms extends 80 km onto northern Boothia Peninsula (Dyke 1979c). The eastward ice flow left a much stronger imprint on the terrain south of Stanwell-Fletcher Lake than that north of it. This is consistent with the suggestion made above, that the ice sheet was thicker in the south than in the north.

The radially flowing local ice cap left no basal flow features under its central region. In fact, it did not disturb the weathered rock mantle, which indicates that it was probably frozen to its bed. The periphery of the ice cap, however, flowed sufficiently vigorously to produce fluted till, crag-and-tails, and ice-moulded bedrock. These features are best developed where the ice streamed from the plateau into valleys as it did near Aston Bay, Cape Anne, Cunningham Inlet, west of Garnier Bay, and in the Creswell River valley systems. The large re-entrant in the boundary between the weathered and scoured rock terrains inland from Elwin Bay indicates that a vigorous ice stream entered that area as well. Subglacial meltwater features occur in the same area as the ice flow features and indicate the same flow directions (Fig. 34).

Ice Retreat Patterns

The pattern of ice marginal recession (Fig. 35) is inferred from the distribution and type of ice marginal features (Fig. 34). The only moraines on the island are a short moraine formed of till and three short kame moraines. These features are of limited use in reconstructing ice marginal positions. Features along the east coast shown as moraines by Craig (1964) and by Prest et al. (1968) were field checked and found to be rubble or till-veneered bedrock ridges and hence are not shown as moraines here.

Although moraines are scarce, ice marginal meltwater channels are widespread and abundant. Nested sets of these arcuate, valleyside, abandoned or grossly overfit channels extend for many kilometres along several valleys and clearly delineate numerous successive ice marginal positions. One of the clearest sets of such features is shown in Figure 36. Valley-to-valley correlation of these features can be achieved simply by extrapolating upslope the gradients defined by the channels until they roughly intersect on interfluves.

Just as the ice flow features demonstrate the eastward flow of an ice sheet and the radial flow of a local ice cap, the ice marginal features show an initially westward recession of the ice sheet and a roughly concentric recession of the local ice cap (Fig. 35). The centre of mass of the local ice cap, however, was displaced continuously westward as the ice cap shrank so that its last remnants were situated near its former western limit.

Although the ice sheet margin initially retreated westward, the retreat pattern was somewhat complicated later by flooding of the sea into Peel Sound. This created a southward-calving bay in the sound and isolated a fragment of the ice sheet between Aston Bay and Stanwell-Fletcher Lake (Fig. 35). This remnant ice cap retreated to the highest ground available, which coincidentally lay near its former margin. During its recession small eskers and meltwater channels with a generally westward orientation were formed (Fig. 34).

Marine Limit and Date of Ice Recession

The marine limit was formed at the instant of deglaciation of areas behind the glacial limit or when the crustal rebound rate exceeded the rate of sea level rise for areas beyond the glacial limit. Because the entire southern peninsula and western coastal zone were overridden by the eastward-flowing ice sheet, the marine limit in these areas must date from the time of deglaciation. The exact position, however, of the outer limit of the local ice cap from the head of Creswell Bay counter-clockwise to Cape Anne is not known. It probably terminated on land in some areas, particularly on high plateaus between coastal embayments, and extended offshore in other areas; however, because of the small size of the ice cap, it could not have extended far offshore, and along the east coast the margin probably coincided with the high coastal cliffs. It is possible that the local ice cap coalesced with a large Laurentide outlet glacier or an ice shelf in Prince Regent Inlet, but no evidence of ice in the inlet has been found. Hence, the marine limit probably formed slightly beyond the glacial limit along some segments of the coast and slightly behind it in others. In either case the age of the marine limit should reasonably reflect the onset of deglaciation.

