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J.M. Aylsworth
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Authors' addresses

J.M. Aylsworth
W.W. Shilts
Geological Survey of Canada,
401 Lebreton St.,
Ottawa, Ontario,
K1A 0E8

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SURFICIAL GEOLOGY OF COATS AND MANSEL ISLANDS, NORTHWEST TERRITORIES

Abstract

The surficial materials of Coats and Mansel islands fall into five genetic categories — rock, till, glaciofluvial, marine, and alluvial sediments. Marine sediments, particularly nearshore sediments, are predominant and raised beaches comprise the most outstanding landforms on these islands. Unusual transverse gravel bars that are oriented perpendicular to the shoreline on and around Mansel Island are the result of wave refraction initiated by local bedrock protuberances in the generally smooth, gently sloping, and isostatically emerging offshore bottom.

During most of the last glaciation ice flow was northeasterly across Coats Island and northerly across Mansel Island as ice moved out of Hudson Bay into Hudson Strait. Distribution of "dark" erratics from Quebec and "red" erratics from District of Keewatin indicates that Mansel Island was glaciated exclusively by ice flowing away from the Quebec-Labrador Ice Divide and that Coats Island was glaciated by ice flowing from the Keewatin Ice Divide. At least once Labrador ice encroached on Coats Island. The contact between Keewatin and Labrador ice lay between Coats and Mansel islands, sometimes overlapping onto Coats Island as the relative strength of the two ice masses waxed and waned. Petrological evidence suggests that similar ice flow conditions may have existed during earlier glaciations as well.

Deglaciation began with the opening of a marine reentrant between Coats and Mansel islands, leading to drastic shifts in ice flow directions due to the drawdown effect of this reentrant. Most of the area was submerged during deglaciation. As one of the first areas in Hudson Bay region to be deglaciated, the relatively low elevation of marine limit (124 m) on northeastern Coats Island implies that the Laurentide Ice Sheet was thin near the outlet of Hudson Bay prior to deglaciation.

Résumé

Les matériaux superficiels des îles Coats et Mansel appartiennent à cinq catégories génétiques — roches, till et sédiments fluvio-glaciaires, marins et alluviaux; ces matériaux sont cartographiés et décrits dans le présent rapport. Les sédiments marins, particulièrement les sédiments littoraux, sont prédominants et des plages soulevées constituent la forme de relief la plus remarquable de ces îles. Des bancs de gravier transversaux de nature insolite, perpendiculaires à la ligne de rivage et situés dans l'île Mansel et autour de celle-ci, sont le résultat de la réfraction d'onde déclenchée par des protubérances locales du socle situées sur le fond sous-marin généralement lisse et faiblement incliné qui émerge sous l'effet isostatique.

Au cours de la majeure partie de la dernière glaciation, l'écoulement glaciaire se faisait vers le nord-est sur l'île Coats et vers le nord sur l'île Mansel, la glace sortant de la baie d'Hudson pour entrer dans le détroit d'Hudson. La répartition de blocs erratiques "foncés" provenant du Québec et de blocs erratiques "rouges" provenant du district de Keewatin indique que l'île Mansel était couverte exclusivement de glace qui s'écoulait de la ligne de partage des glaces du Québec et du Labrador tandis que la glace recouvrant l'île Coats écoulait de la ligne de partage des glaces de Keewatin. Une fois, au moins, la glace du Labrador a recouvert l'île Coats. Le contact entre la glace du Keewatin et celle du Labrador se trouve entre l'île Coats et l'île Mansel, chevauchant parfois l'île Coats, selon la force relative des masses glaciaires qui était variable. Des indices pétrologiques laissent supposer que des conditions similaires d'écoulement glaciaire pourraient également avoir existé au cours des premières glaciations.

La déglaciation a commencé avec l'ouverture d'une échancrure marine entre l'île Coats et l'île Mansel, bouleversant les directions de l'écoulement glaciaire, par suite de l'effet de convergence causé par cette échancrure. La majeure partie de la région a été submergée pendant la déglaciation. Étant une des premières zones de la région de la baie d'Hudson à se débarrasser de sa glace, l'altitude relativement faible de la limite marine (124 m) dans le nord-est de l'île Coats semble indiquer que l'inlandsis Laurentidien était mince près de la sortie de la baie d'Hudson avant la déglaciation.

SUMMARY

Surficial materials. The surficial materials of Coats and Mansel islands are divided into five genetic categories. Bedrock forms or lies near the surface of large parts of both islands, but unquestionable outcrops of the Paleozoic bedrock which underlies Mansel and most of Coats islands are rare. Generally, the Paleozoic bedrock surface consists of a frost shattered rubble with or without a fine grained matrix which might be glacial, marine, or even insoluble residues and secondary carbonate deposits derived from solution of the outcrop. In contrast, the Precambrian inlier that forms northern Coats Island is glacially polished or striated with little evidence of weathering. A carbonate-rich till covers 18% and 13% of Coats and Mansel islands, respectively. The upper part of most till exposures has been mixed with fine grained marine sediments by periglacial processes and wave reworking during isostatic rebound. Very little debris from the Precambrian bedrock of northern Coats Island is found in the overlying carbonate-rich till, probably due to the small area and resistant nature of the inlier. Flutings are common on both the till and bedrock surfaces of these islands. Glaciofluvial deposits are restricted to a few eskers, all of which have been flattened by wave reworking during rebound. Marine deposits are the most significant units on both islands. Nearshore marine sediments comprise 45% and 75% of the area of Coats and Mansel islands, respectively, and include spectacular flights of raised cobble beaches, thin sand sheets left as lag deposits, and strip deltas, a landform formed by a combination of alluvial and marine processes. Unusual transverse gravel bars oriented perpendicular to the shoreline on Mansel Island and extending up to 3 km offshore are thought to be the result of wave refraction initiated by local bedrock protuberances on the generally smooth, gently sloping, isostatically emerging offshore bottom. Raised fine grained marine offshore deposits, commonly covered by an organic mat, form broad coastal plains on Coats Island and fill the intervening flat areas between nearshore units on both islands. Modern alluvial deposits are restricted to small areas of alluvium on floodplains and in channels on the outer slopes of Coats Island and northwestern Mansel Island or small alluvial fans along their steeper eastern slopes.

Glacial history. Several directions of glacial flow are recorded by the flutings, drumlins, and striae on Coats Island. The most common and best preserved flow indicators and the oldest striae, northeastward and parallel to the long axis of the island, probably represent ice movement throughout most of the glaciation. On Mansel Island the predominant direction of ice flow was slightly west of northerly, and likewise represents movement throughout most of the glaciation. Lying as the islands do, near the outlet of Hudson Bay, that portion of the Laurentide Ice Sheet which occupied Hudson Bay had to cross the islands in a northerly direction before flowing out into Hudson Strait.

SOMMAIRE

Dépôt superficiels. Les dépôts superficiels des îles Coats et Mansel sont répartis en cinq catégories génétiques. Le socle rocheux est à la surface ou près de la surface de grandes parties des deux îles, mais des affleurements indiscutables du socle paléozoïque sous-jacent à l'île Mansel et à la majeure partie de l'île Coats sont rares. En général, la surface du socle paléozoïque se compose de blocaille gélifractée, enchâssée ou non dans une matrice à grain fin qui pourrait être d'origine glaciaire ou marine, ou même formée de résidus insolubles et de dépôts carbonatés secondaires provenant de la dissolution de l'affleurement. Par contre, la fenêtre précambrienne qui forme le nord de l'île Coats a été polie et striée par les glaciers et montre peu de signes d'érosion. Un till riche en carbonate couvre, respectivement, 18 % et 13 % des îles Coats et Mansel. La partie supérieure de la plupart des tills exposés a été mêlée à des sédiments marins à grain fin par des processus périglaciaires et par l'action de vagues qui ont remanié les dépôts pendant le relèvement isostatique. On retrouve très peu de débris du socle précambrien du nord du l'île Coats dans le till sus-jacent riche en carbonate, probablement en raison de la petite taille de la fenêtre et de la résistance de la roche exposée. Dans ces îles, la surface du till et du socle rocheux est fréquemment marquée de cannelures glaciaires. Les dépôts fluvio-glaciaires se limitent à quelques eskers, qui ont tous été aplanis par l'action des vagues au cours du relèvement. Des dépôts de sédiments marins représentent les plus importantes unités des deux îles. Les sédiments marins littoraux forment 45 % et 75 % de la surface des îles Coats et Mansel, respectivement, et comprennent des plages de galets soulevées formant de remarquables escaliers, de minces couches de sable qui sont des résidus de déflation et des deltas en forme de bande (strip delta), entité formée par l'action conjointe de processus alluviaux et marins. On note, dans l'île Mansel, la présence de bancs de gravier transversaux assez insolites qui sont perpendiculaires au rivage et s'avancent jusqu'à 3 km dans la baie : ces bancs pourraient être le résultat d'une réfraction de l'onde causée par des protubérances locales du socle situées, au large des côtes, sur le fond marin généralement lisse et faiblement incliné qui émerge sous l'effet isostatique. Des sédiments marins soulevés, à grain fin, qui avaient été déposés au large des côtes, sont fréquemment couverts d'un tapis organique et forment de vastes plaines littorales dans l'île Coats, en plus de combler les régions planes entre les unités littorales des deux îles. Les gîtes alluvionnaires contemporains se limitent à de petites accumulations d'alluvions dans les plaines d'inondation et dans les chenaux des versants extérieurs de l'île Coats et du nord-ouest de l'île Mansel ou encore, à de petits cônes de déjection le long des pentes plus prononcées de la côte est.

Histoire glaciaire. Les cannelures glaciaires, les stries et les drumlins étudiés dans l'île Coats révèlent que les glaces se sont déplacées dans plusieurs directions. Les indicateurs les plus courants et les mieux conservés de l'écoulement glaciaire ainsi que les stries les plus anciennes, vers le nord-est et parallèlement au grand axe de l'île, témoignent probablement du mouvement des glaces pendant la majeure partie de la période glaciaire. Dans l'île Mansel, la direction prédominante de l'écoulement

The actual sources of the ice flow were determined by the distinctive lithologies of specific indicator erratics on these islands — the "dark" erratics of the Proterozoic Circum-Ungava belt of Quebec and the "red" erratics of the Dubawnt. Group of central Keewatin. Precambrian erratics on Mansel Island come exclusively from Quebec and represent flow from the Quebec-Labrador Ice Divide. Precambrian erratics on Coats Island include "red" erratics from mainland Keewatin and, particularly along the southeastern coast, "dark" erratics from Labrador. From the petrological evidence it is obvious that two ice masses, moving into Hudson Bay from either side, converged, turned and coalesced to flow northward out of Hudson Bay across these islands. The zone of contact between the Keewatin and Labrador ice sheets lay between Coats and Mansel islands and sometimes shifted over Coats Island with changes in the relative strength of each ice sheet.