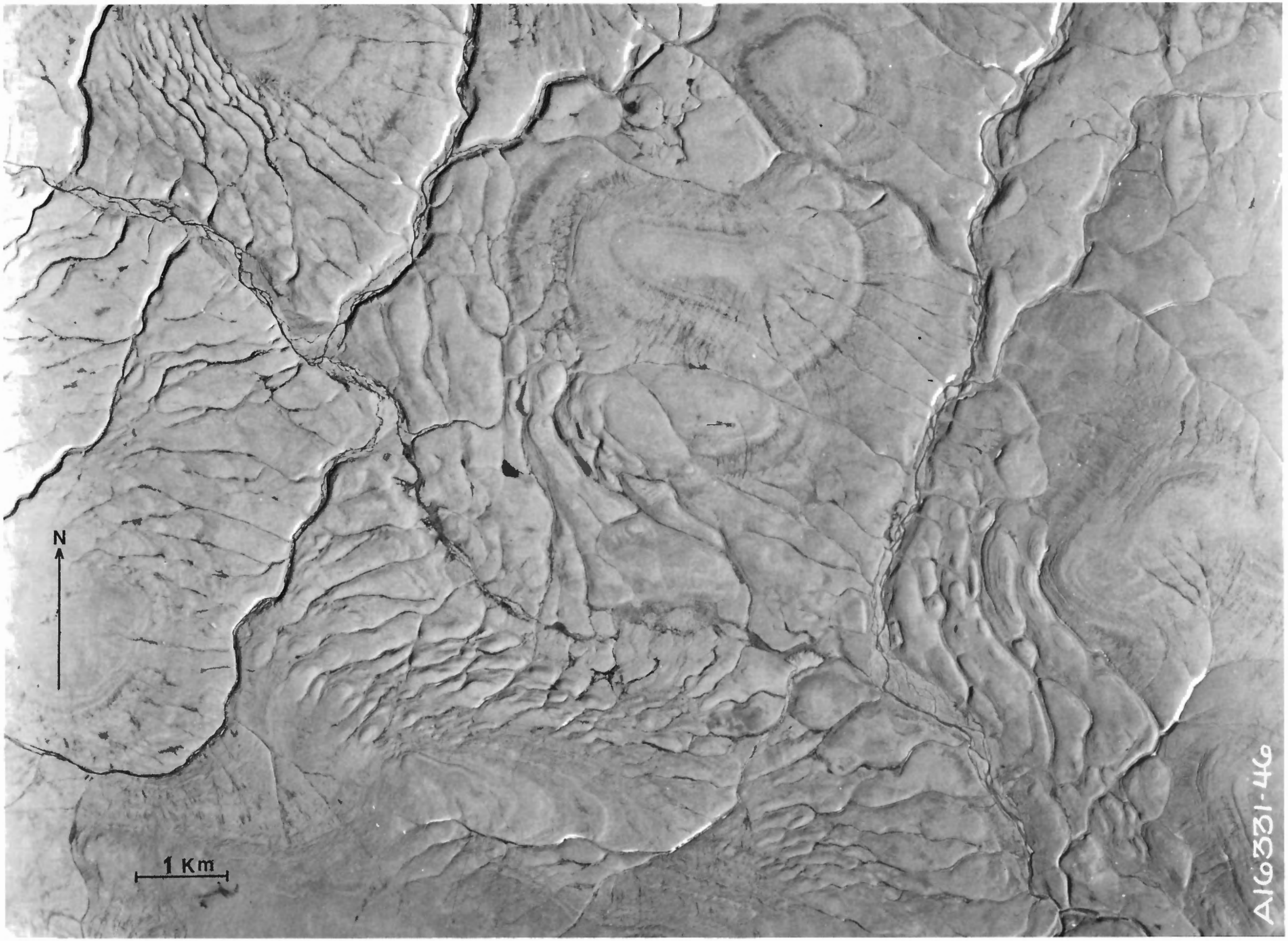

Figure 36. *Sets of nested arcuate hillside meltwater channels showing the pattern of ice recession in a valley near the headwaters of Cunningham River. NAPL-A16331-46*

Table 6. Radiocarbon dates pertaining to the Holocene marine limit and to deglaciation of Somerset Island (Fig. 34).

Date	Lab. No	Material	Elevation(m)	Location	Reference
9590 ± 115	S-1381	Whale bone	69	74°01'50"N 94°48'W	Dyke, 1980
9480 ± 190	BGS-333	Peat	53	73°46'N 95°02'W	Zoltai et al., 1978
9380 ± 180*	GSC-319	Shells	119	74°53'30"N 95°19'W	Smith, 1972; Dyke, 1979a
9310 ± 90*	GSC-2272	Shells	90	72°49'10"N 92°01'W	Dyke, 1979a
9270 ± 90*	GSC-2596	Shells	120	72°50'45"N 93°36'W	Dyke, 1979a
9240 ± 90*	GSC-2561	Shells	107	72°46'30"N 94°21'W	Dyke, 1979a
9210 ± 120*	S-1405	Whale bone	76	73°55'40"N 90°37'30"W	Dyke, 1979a
9210 ± 80	GSC-2554	Peat	100 ±	74°02'30"N 94°46'30"W	this paper
9200 ± 100*	GSC-2445	Shells	84-88	72°48'50"N 92°56'W	Dyke, 1979a
9180 ± 170*	GSC-150	Shells	62	72°59'N 93°40'W	Craig, 1964; Dyke, 1979a
9180 ± 170*	GSC-136	Shells	127	72°11'30"N 94°05'W	Craig, 1964; Dyke, 1979a
9030 ± 80	GSC-2493	Shells	90	72°56'N 93°46'W	Dyke, 1979a
9000 ± 90	GSC-2660	Shells	95-99	74°01'19"N 93°45'W	Dyke, 1979a
8990 ± 210*	GSC-2732	Shells	102	73°59'N 93°20'W	Dyke, 1979a

*pertain to marine limit

Nine radiocarbon dates relate to the marine limit along the southeast and north coasts (Fig. 34, Table 6); all dates range from 9200 to 9300 years B.P. This means that the marine limit was formed everywhere along these coasts at roughly the same time. The 9200 to 9300 year-old shoreline declines from nearly 160 m a.s.l. at the head of Creswell Bay to 76 m a.s.l. on the northeast corner of the island (Fig. 37)[1]. Its west-southwestward rise reflects the isostatic domination of the area by the eastward-flowing ice sheet, and its maximum gradient is near the limit suggested above for that ice sheet (see Dyke, 1979a for further discussion).

No dates have been obtained on the marine limit along the west (Peel Sound) coast of the island; however, it is lower there than it is at the head of Creswell Bay (about 90 m a.s.l. between Home Harbour and Cape Whitehead compared with 160 m at Creswell Bay). This indicates that it is less than 9200 to 9300 years old. It cannot, however, be much younger, because the sea had penetrated to the adjacent east coast of Prince of Wales Island by 9200 ± 160 years ago (L-571B, Olson and Broecker, 1961), and had reached as far south as Wrottesley Valley on western Boothia peninsula, about 110 km south of Bellot Strait, 9040 ± 100 years ago (GSC-2722, Dyke, 1979c). Hence, the marine limit on western Somerset Island south of Aston Bay is more than 9000 but less than 9300 years old. This means that the main (eastward-flowing) ice sheet completely disappeared from this area within a period of one or two centuries. The local ice cap probably melted entirely during this same period.

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[1] The elevation of 122 m shown in figure 37 for the northwest corner of the island is an altimeter measurement made by D.I. Smith in 1964. G. Mizerovsky determined the elevation of the sample site as plotted on an airphoto to be 75 ± 5 m by sterotope plotter. Thus, some question exists as to the accuracy of Smith's measurement. I prefer to use the original measurement because (a) the site could have been misplotted on the airphoto and (b) sea level 9380 ± 180 years ago (GSC-319, Smith's collection) was certainly much more than 75 m above present level – for example, it was at 99 m a.s.l. as late as 9000 ± 90 years ago (GSC-2660) at nearby Cape Anne (Fig. 38 and Dyke 1979a).