Because of the distance that the "red" Keewatin erratics travelled to reach Coats Island, it is likely that a significant length of travel time was required, implying that flow conditions remained constant for much of the last glaciation. As well, the exclusion of "red" erratics from Mansel Island suggests that the flow conditions described above were similar throughout most of the last and during earlier glaciations.

The later, shifting directions of ice movement on these islands reflect drawdown towards a marine reentrant which opened between Coats Island and Mansel Island as the sea penetrated Hudson Bay late in the existence of the Laurentide Ice Sheet.

Deglaciation of the islands occurred beneath marine waters with the exception of northernmost Coats Island. There, marine limit is unexpectedly low (124 m) for one of the earliest deglaciated areas of Hudson Bay, indicating that the ice sheet must have been thin over this area just prior to deglaciation. As the islands isostatically rebound through wave base, the glacial deposits were reworked into the extensive flights of raised beaches that comprise the most outstanding landforms of Coats and Mansel islands today.

glaciaire était juste un peu à l'ouest du nord et, là encore, il s'agit de la direction empruntée par les glaces pendant la majeure partie de la période glaciaire. Étant donné la position géographique de ces îles, c'est-à-dire près de la sortie de la baie d'Hudson, la section de l'inlandsis Laurentidien qui occupait la baie d'Hudson n'a pu que traverser les îles en direction nord pour atteindre le détroit d'Hudson.

L'origine réelle de l'écoulement glaciaire a été établie en s'appuyant sur la lithologie caractéristique d'indicateurs particuliers présents dans ces îles, soit les blocs erratiques "foncés" de l'arc protérozoïque péri-ungavien, au Québec, et les blocs erratiques "rouges" du groupe de Dubawnt, dans la partie centrale du district de Keewatin. Les blocs erratiques précambriens de l'île Mansel ne viennent que du Québec et témoignent d'un écoulement glaciaire provenant de la ligne de partage des glaces du Québec et du Labrador. Dans l'île Coats, en revanche, les blocs erratiques précambriens comprennent des blocs "rouges" de la partie continentale du district de Keewatin et, particulièrement le long de la côte sud-est, des blocs "foncés" du Labrador. Ces observations pétrologiques montrent de façon évidente que deux masses glaciaires qui étaient situées de part et d'autre de la baie d'Hudson et se déplaçaient vers cette derniére ont convergé, ont viré et se sont fusionnées pour ensuite s'écouler en direction nord et quitter la baie d'Hudson en traversant les îles à l'étude. La zone de contact des inlandsis de Keewatin et du Labrador se trouvait entre les îles Coats et Mansel; parfois, le contact s'est établi au dessus de l'île Coats en raison de changements se produisant au niveau de la puissance relative des deux inlandsis.

En raison de la distance que les blocs erratiques "rouges" du Keewatin devaient parcourir pour atteindre l'île Coats, il est vraisemblable que ces déplacements ont pris beaucoup de temps. On peut donc supposer que les conditions d'écoulement sont restées constantes pour une bonne partie de la dernière période glaciaire. De même, l'absence de blocs "rouges" dans l'île Mansel semble indiquer que les conditions d'écoulement décrites plus haut étaient presque les mêmes au cours de la majeure partie de la dernière période glaciaire ainsi que pendant les périodes glaciaires antérieures.

La direction de l'écoulement glaciaire dans les îles a changé plus tard : cela reflète une convergence des glaces vers une échancrure marine qui s'est ouverte entre les îles Coats et Mansel lorsque la mer a envahi la baie d'Hudson, à un stade avancé de l'inlandsis Laurentidien.

Les îles étaient recouvertes d'eau salée au moment de la déglaciation, à l'exception de l'extrême nord de l'île Coats. La limite marine est étonnamment basse (124 m) dans cette région, étant donné qu'il s'agit d'une des premières parties de la baie d'Hudson à être libérées des glaces. Ce fait indique que l'inlandsis devait être mince à cet endroit juste avant la déglaciation. À mesure que les îles ont émergé avec le relèvement isostatique, en traversant le niveau inférieur d'action de l'onde, les dépôts glaciaires ont été remaniés de manière à former les vastes escaliers de plages soulevées qui forment aujourd'hui les plus remarquables entités topographiques des îles Coats et Mansel.

INTRODUCTION

Objectives

In 1979 a reconnaissance was made of the surficial geology of Coats and Mansel Islands. These islands lie in the most northerly part of Hudson Bay between Southampton Island and Ungava Peninsula, Quebec (Fig. 1).

There were three objectives of this survey:

1) The principal objective of the reconnaissance was to determine the nature of the Precambrian erratics on Coats and Mansel islands. They lie athwart the outlet of Hudson Bay where the part of the Laurentide Ice Sheet that occupied the bay flowed northward and northeastward into Hudson Strait. The main types of erratics sought were distinctive — unmetamorphosed, Proterozoic age, red sedimentary and volcanogenic rocks that outcrop in the Baker Lake - Dubawnt Lake region of the District of Keewatin and the black and dark grey sedimentary and volcanogenic rocks that outcrop in the Circum-Ungava belt which cuts across northern Nouveau-Quebec and underlies the eastern part of Hudson Bay (Fig. 1). Both types of erratics are easily distinguishable from both the local light-coloured Paleozoic carbonate lithologies, and the Precambrian gneiss that forms the north tip of Coats Island.

2) A second objective was to determine the maximum level of marine submergence on Coats Island and, if possible, to collect marine shells for dating purposes from the extensive flights of beaches developed on both islands.

3) The final objective was to confirm the accuracy of preliminary airphoto interpretation maps of surficial geology made for both islands and to investigate the nature of the surficial deposits, with the intention of producing maps of the surficial geology of both islands.

Logistics and method

The Canadian Coast Guard icebreaker CCGS Pierre Radisson was made available to the Geological Survey of Canada to provide a mobile base from which a helicopter reconnaissance of the surficial geology of Coats and Mansel Islands could be undertaken. W.W. Shilts and R.N.W. DiLabio joined the ship on July 24, 1979 at Deception Bay, Québec and remained with the ship until August 6. During this time 5 helicopter traverses with 32 landings were made on Coats Island (inset, Map 1633A) and 4 traverses with 20 landings were made on Mansel Island (inset, Map 1632A). Weather conditions prevented further flying during the time that the vessel was in these waters. Brief reconnaissance and several stops were also made on Bencas Island and on Walrus Island, the latter being located approximately midway between Coats and Southampton islands.

Previous to the field season a preliminary map of the surficial geology of the islands was prepared from airphoto interpretation by the second author. During the reconnaissance the field officers made observations on the nature of the surficial deposits and geomorphic features including the notation of changes or additions to the preliminary map. As well, direction of striae and elevation of marine limit were measured and sediment samples were collected. These samples were analyzed in the laboratory for texture, Atterberg limits, trace elements, heavy minerals, and pebble lithology. The results of the pebble lithology count were included in Shilts (1982).

In 1983-84 a final airphoto interpretation was made by the first author and the accompanying surficial geology maps were compiled of Mansel (Map 1632A) and Coats (Map 1633A) islands.

Geography

Coats Island (5500 km^2) and Mansel Island (3180 km^2) lie near the outlet of Hudson Bay between Southampton Island and Ungava Peninsula, Quebec. Both islands have flat to gently rolling surfaces with elevations generally below 120 m a.s.l. Their surfaces are characterized by frost-shattered bedrock, complex patterns of raised beaches and spits, and large areas of wetlands covered with peat and tundra ponds.

The climate of the islands is characterized by long cold winters and short cool summers with a summer precipitation maximum. During the summer the surface winds are variable in direction, reflecting the changing position of the low pressure areas moving past the region. Storm winds often move directly across Hudson Bay from the west and southwest (Thompson, 1968). The surrounding cold seas cause much fog and low cloud.

Coats Island supports a permanent caribou herd and its coastal wetlands are a breeding area for waterfowl. Numerous polar bears were observed on both Coats and Mansel islands and the adjacent waters abound in walrus. The elongate lakes in the central valley of Mansel Island are reputed to be rich in fish, particularly Arctic char.

Human settlement

No permanent human settlements are maintained on the islands, but fishing and hunting are carried out on both from temporary camps.

Mathiassen (1931) reported that G.F. Lyon landed on the south coast of Coats Island in 1824 and encountered a tribe of people, the Sadlermiut, who also inhabited Southampton Island. The Sadlermiut disappeared from Coats Island some time in the last century and the last remaining settlement on Southhampton Island was wiped out during a typhoid epidemic in 1902 (Collins, 1955). As far as is known, these people, the last remnants of the prehistoric Dorset culture, have disappeared as an identifiable group (Collins, 1956). The Hudson's Bay Company operated a post on Coats Island until 1924 and until that time, another group of people, the Okomiut, who had been transported from southern Baffin Island, maintained permanent residence on Coats Island. These people were ultimately resettled on Southampton Island (Bird, 1953, p. 50).

Previous work

No previous study of glaciation of Coats and Mansel islands has been reported. In fact, until the work of Heywood and Sanford (1976), who mapped the geology of the islands in 1968-1970, little geological information of any sort was available for these islands. A summary of the scanty early geological observations of Coats and Mansel (Mansfield Island in 19th century) islands is presented by Nelson and Johnson (1966) who visited the islands briefly themselves.

Prior to the 1979 reconnaissance by W.W. Shilts and R.N.W. DiLabio, it was known from airphoto interpretation that both islands were almost entirely below marine limit, that they were covered by extensive beach deposits, and that glacial flutings were oriented approximately parallel to their long axes (Prest et al., 1968). The source of information about striae recorded on Coats Island by Prest et al. (1968) is not known.