Three other radiocarbon dates are relevant to the timing of deglaciation of Somerset Island, and all are from sites near the northwest corner of the island. Near Cape Anne (Fig. 34; Dyke, 1980) whalebone from a site 69 m a.s.l., but considerably below the Holocene marine limit (Fig. 38), yielded an age of 9590 ± 115 years[1] (S-1381). The site must have been ice free at that time. About 1 km east of that site and at an elevation close to that of the Holocene marine limit[2], a sand-rich bed of terrestrial plant material yielded an age of 9210 ± 80 years (GSC-2554). The organic bed rested on grey sand with blebs of organics and was overlain by a 63 cm-thick layer of red till or colluviated till, which in turn was overlain by 67 cm of red sand with marine shell fragments. Obviously the site was ice free at the time of plant growth, but whether the overlying "till" represents a readvance or simply a period of solifluction is not known. The uppermost unit, red sand with shell fragments, could be a marine sediment, slope wash deposit, or eolian deposit. Finally, cryoturbated terrestrial plant fragments (including **Salis arctica**) from an earth hummock near the north shore of Aston Bay (Fig. 34, Table 6, and Zoltai et al., 1978) yielded an age of 9480 ± 190 years[1] (BGS-333). Both dates on terrestrial plant material overlap with the oldest dates on marine shells and whale bones (Table 6) and confirm the reliability of radiocarbon dates on marine organisms in establishing deglacial chronologies.

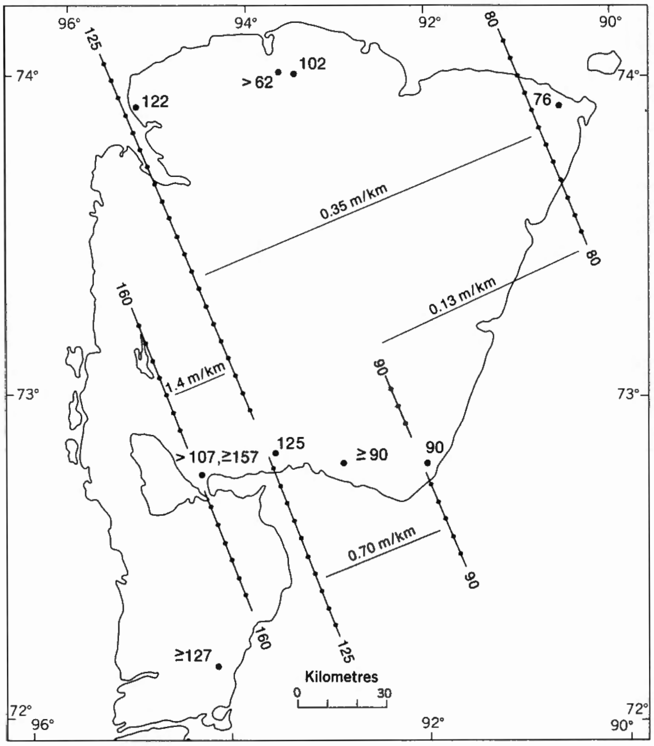

Figure 37. Isobases (barbed lines) on the 9200 to 9300 year-old shoreline on Somerset Island, with average gradients noted along orthogonal lines; numbers refer to elevations (m a.s.l.) (from Dyke, 1979a).

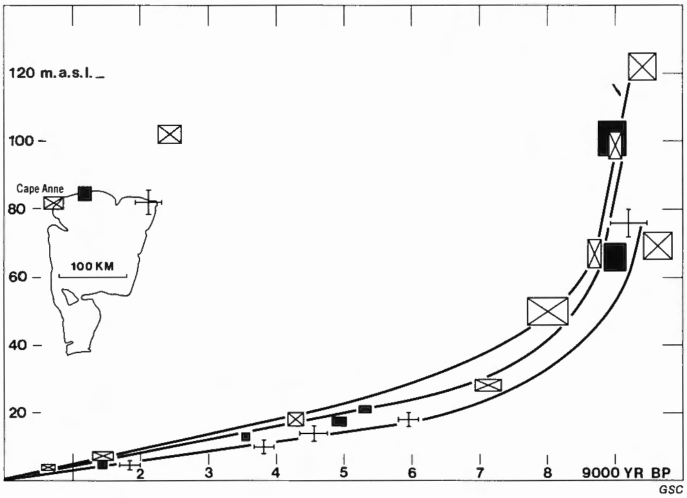

Figure 38. Holocene emergence curves for northern Somerset Island (from Dyke, 1980). The height of each symbol is the estimated error on elevation measurements and the width is 2 sigma error on the radiocarbon age determination.

Postglacial Events

Emergence

The Holocene emergence of Somerset Island, brought on by rapid deglaciation between 9300 to 9100 years ago, has been treated in some detail by Dyke (1979a, 1980). Only the most significant conclusions need be repeated here.

The pattern of emergence of the north coast of the island is shown by three emergence curves in Figure 38. These curves show that the western part of the island has consistently emerged at a faster rate than the eastern part. Early emergence rates were high everywhere, averaging 8 to 11 m per century and 56 per cent of total emergence occurred within the first 1000 years after deglaciation.

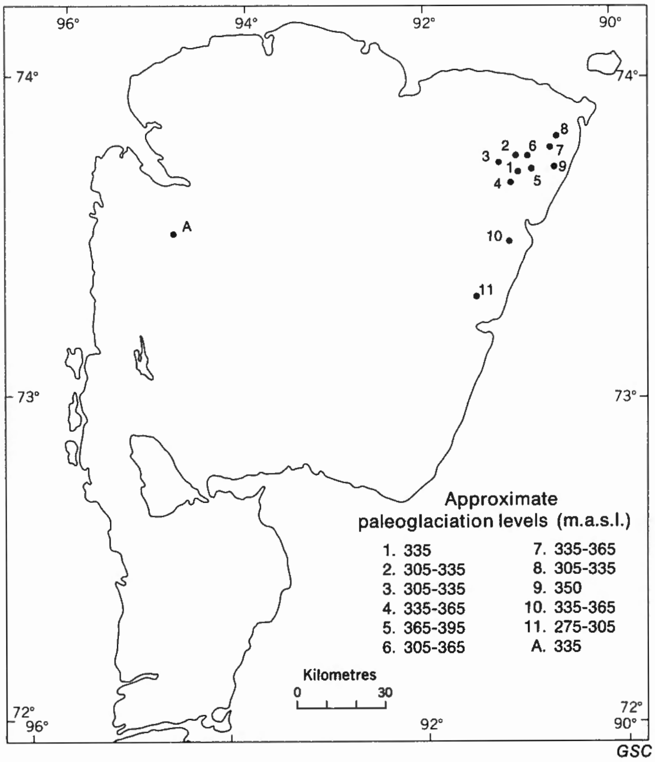

Figure 39. Locations of Neoglacial firn field (A) and ice caps (1-11) and indicated paleoglaciation levels on Somerset Island.

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[1] Error term is 1 standard deviation whereas GSC dates quote 2 standard deviation error.

[2] Elevation not measured in field.

During the last 5000 to 6000 years the west coast has emerged at a constant rate of about 46 cm per century while the east coast has emerged about 28 cm per century. The island continues to emerge at these rates.

Neoglaciation

At some time during the very recent past a climatic deterioration in the central Canadian Arctic lowered the regional snowline sufficiently to cause renewed glacierization of small parts of Somerset Island. Dyke (1978b) discussed lichen-kill areas caused by formerly expanded firn fields and areas of miniature meltwater channels and eskers formed during the meltout of small ice caps. No opportunity to date the growth or decay of these firn fields and ice caps was found, but similar events, which are likely correlative, have been dated at several places on Baffin Island (Falconer, 1966; Locke and Locke, 1977). Extensive thin ice caps and snowfields grew there 100 to 350 years ago and melted during the historic warm interval of the first half of this century. Remnants of the small ice caps on Somerset Island exist today as stagnant ice plugs in canyons (Grey, 1976, his plates 42, 43).

The elevations of the land on which these small ice caps and firn fields sat approximate the paleoglaciation level, a type of regional snowline (Fig. 39). That snowline was 300 to 350 m a.s.l. over northeastern and northwestern Somerset Island but must have been somewhat higher over the central part of the island because large areas there at those elevations and slightly higher apparently escaped glacierization.

SUMMARY

Pre-Quaternary Features

The major geographic elements of the central Canadian Arctic Islands, namely the islands and inter-island channels, were formed during the Late Cretaceous-Late Tertiary Eurekian Rifting Episode, a consequence of the rifting of Canada from Greenland. Most of the surface of Somerset Island is a fragment of the Barrow Surface, one of the most extensive and best preserved surfaces of erosional planation in Arctic Canada. That surface was formed before the Eurekian Rifting Episode. Smaller geographic elements, particularly anomalous canyons on northeastern Somerset Island, likely are relict, pre-Eurekian landforms as well.