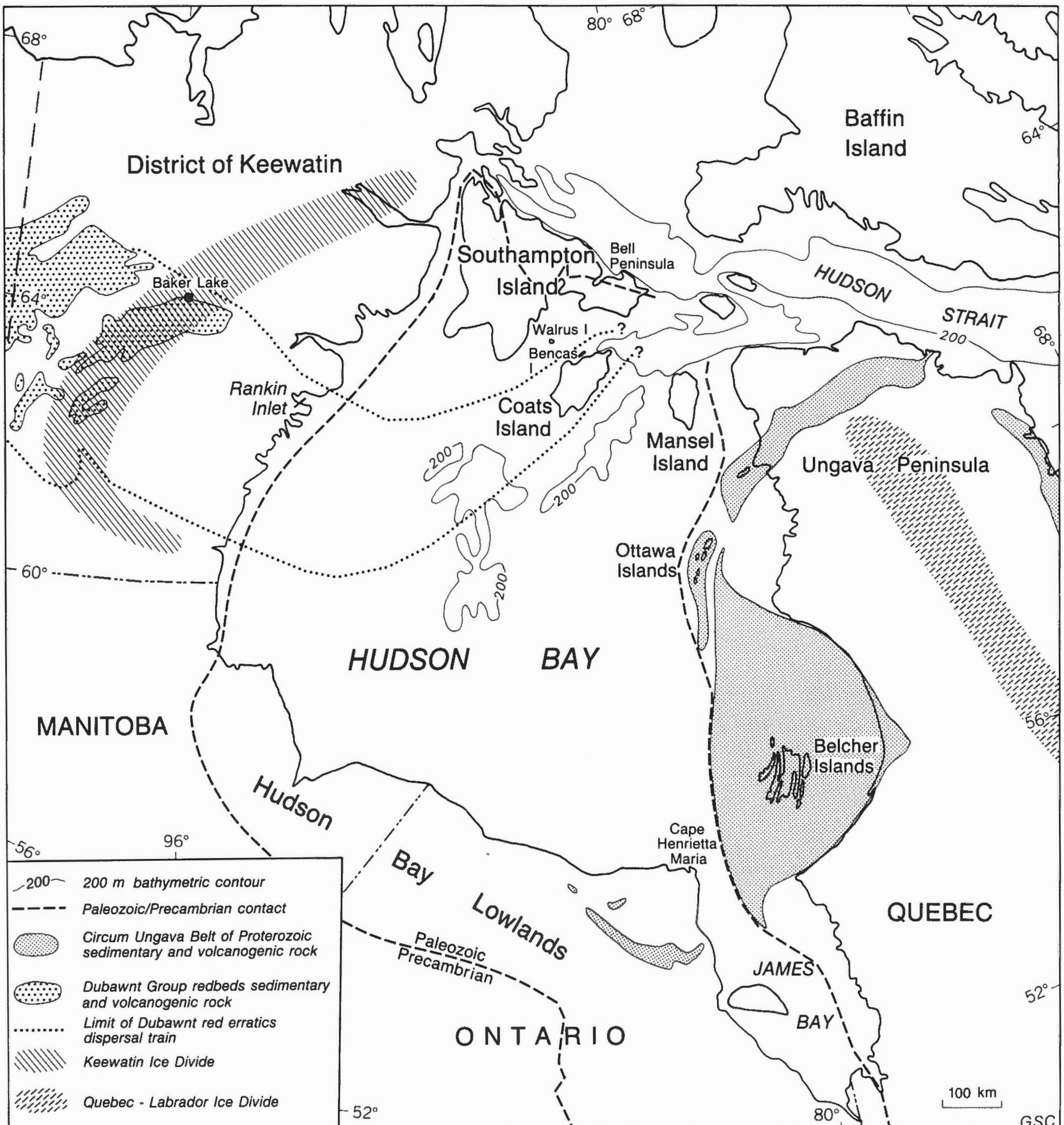

Figure 1. Regional location map of Hudson Bay area, including source areas of distinctive erratics found on Coats and Mansel islands (after Shilts, 1980b).

King (1969) described peculiar ridges transverse to the southern coast of Mansel Island from study of aerial photographs, but she did not visit them in the field. She called these features "chevron ridges" but could provide no definitive explanation of their origin.

Geological setting

Bedrock geology

The bedrock geology of Mansel, Coats, Bencas, and Walrus islands is discussed by Heywood and Sanford (1976) and is shown with that of the surrounding seafloor by Sanford et al. (1979). Coats Island comprises a slice of Precambrian (Archean or Aphebian) basement that has been uplifted by block faulting above the general level of the relatively flat floor of Hudson Bay. The floor of Hudson Bay and most of the fault block are overlain by relatively flat-lying Ordovician and Silurian carbonate sedimentary rocks. The carbonates have been stripped from the basement on the north end of Coats Island, exposing gneissic and granitic rocks cut by an extensive system of pegmatite dikes (Fig. 2).

Small (1 km diameter), stock-like anorthositic bodies protrude through the Paleozoic cover on Southampton and Coats islands and lie in line with several other similar bodies that protrude through the Paleozoic rocks beneath the Bay in an east-west line to Mansel Island. Of these, only Walrus Island projects above sea level, although their local relief may exceed 100 m. This line of anorthositic bodies stands like a

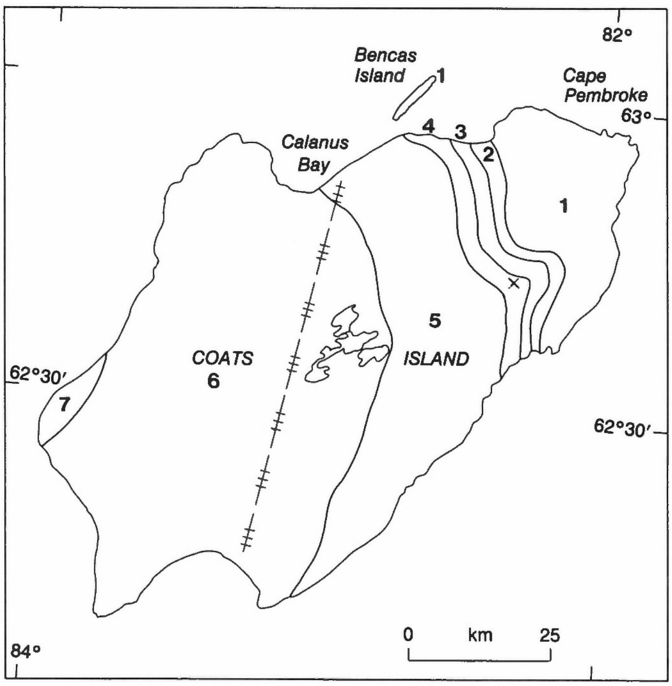

Figure 2. Bedrock geology, Coats Island (after Heywood and Sanford, 1976).

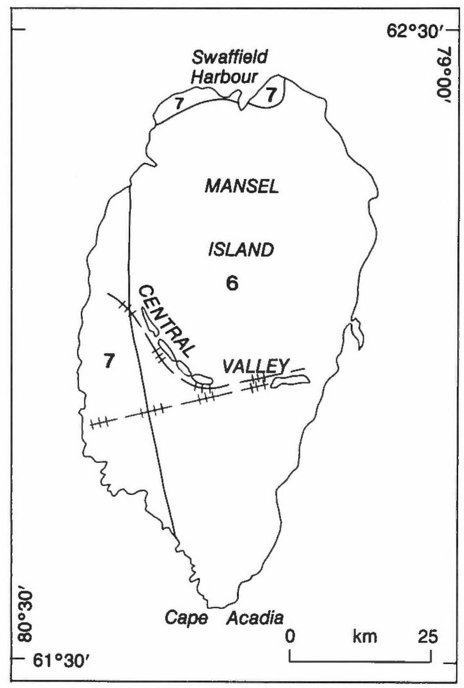

Figure 3. Bedrock geology, Mansel Island (after Heywood and Sanford, 1976).

This legend is common to figures 2 and 3

PALEOZOIC

SILURIAN

- 7 — *ATTAWAPISKAT FORMATION: light grey, tan and brown massive biostromal limestone and dolomite with biohermal swarms*
- 6 — *EKWAN RIVER FORMATION: brown and tan thin-to thick-bedded limestone with massive biostromal lenses*
- 5 — *SEVERN RIVER FORMATION: thin-to thick-bedded light brown and tan mottled limestone and dolomite*

ORDOVICIAN

- 4 — *RED HEAD RAPIDS FORMATION: light tan, uniformly bedded stromatolitic limestone and dolomite with massive biostromal and biohermal facies in upper part*
- 3 — *CHURCHILL RIVER GROUP: greyish brown argillaceous limestone with lenses of orange and brown mottled algal limestone*
- 2 — *BAD CACHE RAPIDS GROUP: light and medium brown, nodular bedded, argillaceous limestone with yellowish orange mottling (includes rocks of Middle Ordovician age)*

PRECAMBRIAN

- 1 — *Gneiss*

Anorthosite .... ×

Geological boundary ....

Possible structural lineament ....

GSC

fence across the mouth of Hudson Bay and must have had some retarding effect on the flow of ice outward into Hudson Strait.

Mansel Island is the highest part of a submarine cuesta formed on gently westwardly dipping Silurian carbonate rocks. The cuesta extends southward and southwestward beneath the eastern part of Hudson Bay some 700 km to Cape Henrietta Maria in the Hudson Bay Lowlands (Heywood and Sanford, 1976). According to B.V. Sanford (personal communication, 1979) the (up to 25 m high) eastward-facing escarpment formed on the Ekwan River Formation along the eastern side of Mansel Island can be traced on bathymetric charts along much of the cuesta.

The central and eastern part of Mansel Island consists of the Ekwan River Formation — thin- to thick-bedded limestone with massive biostromal lenses and small isolated

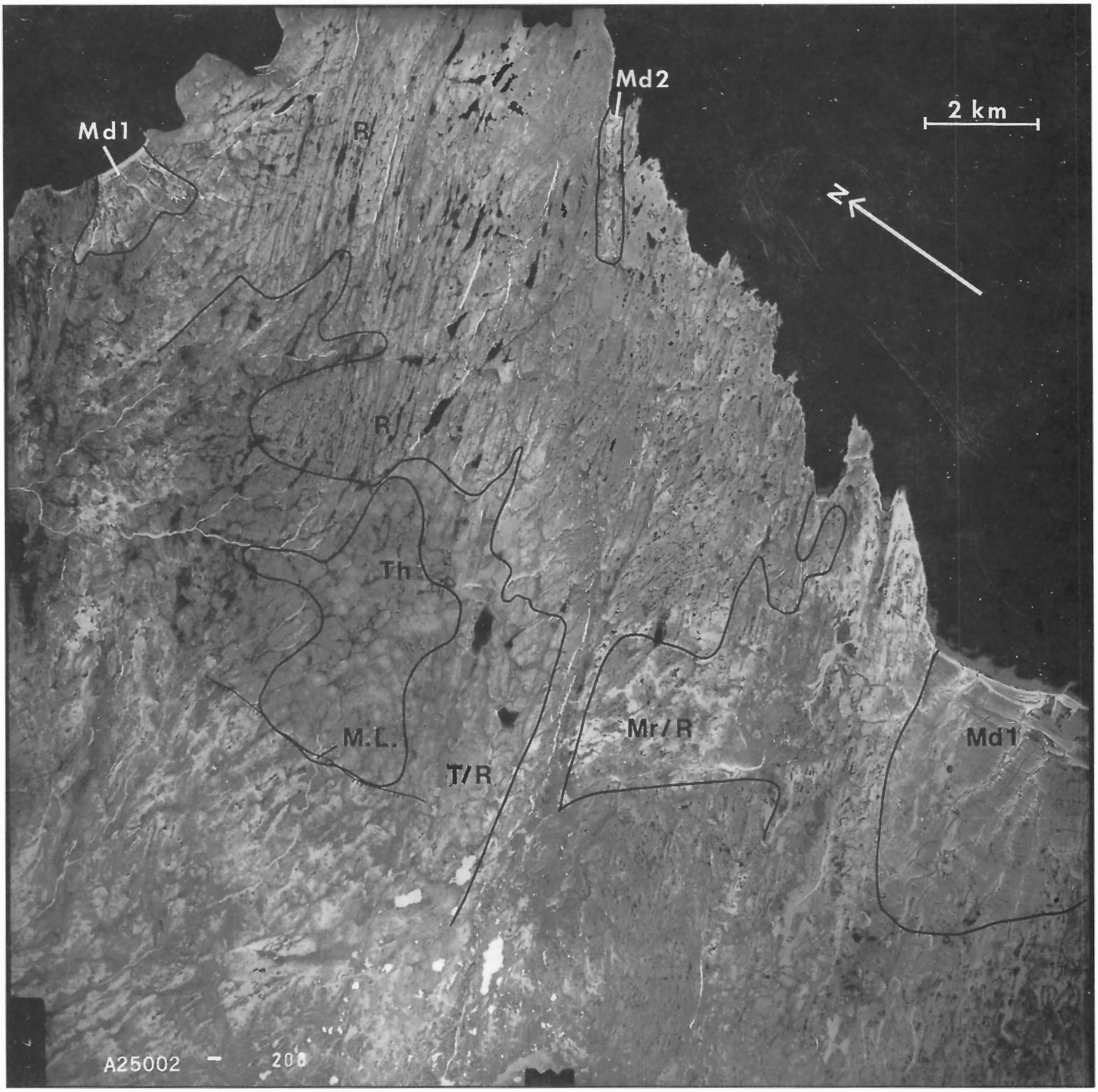

Figure 4. Typical Precambrian terrain, northern Coats Island. Note gneissic bedrock (R), thin till cover over bedrock (T/R), hummocky till (Th), marine limit (M.L.) and strip delta (Md). Two morphological forms of strip delta are illustrated, the embayment type at Md1 and the type confined by bedrock valley walls at Md2. NAPL A25002-208.

biohermal masses (Fig. 3). The formation forms a succession of eastward-facing cuestas, the largest of which is the east shore escarpment. The western quarter of the island is underlain by the Attawapiskat Formation; massive biostromal limestone and dolomite with biohermal reef swarms (Heywood and Sanford, 1976).

Physical features

Mansel Island is elongate with its major axis parallel to the general direction of ice flow recorded on the island. This configuration probably results from a combination of ice moulding processes and from the structural trend of the ridge of which it is a part. The profile along the long axis of the island is asymmetric — the highest point, about 130 m a.s.l., lying about 20 km from the northern end of the island. The terrain slopes gently from that point southward for approximately 75 km to Cape Acadia at the south tip of the island. The eastern side of the island is marked by the 10 to 25 m high escarpment on the Ekwan River Formation, which is the only sharp break in the gently rolling surface.

Mansel Island is bisected by an east-west trending depression that contains several large, elongate lakes and rises less than 40 m from sea level to a drainage divide about 15 km from its western end. The depression is at right angles to the general direction of ice flow on the island, and, although interpreted as a meltwater channel on the Glacial Map of Canada (Prest et al., 1968), it is flanked by gentle till slopes and is floored in many places by periglacially mixed till and shell-bearing marine muds. The depression is thought by the authors and by B.V. Sanford (personal communication, 1979) to be the expression of a major structural feature.

Drainage on Mansel Island is generally sluggish and poorly developed, except through the escarpment on the east coast; the terrain is dotted by numerous shallow (5 m deep) lakes. The lakes occupy bedrock depressions on the higher terrain but lie in thermokarst depressions or are dammed by raised bars, spits, or beaches in the coastal plains of the west and south part of the island. Some of the lakes lying in the central depression may be deeper than 5 m and are the only lakes suitable for floatplane operations.

In some places drainage lines seem to be interrupted, possibly because surface waters escape into joint systems or karst features that lie beneath the surficial sediments. Although no unequivocal karst features were seen, many of the linear patterns observed on aerial photographs may be related to solution along joint systems in the bedrock. Exposed carbonate bedrock and carbonate pebbles on both Coats and Mansel islands show abundant evidence of solution or solution pitting, even where located in positions just above sea level, where exposure could be no longer than a few hundred years. Such extensive evidence of postglacial solution pitting is unusual and is possibly related to the wet maritime location of the islands. Certainly no such solution has been observed on similar carbonate-rich terrain in more temperate areas, such as Ottawa Valley.

The physiography of the southern and northwestern three quarters of Coats Island is similar to Mansel Island, but the northeastern quarter is a relatively high, gently rolling surface underlain by Precambrian gneiss and granite (Fig. 4). The northern coast rises abruptly from the sea to elevations of over 220 m less than 5 km inland. From this elevation the island slopes downward to the southwest to sea level some 110 km distant.

The central part of Coats Island is a level till plain with several large lakes and an average elevation of 100 m a.s.l. (Fig. 5). This surface is slightly depressed below the levels of the crests of the slopes that rise from the sea shores. As a result of this slight depression, the central part of the island shows much less evidence of the effects of marine processes than do its more exposed parts.

Extensive coastal plains covered with innumerable tundra ponds cover the northwestern shore and southwestern quarter of the island.

SURFICIAL MATERIALS

Bedrock

Outcrops of bedrock (R)[1] are relatively rare in the areas underlain by Paleozoic rocks on Coats and Mansel islands, because of their extensive reworking by wave, frost, and solution/soil forming processes. The area of bedrock actually covered by glacial or marine sediments, however, is probably overestimated by Heywood and Sanford (1976). Bedrock outcrops are common in the area underlain by Precambrian bedrock on the north part of Coats Island, particularly below marine limit (~ 124 m) where glacial sediments have apparently been washed from the steeper slopes by wave action.

Outcrops of Paleozoic carbonate rocks are commonly highly disrupted by frost processes and solution (Fig. 6). Consequently, unaltered carbonate bedrock is found only in major stream channels or in the modern tidal zone of Mansel and Coats islands. Some solid limestone outcrops were observed some distance inland in the coastal plain of southwestern Coats Island, but they seem to have been rounded by solution postdating marine submergence. Elsewhere in areas mapped as Paleozoic bedrock or as comprising thin surficial sediments over bedrock (e.g., Mr/R, T/R), the bedrock surface consists of a rubble of limestone chips or blocks with or without a fine grained matrix of glacial or marine sediment. It is possible that some proportion of the mud found in these areas of highly disturbed bedrock is composed of insoluble residues and/or secondary carbonate deposits derived from solution of the surface of the outcrop.

The Precambrian outcrops of Coats Island, in contrast to the Paleozoic outcrops, are "fresh" and commonly striated or polished with little evidence of frost heaving or surface weathering. Bencas and Walrus islands, and the isolated anorthosite outcrop on Coats Island, have almost no surficial sediment cover, other than scattered beaches, and consist of rounded, undisrupted surfaces that are smooth as a result of glacial polishing or wave action (Fig. 7).

[1]Map units on Maps 1632A and 1633A.

Till

The following map units are composed wholly or partially of till: till plain (T), hummocky till (Th), ribbed moraine (Tr), till and marine sediments, undifferentiated (TM), and those units combining till with bedrock (T/R, TM/R, Th/R, Tr/R). All the above units combined comprise approximately 18% and 13% of the surface of Coats Island and Mansel Island, respectively.

Coats Island

Largely because of the extensive marine reworking of these islands, the only unequivocal exposures of till found during the reconnaissance are along two stream valleys on the northern side of Coats Island, one draining the large central lakes into Calanus Bay and the other entering Evans Strait. Till also occurs on the periglacially modified surface above marine limit on the northeastern tip of Coats Island.

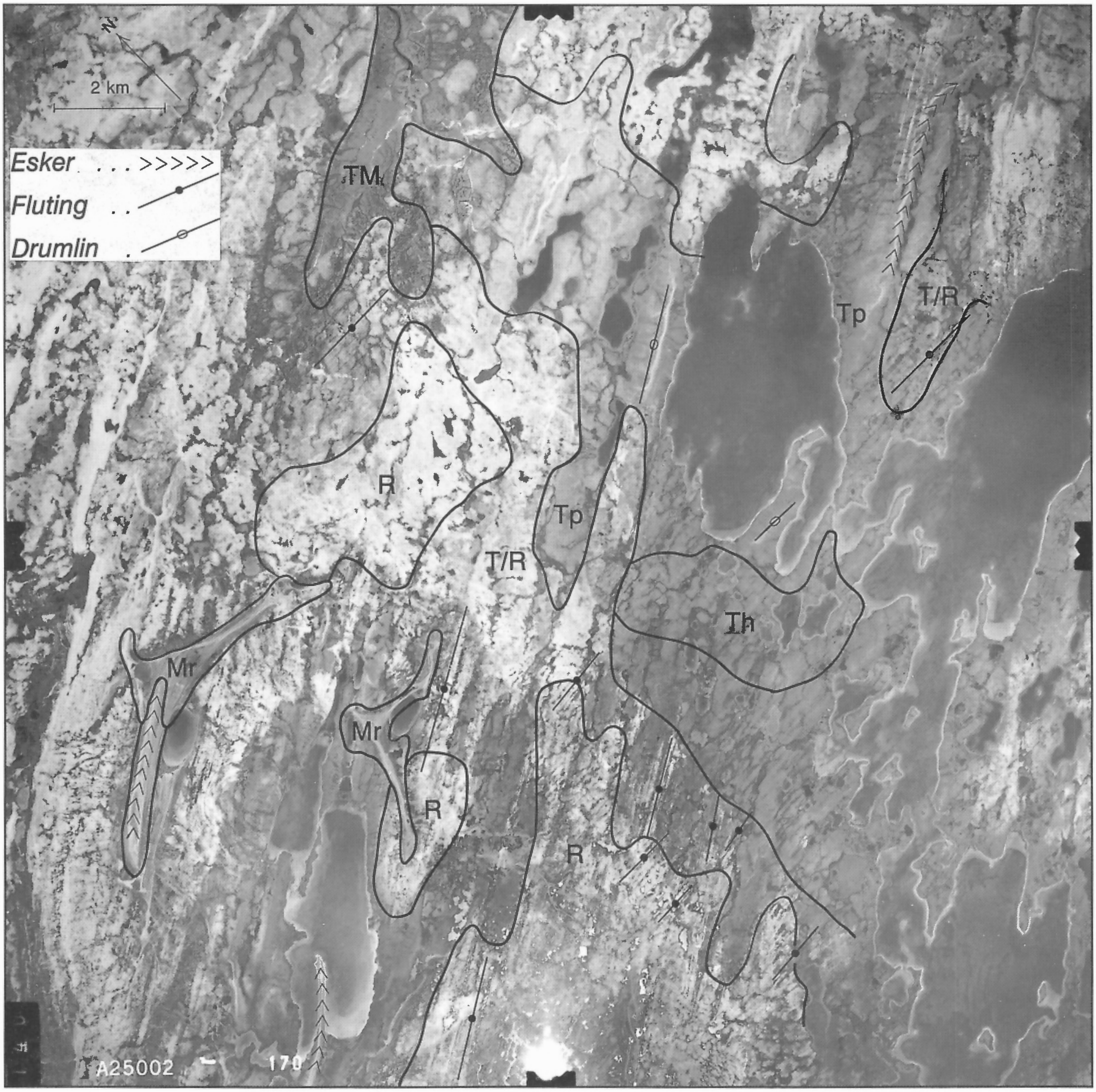

Figure 5. Typical carbonate terrain near the central lakes, Coats Island. This airphoto illustrates many map units described in the text. NAPL A25002-170.