Surface Materials

The surface materials of Somerset Island are divided into eight genetic units. Rock and residuum (weathered rock mantle) cover about 70 per cent of the island. The rock is everywhere modified by glacial erosion which has produced rugged hilly and hummocky topography with deranged drainage. The residuum, on the other hand, mantles smooth low-angle slopes dominated by periglacial landforms (particularly nivation hollows, cryoplanation terraces, and tors) and drained by well-integrated stream systems. The residuum itself has various textures ranging from felsenmeer blocks and grus on granite gneiss to rubbly diamicton on carbonate bedrock. The latter is texturally identical to tills on the island, but the residuum differs from tills in that the colour, composition, and structure of the underlying bedrock is repeated in the residuum.

Till covers about 20 per cent of the island, texturally classifies as loam or sandy loam, and ranges from slightly to extremely calcareous. Tills overlying the Precambrian Shield and tills derived from the Shield, but overlying Paleozoic sedimentary bedrock, are well vegetated. Tills derived from local carbonate bedrock are poorly vegetated or unvegetated. The well vegetated till is thought to have been deposited by Laurentide ice (or some other regional ice sheet) and the poorly or unvegetated tills by a local (island-based) ice cap.

Glaciofluvial gravel and sand (kames. eskers, and proglacial outwash), deposited during the last deglaciation, cover small areas. The two largest kames, near the southern tip of the island, are probably end moraines. Other short-lived deglacial features were small ice-dammed lakes in the north-central part of the island; however, only small amounts of lacustrine sediment accumulated.

Raised marine sediments of deltaic, nearshore, and beach facies form the third most extensive terrain on the island. Especially large raised deltas occur south of Cunningham Inlet and north of Creswell Bay. Extensive raised beach gravels line most coasts underlain by sedimentary bedrock, except the cliffed coast of Prince Regent Inlet.

Postglacial alluvium occurs mainly along the lower reaches of large rivers (Aston, Cunningham, Elwin, Batty, and Creswell rivers) and about half of it underlies active floodplains.

Large areas of colluvium overlie gentle slopes and valley floors in the weathered rock terrains. This material was derived through solifluction, sheetwash, and rillwash from the finer grained components of the residuum that mantles higher slopes.

Economic Geology

Small gravel resources occur in kames, eskers, proglacial outwash, and the upper metre or so of raised deltas. The largest gravel source is raised beaches, but that material in many places consists of angular limestone plates or is muddy. Fluvial gravels are not extensive and about half underlie active floodplains where extraction would be difficult and environmentally harmful. Sand is more plentiful than gravel; large sand resources occur in the topset and foreset facies of raised deltas and in unlithified Cretaceous-Tertiary "sandstones"; smaller amounts occur in raised beaches derived from sandstone or sandy till near Stanwell-Fletcher Lake and Cape Anne. The most widespread granular resource is riprap which occurs as a 1 m-thick veneer of limestone felsenmeer. Because of the shallowness of this material, however, it would probably be more economical and less damaging environmentally to produce riprap by blasting and crushing friable bedrock.

Most tills and weathered bedrock are Cl, Cl-Ml, or ML soils in the Unified Soil Classification System; liquid limits are 15 to 36 per cent, and plasticity indices 1.5 to 12 per cent. Tills derived from sandstone bedrock near Cape Anne and granitic colluvium and residuum are SC and SM soils. Fine grained marine sediments are mostly CL soils (minor OL soils) with liquid limits in the 23 to 37 per cent range and plasticity indices of 2.5 to 15.7 per cent.

Permafrost is about 500 m thick near the coast of Somerset Island and possibly extends beneath the inter-island straits. Temperatures fluctuate seasonally in the upper 20 m or so of frozen ground, and annual temperature ranges increase towards the surface. The primary control on the temperature gradient in the active layer is air temperature.

Ground ice in bedrock is restricted to small joint fillings and partings along bedding planes but growth of these fillings has displaced joint blocks by as much as 1 m from their original positions. A few centimetres to decimetres of segregated ice lenses probably occur at the interface between residuum and rock. Thick tills are the most ice-rich sediments on the islands as indicated by ubiquitous large ice-wedge polygons and many retrogressive-thaw flowslides, both of which indicate massive segregated ground ice. Thin tills lack extensive bodies of massive ground ice, but pore ice, coatings around stones, and small (1-10 cm thick) ice lenses produce natural moisture contents that exceed the liquid limit of the soil, especially in the metre of material just above bedrock. Kames, outwash, marine sand and gravel, and fluvial sand and gravel have excess ice in the form of ice wedges. Colluvial sediments, because they have accumulated in wet areas, probably have much segregated ground ice.