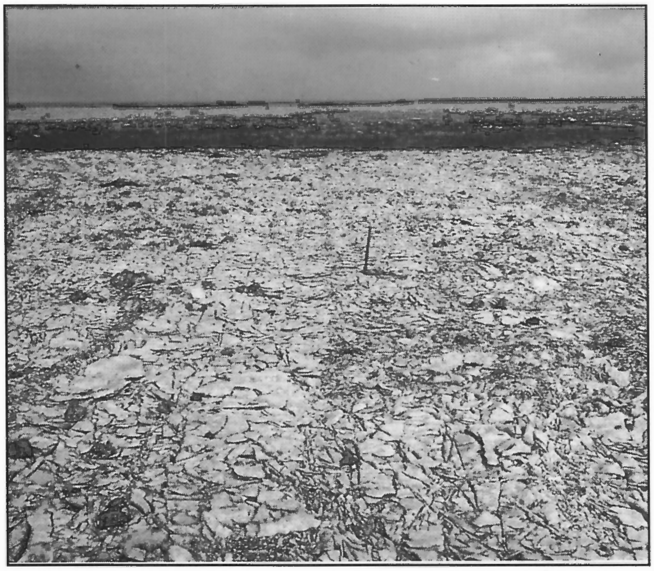

Figure 6. Frost shattered carbonate bedrock surface, northern Mansel Island. Photo by R.N.W. DiLabio. GSC 203538-V

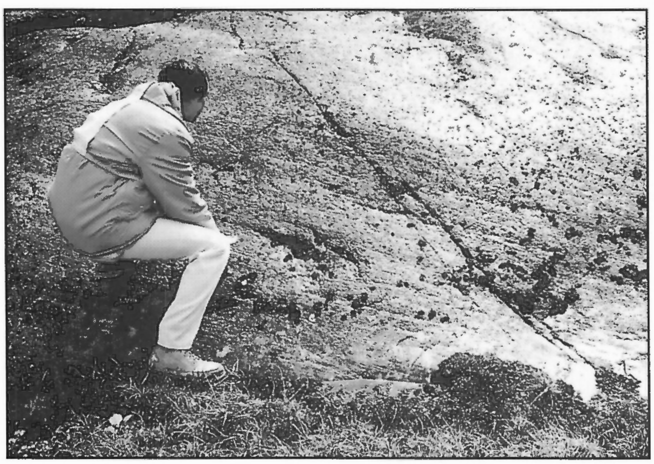

Figure 7. Polished and striated surface of anorthosite outcrop, Coats Island. Photo by R.N.W. DiLabio. GSC 203538-R

The stream draining into Calanus Bay has cut deeply into both overburden and underlying Paleozoic bedrock, revealing 3 to 12 m of till overlying polished and striated fossiliferous limestone. The second valley is cut through at least 2.5 m of till lying in depressions in glacially polished Precambrian rock which forms the floor of the stream (Fig. 8). Despite the radically different underlying bedrock, till at both exposures has similar composition and physical properties. It is very compact, chocolate brown to buff, calcareous, clayey silt till with 5 to 20% Precambrian erratics in the 2-6 mm fraction. The till in these exposures bears a strong resemblance to tills observed in the southwestern Hudson Bay Lowlands. The latter tills are composed of material from the same source areas (Shilts, 1982).

Most of the diamictons seen on Coats Island in sections or mudboils may be described as buff coloured, soft, wet, limy mud with limestone clasts, few Precambrian erratics, and

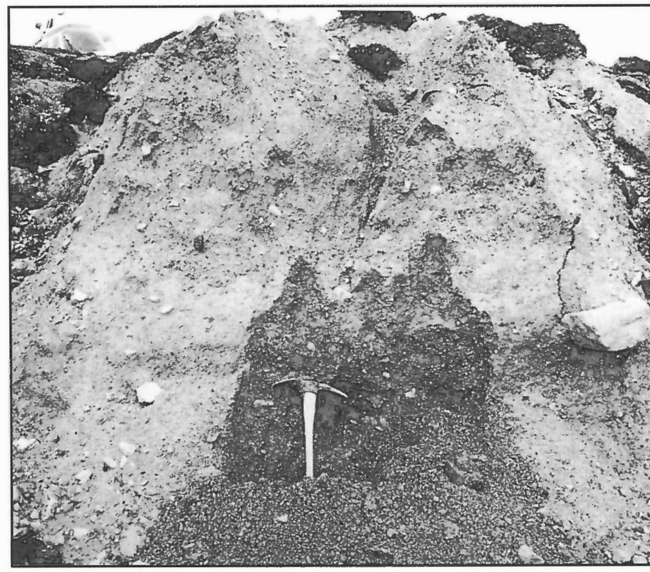

Figure 8. Lodgment till, northern Coats Island. Although it overlies Precambrian terrain, till is almost totally composed of limestone fragments.

some marine shells, at least at the surface. At some sites this diamicton is probably a weathered bedrock residue rather than till, while at others it is a marine stony mud. It is likely that much of the till has been mixed with marine sediments by periglacial processes as well as by wave action. Areas where this is most probable have been designated unit TM.

The till cover is generally thin. In a 10 m section along the river flowing into Calanus Bay, no evidence was found of more than one stratigraphic unit.

Mansel Island

On Mansel Island vertical exposures are rare, and those examined were in stream channels incised into unconsolidated deposits along the flanks of the central valley. These sections exposed a buff coloured, calcareous, loose, silty, till-like diamicton with a matrix-supported framework of angular fragments of Paleozoic limestone and dolomite. The 2-6 mm clast fraction contains less than 3% crystalline Precambrian erratics and the remainder is made up of Paleozoic rocks.

Sediment that forms mudboils is a soft, limy, stony mud, commonly containing marine shell fragments, and is similar to the diamictons found on most of Coats Island. Because Mansel Island lies entirely below local marine limit, it is probable that the stony mud is composed of a fine fraction derived from marine deposits mixed with till by periglacial processes or waves and is best mapped as unit TM, till and marine undifferentiated.

On both islands solution and redeposition of carbonate is common on almost all fragments examined.

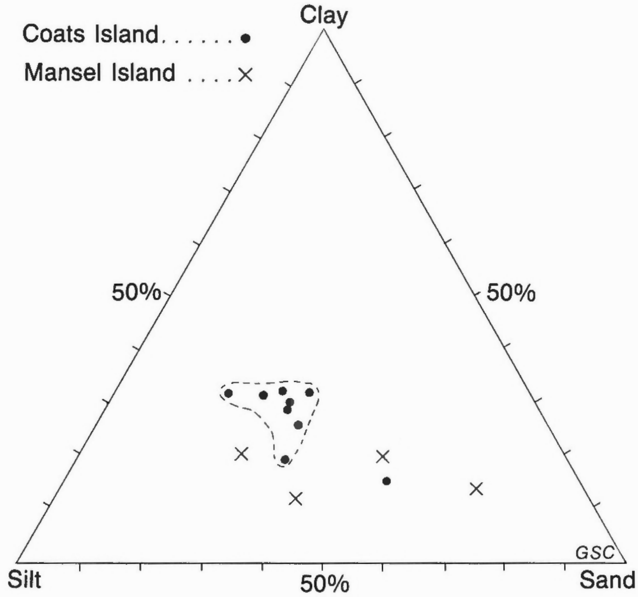

Figure 9. Sand-silt-clay ratios for till or till-like diamicton samples from Coats and Mansel islands.

Texture and composition

The majority of the till samples (9) from Coats Island fall within a narrow range of textural parameters (Table 1; Fig. 9, 10). The four samples of till or diamicton collected from Mansel Island are coarser than those of Coats Island and are scattered over a wide range from silty to very sandy sediment (Table 1; Fig. 9, 11).

The results of Atterberg limit tests run on the above samples indicate that, on both islands, the till matrix has very low plasticity and a narrow range of plastic and liquid limits (Table 1).

The total carbonate values (<64μm fraction) for till samples from Coats Island are moderate to high, ranging from 41.8% to 62.6%, with the exception of one anomalously high value of 81.8% (Table 1). Of the total carbonate content, the average calcite: dolomite ratio is 63:37. No obvious correlation exists between carbonate content and underlying bedrock type, particularly in the area of Precambrian outcrop which is overlain by limestone-rich till similar to that which covers the Paleozoic rocks on the island. There does not seem to be any correlation between total carbonate content and grain size (Fig. 12). The total carbonate values for Mansel Island samples are higher (52.6%-80.8%) and calcite/dolomite ratios are higher than those of diamictons from Coats Island (Table 1).

Table 1. Summary of till/diamicton analyses for Coats Island (CI) and Mansel Island (MI) samples.

Sample	Weight (%)			Chittick (%)			Atterberg Limits (weight % water)		
	Sand	Silt	Clay	Calcite	Dolomite	Total Carbonate	Liquid Limit	Plastic Limit	Plasticity Index
CI 1	32.8	41.1	26.1	38.4	24.2	62.6	17.9	12.7	5.2
CI 2	35.5	45.2	19.3	28.2	20.0	48.2	17.6	13.7	3.9
CI 3	53.8	30.6	14.6	37.0	19.0	56.0	14.4	11.4	3.0
CI 4	29.5	40.9	29.5	28.6	22.2	50.8	19.2	11.9	7.3
CI 5	22.3	45.6	32.0	59.6 62.0	20.8 19.8	80.4 81.8	17.3	13.5	3.8
CI 6	26.6	42.5	31.8	37.6	18.8	56.4	19.0	12.1	6.9
CI 7	28.0	39.5	32.4	25.6	16.2	41.8	20.1	12.1	8.0
CI 8	30.9	40.0	29.0	24.8	19.8	44.6	19.6	12.0	7.6
CI 9	32.1	35.6	32.2	31.2	17.2	48.4	19.9	12.9	7.0
CI Mean				34.5	19.7	54.4	18.3	12.5	5.9
MI 1	27.4	52.7	19.8	39.0	13.6	52.6	19.4	16.1	3.3
MI 2	51.6	29.4	18.9	76.0	4.8	80.8	16.0	12.5	3.5
MI 2A	40.7	46.6	12.2	67.6	11.0	78.6	19.8	17.3	2.5
MI 3	68.8	16.6	14.4	52.0	6.2	58.2	18.3	12.4	5.9
MI Mean				58.7	8.9	67.5	18.4	14.6	3.8

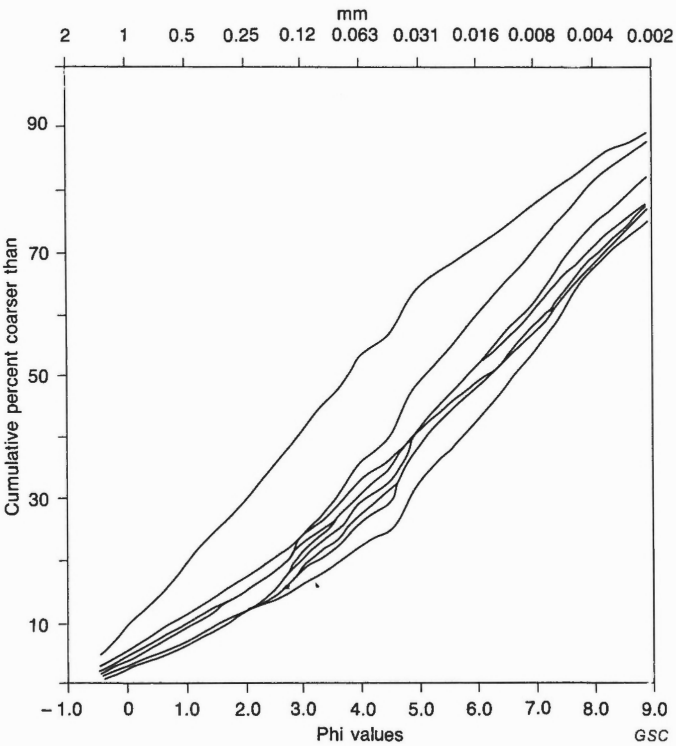

Figure 10. Grain-size distribution of till samples from Coats Island.

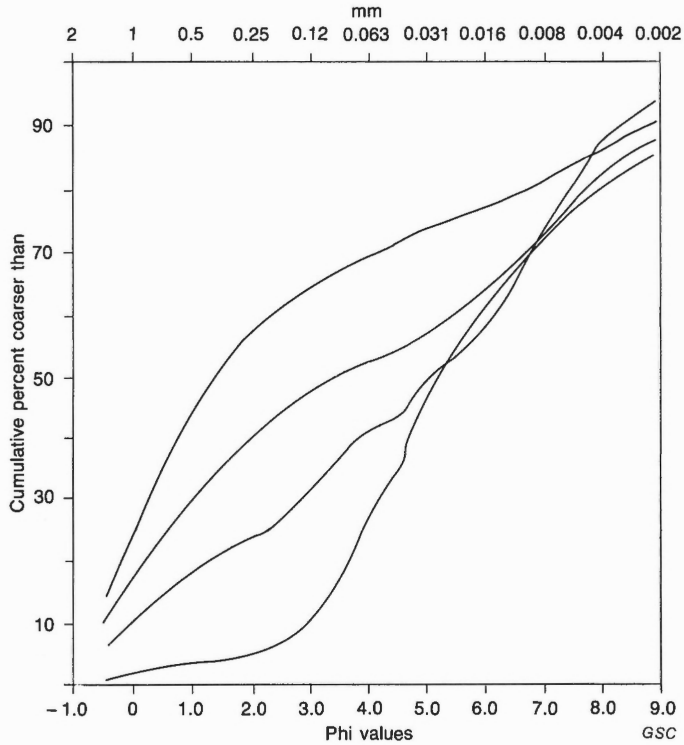

Figure 11. Grain-size distribution of diamicton samples from Mansel Island.

Table 2. Trace element values of clay (<2µm) fraction of till/diamicton samples from Coats Island (CI) and Mansel Island (MI) (values in ppm, Fe in percentage).

Sample	Cu	Pb	Zn	Co	Ni	Cr	U	Mo	Mn	Fe
CI 1	22	6	62	9	25	43	1.4	5	350	1.70
CI 2	29	6	75	13	33	50	1.6	4	460	2.25
CI 3	28	4	67	10	28	44	1.4	4	370	1.60
CI 4	19	2	54	9	22	35	2.0	3	370	1.55
CI 5	13	3	42	5	14	25	1.7	6	235	0.90
CI 6	19	2	56	8	22	37	1.6	4	365	1.30
CI 7	22	3	71	11	32	54	3.0	3	460	2.00
CI 8	21	2	68	10	31	45	2.5	4	430	1.90
CI 9	29	6	76	13	32	50	0.7	4	450	2.20
MI 1	30	5	103	16	46	82	1.5	6	485	3.50
MI 2	16	6	32	7	23	19	1.2	5	285	1.00
MI 2A	17	3	52	10	32	30	1.5	4	460	1.45
MI 3	20	8	49	8	30	29	0.9	4	310	1.40

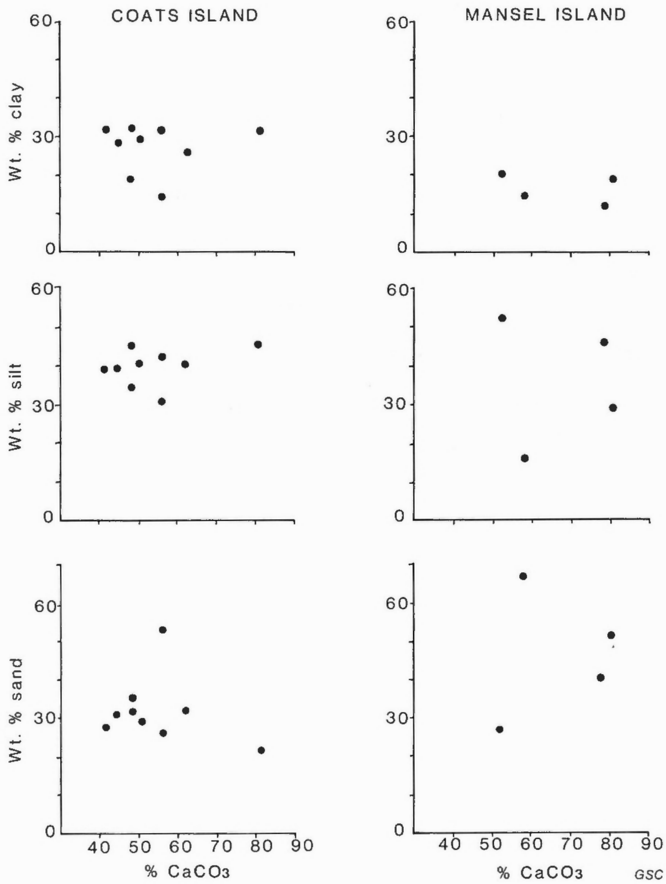

Figure 12. Comparison of carbonate content to grain size (9 samples from Coats Island, 4 samples from Mansel Island).

Table 3. Heavy mineral content of till sample CI 8. The heavy mineral content is 2% by weight of 63-250 mm fraction. Magnetic fraction is 28% by weight (after Paré, 1982).

hematite	25%
garnet	20%
pyrite	18%
epidote	13%
ilmenite	10%
orthopyroxene	4%
siderite	4%
titanite	1%
leucoxene	1%
rutile	1%
zircon	trace
unknown	4%

Trace elements concentrations in clay (<2µm) from Coats Island till or diamicton are uniformally low, and the range of values is narrow (Table 2). The same may be said for the diamicton samples from Mansel Island. No significant difference in trace element levels exist between the two islands. The values resemble the generally low, homogeneous concentrations of trace elements in the clay fraction of tills of the Hudson Bay Lowlands (Shilts, 1980a) and the calcareous tills of northern Manitoba (Dredge, 1983; C. Kaszycki, personal communication, 1987), and probably reflect the influence of high proportions of Paleozoic carbonates in their fine fractions.

One till sample (CI8) from northwestern Coats Island was analyzed for heavy minerals (Paré, 1982; Table 3), and compared with heavy mineral assemblages in samples taken along a transect from Somerset Island in the Arctic Islands to Longlac, Ontario. Paré concluded that the heavy mineral assemblage suggests sediment transport from central Hudson Bay and ice flow from a centre over Nouveau Québec-Labrador.

Erratics

As the principal objective of studying these islands was to determine the nature of the Precambrian erratics found on them, particular attention was paid to the lithological character and frequency of these erratics. On both islands, the bulk of the clasts (granule to boulder size) in the till is of Paleozoic origin, but on Coats Island fine gravel (2-6 mm) separated from till and till-like diamictons contains from 5% to just over 20% Precambrian erratics. On Mansel Island, less than 3% of the fine gravel fraction of the till-like diamicton is of Precambrian origin. Till surfaces and stream gravels on Mansel Island are, however, covered with numerous Precambrian erratics which stand out because of their resistance to the frost-shattering and solution which renders most calcareous clasts into pitted, chip-like fragments where exposed to the atmosphere (Fig. 13).

On Mansel Island, the most common noncarbonate erratics noted were gabbroic and granitic gneisses, fine grained black to dark grey igneous rocks, black metasandstones, and green basic metavolcanic rocks. Less numerous but distinctive erratics included thin-bedded magnetite iron formation; massive, hematite-magnetite iron formation; and serpentinized peridotite. Individual fragments of red siltstone with micaceous bedding planes, white orthoquartzitic conglomerate, and amphibolitic gneiss were found (among several thousand erratics examined). The metavolcanic, metasedimentary, ultrabasic, and iron formation erratics are all common lithologies in the Circum-Ungava geosyncline (Dimroth et al., 1970), a sinuous belt of Proterozoic sedimentary, volcanic, and associated intrusive rocks which lies 100-150 km southeast of Mansel Island in Nouveau-Québec.

On Coats Island, the nongneissic Precambrian component also includes black to dark grey sedimentary erratics similar to those found on Mansel Island. These "dark erratics" (Shilts, 1980b) are most concentrated on the southeast coast, but have also been noted in small amounts in the central part of Coats Island. In addition, red sandstone, red siltstone, red volcanogenic rocks, and white to pink orthoquartzite erratics are common at every site examined along the northwestern and central parts of the island, but are rare to absent on beaches of the southeastern coast. The red erratics comprise 1-2% of the fine gravel of till and esker sediments. The red erratics can be confidently assigned to source areas in the sedimentary basin containing rocks of the Proterozoic Dubawnt Group, a sequence of terrestrial sedimentary and volcanogenic rocks which characteristically includes a number of distinctive, red facies. These "redbeds" outcrop southwest of Baker Lake in the District of Keewatin (Donaldson, 1965; Lecheminant et al., 1979, 1980, 1981). The orthoquartzites bear a strong resemblance to the Proterozoic Hurwitz quartzite or similar quartzites which outcrop in several areas in southern Keewatin.

A few red erratics were noted on Walrus Island during the brief reconnaissance trip made there.