Slope instability could be triggered by thawing the uppermost ice-rich permafrost, by disturbing or loading slopes during the spring when most active layer materials (particularly diamictic soils) are saturated beyond their liquid limits, or by artificially saturating slopes during other parts of the thaw season.

Trafficability varies seasonally and according to type of vehicle. Rugged terrain, canyons, and gullies reduce accessibility to certain areas; blockfields, bouldery tills, ice-wedge polygon troughs, and high-relief mudboils create surfaces that are probably too rough for small-wheel and air cushioned vehicles; and springtime saturation of the active layer produces traction problems.

Metal content analysis of drift samples has identified two areas of possible economic interest. An area of weathered granite gneiss cut by diabase dykes 15 km east of Fiona Lake has high copper, zinc, nickel, and chromium concentrations, and locally derived till over carbonate bedrock northeast of Aston Bay has high zinc, nickel, and manganese concentrations. Isolated sample anomalies occur elsewhere but are difficult to evaluate bacause of low sample density.

Quaternary History

The earliest Quaternary events currently recognized on Somerset Island are bedrock weathering, which produced the extensive residual and colluvial soils, and glaciations(s), which left scattered erratics in the weathered rock terrains. The relative ages of these events are not known but they occurred before the last glaciation. The erratics, because of their widespread distribution, must have been deposited by a regional ice sheet.

Two lines of evidence point to nonglacial conditions and a marine transgression prior to the last glacial advance. Driftwood from a raised glaciomarine delta, situated considerably above the Holocene marine limit in Creswell Bay, yielded a radiocarbon age of more than 38 000 years (GSC-2542); shells in beach sediments near the delta and the youngest erratic shells in till deposited by the last ice sheet appear, from their amino acid ratios, to date from a period within the Wisconsin Glaciation. The distribution of the erratic shells in till requires that Peel Sound was ice free during the nonglacial interval.

During the last glacial episode (late? Wisconsin) southern and western Somerset Island were overridden by an eastward-flowing ice sheet, while the northeastern plateau supported a radially flowing local ice cap. The ice sheet and ice cap coalesced in Aston Bay and at the head of Creswell Bay. Elsewhere they were separated by nunataks. Glacial limits recorded at the edge of the nunataks are 240 m a.s.l. near the northwest corner of the island and 330 m a.s.l. just south of Aston Bay and just north of Creswell Bay. Land more than 460 m a.s.l. south of Creswell Bay was overridden by vigorously flowing (strongly eroding) ice, indicating a southward increase in ice thickness.

The pattern of ice marginal recession is clearly indicated by a multitude of ice marginal meltwater channels. The main ice sheet retreated westward on land and southward by calving down Peel Sound. Calving in the sea was more rapid than retreat on land, resulting in isolation of a remnant of the ice sheet between Aston Bay and Stanwell-Fletcher Lake. That remnant ice cap then retreated from lower to higher ground. The main local ice cap retreated in a roughly concentric pattern, but with a westward migration of its centre.

Nine radiocarbon dates on the marine limit along the south, east, and north coasts all fall in the interval 9200 to 9300 years B.P. The 9200 to 9300 year-old shoreline declines from nearly 160 m a.s.l. at the head of Creswell Bay to 76 m a.s.l. at the northeast corner of the island, thus reflecting the isostatic domination of the area by the main (eastward-flowing) ice sheet. The marine limit along the west coast is lower than at the head of Creswell Bay because that coast was deglaciated later than 9300 years ago; however, it must have become ice free shortly thereafter because the sea had reached eastern Prince of Wales Island by 9200 ± 160 years ago. (L-571B) and penetrated as far south as Wrottesley Valley on the west coast of Boothia Peninsula by 9040 ± 100 years ago (GSC-2722).