Landforms composed of till

In addition to relatively level till plains (T) we have distinguished four types of till landform; hummocky till (Th), ribbed (rogen) moraine (Tr), drumlins and flutings, and De Geer moraines. The distribution of these landforms is indicated on Maps 1632A and 1633A by a unit designator for the first two landforms and by symbols for the others.

Hummocky till (Th) comprises only 1% of the surface of each island and is characterized by irregular, but rounded, hummocks approximately 100 to 300 m in diameter and 5 to 10 m high (Fig. 4, 5). Similar terrain is common near the Keewatin Ice Divide where its origin is ascribed to basal meltout of debris beneath stagnant ice (Shilts et al., 1987). A similar origin is likely here.

Figure 13. Limestone bedrock surface, Mansel Island. Rounded, Precambrian erratics stand out in contrast to frost shattered bedrock surface. Dark boulders in foreground were transported from the Circum-Ungava belt of Proterozoic rocks. Photo by R.N.W. DiLabio. GSC 203538-J

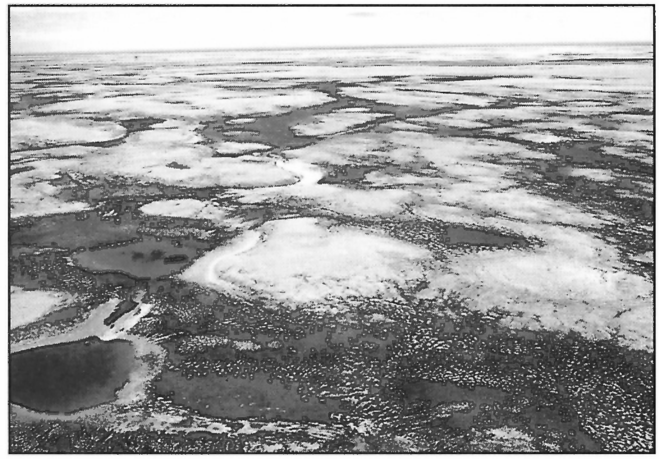

Figure 14. Ribbed moraine, central Mansel Island. Photo by R.N.W. DiLabio. GSC 203538-I

Ribbed moraine (Tr) comprises 3% of the surface of Mansel Island and is not present on Coats Island. It is characterized by fields of straight to sinuous ridges or irregular blocky-looking hummocks which seem to be parts of discontinuous ridges (Fig. 14). Ridges are generally less than 1.5 km long, commonly much less, and may be asymmetric in cross-section. They are commonly oriented transverse to ice movement. Although formed by active ice and probably representing stacked debris bands in the glacier, their preservation as identifiable features probably depends on ice stagnation during deglaciation (Shilts et al., 1987; Aylsworth and Shilts, 1989).

Drumlins are limited to the central depression of Coats Island but bedrock and drift flutings are common on Coats Island and on the northeast quarter of Mansel Island. The flutings are long (1-3 km), narrow, straight features which commonly occur in clusters of 5 to 20 closely spaced, parallel ridges. The flutings are obvious on airphotos but they are difficult to distinguish on the ground. Some are formed from ice-scoured bedrock (Fig. 15), others are composed of till (Fig. 16). The axis of the latter may be slightly irregular (Fig. 17).

On Coats Island the orientation of flutings varies from northerly to east- southeasterly. One prominent group trends northeasterly along the axis of the island and another prominent group trends easterly and east-southeasterly. In some locations these flutes actually intersect each other (Fig. 5). The northeasterly orientation seems to be oldest. Striae measurements confirmed both the direction and age relationship of the Coats Island flutings. On Mansel Island the dominant orientation of flutes is northerly, although a secondary southwesterly-northeasterly trend exists.

Certain short straight ridges on Coats Island have been interpreted as De Geer moraines. The ridges are approximately 1 km in length, straight, and subdued, with less than 2 m relief. Their composition varies. Of three ridges examined, one was composed of well sorted pebble gravel with no sand, one was sorted pea gravel and sand, and one was more till-like. The latter was fairly coarse grained but had mudboils and erratics on the surface. The ridges have beaches cut into them but are not nearshore features themselves. Their origin is not obvious, but they look similar to the De Geer moraines along the coast of Hudson Bay south of Rankin Inlet.

These De Geer moraines are most numerous on the coastal plain at the head of Shoran Bay, Coats Island, where they occur up to 6 km inland. The orientation of their long axes changes from the east to the west side of the Bay, beginning with a northeasterly orientation and rotating past north to a north-northwesterly orientation. They also occur 1 to 4 km inland along the central east coast of Coats Island and are oriented northwesterly.

A few similar features, oriented west-east, occur in a limited area near the east coast, south of the central valley, on Mansel Island. Although not examined in the field, they look more like De Geer moraines than like the transverse gravel bars (discussed later in report) which are common on Mansel Island.

Marine and periglacial modification of till surfaces

All of Mansel Island and most of Coats Island were submerged by Tyrrell Sea after retreat of glaciers from Hudson Bay; only a small area of northeastern Coats Island near Cape Pembroke was above sea level.

A distinct difference in appearance exists between areas above and below marine limit. Small sorted circles on till surfaces are best developed above marine limit and striations are better preserved in comparison to those below marine limit. The stream valleys change character markedly at about marine limit — above marine limit they are swale-like, vegetated, with sluggish drainage; below, they are broad, unvegetated, composed of bouldery alluvium with well defined banks and, of course, are commonly flanked by beaches.

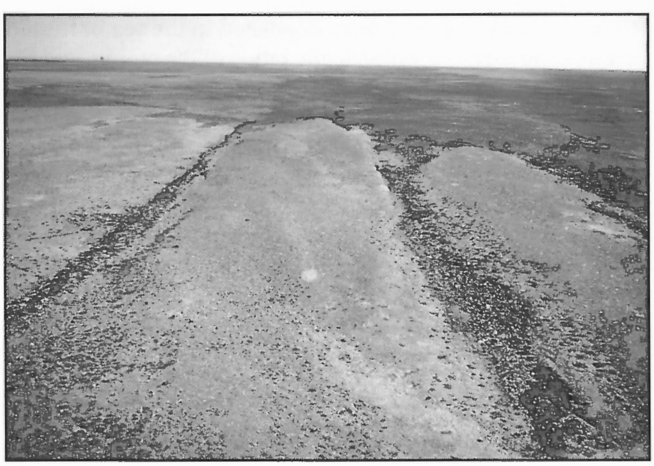

Figure 15. Fluted bedrock surface, northwestern Mansel Island. Photo by R.N.W. DiLabio. GSC 203538-E

On both Coats and Mansel islands till plains and till landforms are best preserved in parts of the islands where low bedrock ridges protected the glacial deposits from the most severe effects of wave action. This is particularly true in the central depression of Coats Island. Elsewhere the till surfaces have been washed, leaving a gravel, commonly fossiliferous, on the higher surfaces and marine muds in the lower areas.

Following emergence of the land, cryoturbation processes resulted in mixing of till and marine sediments. Few exposures on Coats Island and none on Mansel Island revealed a till that was free of cryoturbation. On the maps, areas where till and marine sediment mixing are likely have been designated unit TM: till and marine undifferentiated. Although not so designated, it is probable that similar processes occurred in parts of units Th and Tr as well.

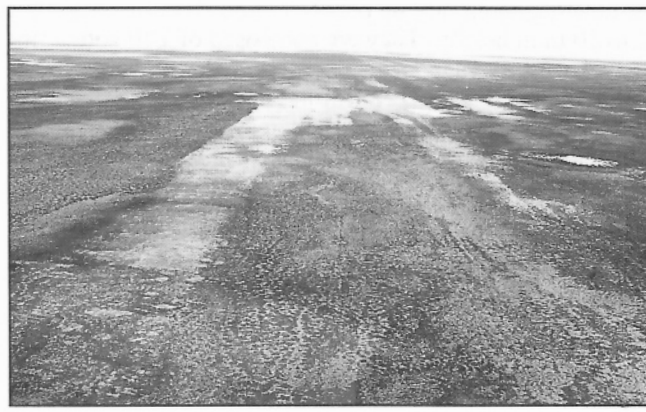

Figure 16. Fluted till plain northeast of the central lakes, Coats Island. Flutings have aspect of parallel highways. Photo by R.N.W. DiLabio. GSC 203011-Z

Figure 17. Flutings on till plain south of the central lakes, Coats Island. Edges of flutings are irregular, creating an unusual wavy appearance in this area.
Photo by R.N.W. DiLabio. GSC 203011-X

The till surface is marked by polygonal to circular patterned ground with average cell diameters of about 1 m (Fig. 18). It is sparsely vegetated, and the patterns seem to form an evolutionary sequence from small polygonal cells to unsorted and sorted circles (mudboils; Shilts, 1978). When examined (July 31-August 2, 1979), the bare till centres of the sorted circles were soft and wet. It is not known whether these properties are typical of muds during the thaw season or whether the prevailing rain at the time of examination was responsible for the condition of the till.

Glaciofluvial deposits

The only deposits of ice-contact stratified drift positively identified on these islands occur in eskers (G).

The eskers form long, narrow, sinuous ridges with recognizable segments varying between 1 and 20 km in length and 2 to 10 m in height. They are composed of well sorted fine gravel with average size 1 to 2 cm and with few pebbles greater than 5 cm. Except for the Precambrian erratics, the stones at the surface are frost shattered; however, less than 50 cm below the surface, the Paleozoic pebbles are rounded.

Because they lack the protective cover produced elsewhere by the winnowing of fines from boulder-sized material, the eskers were susceptible to reworking by wave action (Fig. 19). The extensive wave reworking of the eskers makes it difficult to distinguish them from the multitude of linear nearshore features on these islands. This is particularly true on Mansel Island where few eskers have been recognized, possibly as a result of vigorous wave action. Eskers are slightly easier to identify on Coats Island where they are larger and meander across the till plain of the protected central depression.

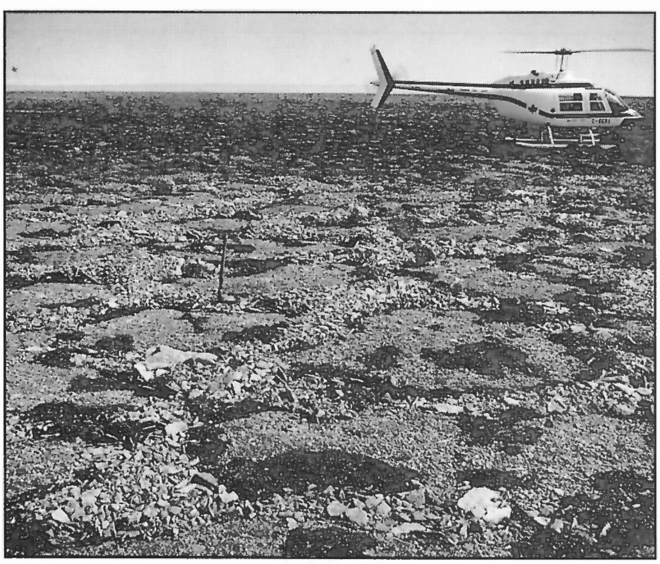

Figure 18. Till surface characterized by mudboils, sorted circles with fine grained centres. Till is almost a rubble of angular limestone pieces. Photo by R.N.W. DiLabio. GSC 203538-H

Figure 19. Meandering esker on fluted till plain, northeast of the central lakes, Coats Island. Subdued relief of esker is due to destructive action of waves as esker rose through wave base during isostatic rebound. Photo by R.N.W. DiLabio. GSC 203538-S

Eskers can be differentiated from marine nearshore linear features by their (esker) meandering pattern, by their position crossing contour levels, and by their composition, which is erratic-rich in striking contrast to the generally erratic-poor nearshore features.