Somerset Island has continued to emerge throughout the Holocene. Initial emergence was 8 to 11 m per century but this slowed to 46 (west coast) and to 28 (east coast) cm per century by 5000 to 6000 years ago.

Some time in the very recent past (Neoglacial) a climatic deterioration led to snowline lowering and expansion of a number of small ice caps and firn fields. The paleoglaciation level at that time was 300 to 350 m a.s.l.

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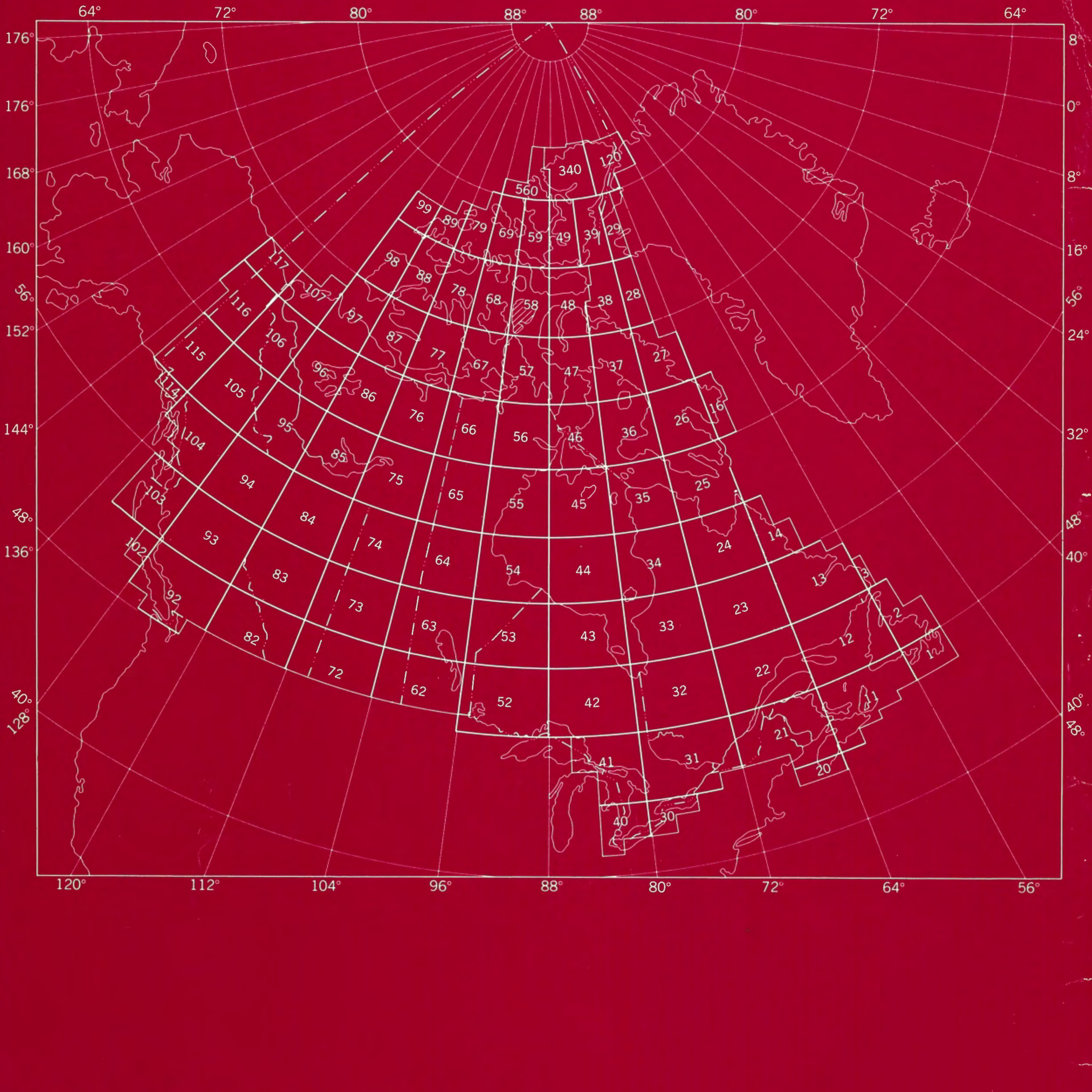

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