Marine deposits

Marine limit

The maximum level of marine submergence on Coats Island occurs on the northeastern point of the island at 124 m a.s.l. This is based on the elevation of the highest marine beach, and is confirmed by the difference in character of the sediments and landforms above and below this level.

Offshore deposits

Clay, silt, and fine sand were deposited in the sea in front of a retreating ice cliff during deglaciation of the region, and fine sediments were washed from till-covered slopes during emergence or were deposited in the receding sea by rivers flowing from higher ground. Where these marine sediments collected in low or flat areas, they were not significantly eroded as the receding shoreline passed over them. The following map units include greater or lesser areas underlain by marine fine grained sediment: MO, MrO, and TM. Fine grained sediments are also significant components of units MO/R, MrO/R, TM/R, which occur in pockets amongst bedrock outcrops or lie as a thin veneer over bedrock.

The most common offshore sediment unit (MO) is an undifferentiated complex of poorly drained, fine grained sediments and similar sediments covered by organic growth postdating deposition of the sediment. This unit, which is largely confined to areas within the coastal plain, is generally covered by a mat of peat and sedge meadows, with many ephemeral lakes, and includes undifferentiated alluvium.

The dominant sediments are marine clayey silt with few stones and little sand. Because of the organic cover, the exact nature of the sediment is hidden except where fossiliferous mudboils extrude through the turf hummocks or streams expose the sediment. Scattered low strandlines were formed on this unit during marine regression. These and other surface irregularities have completely disrupted drainage, resulting in numerous swamps and shallow lakes. This terrain is covered also with a network of tiny rivulets amongst the turf hummocks. These rivulets expose and rework the marine sediments. The poorly drained surfaces are characterized by

Figure 20. Coastal plain of northwestern Coats Island illustrating many marine map units. MO is an undifferentiated complex of poorly drained, fine grained offshore sediments with or without a postdepositional organic cover. Mr consists of nearshore beach ridges. MrO is an intermediate unit with greater than 25% nearshore ridges with intervening low areas of MO. Mw is a sand sheet. Mdr is strip delta covered with strandlines in a chevron pattern. Note difference between Precambrian terrain to northeast and carbonate terrain to south. NAPL A 25002-201

peat cover, frost polygons, and extensive areas of tundra ponds. The well drained surfaces are characterized by mud-boils.

Similar sediments may underlie the organic mat covering the low flat areas between beach ridges in unit MrO (see Nearshore deposits).

In areas of undifferentiated till and marine sediments (TM), cryoturbation processes have mixed the fine grained marine muds with till. Mudboils with shells at the surface are common.

The only significant areas of marine coastal plain (MO) on Mansel Island occur along the southwest coast, although pockets of marine offshore sediment occur in swales between beaches. Mixtures of till and marine mud (TM and TM/R) are found in the north-central part of the island and in the central valley.

On Coats Island a broad belt of marine coastal plain (MO) deposits crosses the northern part of the island, separating the Precambrian inlier from the Paleozoic outcrops (Fig. 20). As well, extensive coastal plains cover much of the western and southern part of the island. Till and marine sediment mixtures (TM) have been mapped in the central part of the island and are probably more common than has been shown.

On Coats Island, there are some lineations, either straight or curving, on the surface which are thought to have been formed by drifting icebergs or pack ice during isostatic rebound of the island (Fig. 21). Iceberg scours are distinguishable from other lineations by their random orientations and irregular paths. The scours have low relief and stand out due to vegetation differences with their surroundings.

Figure 21. Iceberg scours preserved on the surface of Coats Island, south of central lakes. Photo by R.N.W. DiLabio. GSC 203538-N

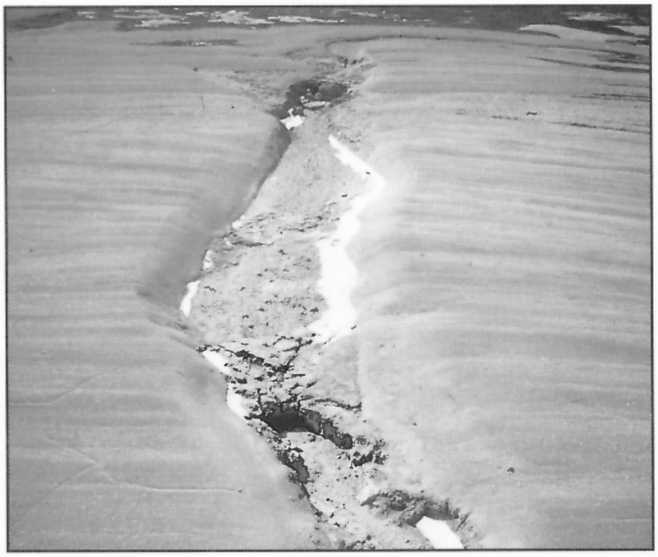

Figure 22. Flow from the catastrophic draining of a small lake eroded a gully through 2-3 m of shingle beach, exposingunder-lying limestone bedrock, east side of Mansel Island. Photo by R.N.W. DiLabio. GSC 203538-D

Nearshore deposits

Nearshore sand, gravel, and cobbles are the most striking deposits, comprising approximately 45% and 75% of the surface area of Coats and Mansel islands, respectively. They were formed by wave action on till, bedrock, and eskers, and by wave reworking of alluvial and deltaic sediments during offlap of the Tyrrell Sea from the isostatically rising islands. The sediments were deposited as ridges (Mr, Mr1, MrO), thin sand sheets (Mw), and "strip deltas" (Md, Mdr).

The most extensive beach cover on the islands developed on steeper, till-covered, bedrock slopes in exposed locations, where a ready supply of reworkable material was subjected to the most efficient wave action. On Coats Island the best beach development is on the gentle escarpment or slopes that form the coastline around most of the island. On the flat southwestern end of the island, beach development gives way to sand sheets and swampy, organic-covered areas with scattered beach ridges. The central lowland of Coats Island was protected from wave action by surrounding low bedrock promontories and few nearshore deposits exist there. With the exception of a flat area in the north-central part of Mansel Island, most of that island is beach covered. Once again, the best developed beaches occur on the steeper slopes. Where gullies have been eroded through the beaches on Mansel Island, 2 to 3 m of shingle gravel is exposed overlying bedrock (Fig. 22).

Although fossiliferous muds are common on both islands, the beaches themselves are generally devoid of shells. In the brief reconnaissance of the islands, no datable material was found that could be reliably related to a specific sea level.

On both islands beach ridges, formed parallel to the shore, have disrupted normal drainage, producing shallow lakes or wetlands and causing water movement to be diverted parallel to the ridge. Streams either flow around the end of the ridges or erode through them. When a stream bursts through a ridge, draining a lake, the beach is eroded, commonly into underlying bedrock, and a fan is deposited at the base of the beach slope. On steeper beach slopes there are dry gullies with evidence of erosion by intermittent outflow from springs.

The most important nearshore unit, Mr, consists of shingle beaches (including bars and spits) commonly made up of flat, 10 to 12 cm diameter cobbles, although grain size ranges from pebbles to boulders. The beaches are composed of up to 98% local limestone chips which generally exhibit evidence of solution pitting and carbonate redeposition. Local carbonate cobbles are frost shattered into platy chips less than 1 cm thick on all beaches more than 3 to 4 m above present high tide, in some cases making it difficult to distinguish beaches from frost shattered bedrock (Fig. 23). The beaches may include 5 to 10% Precambrian erratics, which, due to their resistance to frost shattering, stand out readily from the small, flat, solution-pitted and frost shattered chips. Like the glacial deposits from which they are derived, the beach erratics consist of lithologies common to the Keewatin mainland on Coats Island and lithologies common to the Quebec mainland on Mansel Island and southwest Coats Island.

Although modern beaches are (generally) unvegetated, some sandier beaches have been colonized by plants. Presumably, this is due to the capacity of sand, as opposed to shingle beach, to retain moisture near the surface of the beach and, thus, within the root zone. These areas of vegetated beach have been mapped as unit Mr1.

Figure 23. Shingle beach, central Mansel Island. Beach consists of frost shattered, limestone fragments and is similar to a shattered bedrock surface. Photo by R.N.W. DiLabio. GSC 203538-T

Figure 24. Characteristic landscape of gradational marine unit MrO which contains both nearshore and offshore deposits. Note shallow lakes formed behind widely scattered beach ridges, Mansel Island. GSC 203538-B

On flatter areas, close to the coast on Coats Island and to a lesser extent on Mansel Island, a gradational unit (MrO) between nearshore (Mr) and offshore (MO) units has been mapped. This is an area of sand and gravel beach ridges, parallel to former shorelines, with intervening flat areas composed of peaty organic deposits and shallow lakes underlain by marine mud or sand sheets (Fig. 20, 24). The intervening areas also contain some alluvium deposited by streams which wander across the area, trapped behind and more or less parallel to beach ridges. The beach ridges themselves comprise greater than 25% of the unit area.

Two other types of nearshore deposits, sand sheets (Mw) and strip deltas (Md), have been mapped. The former (Mw) is a thin sheet of sand deposited as a lag from wave reworking of marine clayey sand or silty sand by a migrating shoreline. Although it occurs in scattered patches around the island, its only significant extent is on the flat coastal plain of southwest Coats Island.

Strip deltas (Md) consist of sand and gravel deposited in an offlap deltaic sequence. Strip deltas are formed by a combination of fluvial and nearshore processes which are peculiar to the rapidly migrating shoreline of an offlapping sea. A strip delta complex forms when sediment is deposited at the mouth of a stream where uplift is so rapid that tidal processes and wave action do not permit the delta front to build seaward much beyond the trend of the coastline. The isostatically uplifting deltaic sediments are partially reworked by fluvial erosion and are continuously redeposited at the seawardly migrating river mouth. These processes produce a strip of raised deltaic and fluvial sediments. In these areas of low relief, constant sediment supply and steady, continuous uplift the strip is fairly narrow with respect to its length (ratios of 1:10 being common), thus giving rise to the

Figure 25. Strip delta contained in long, narrow valley in Precambrian rock near Cape Pembroke, Coats Island. Photo by R.N.W. DiLabio. GSC 203011-Y

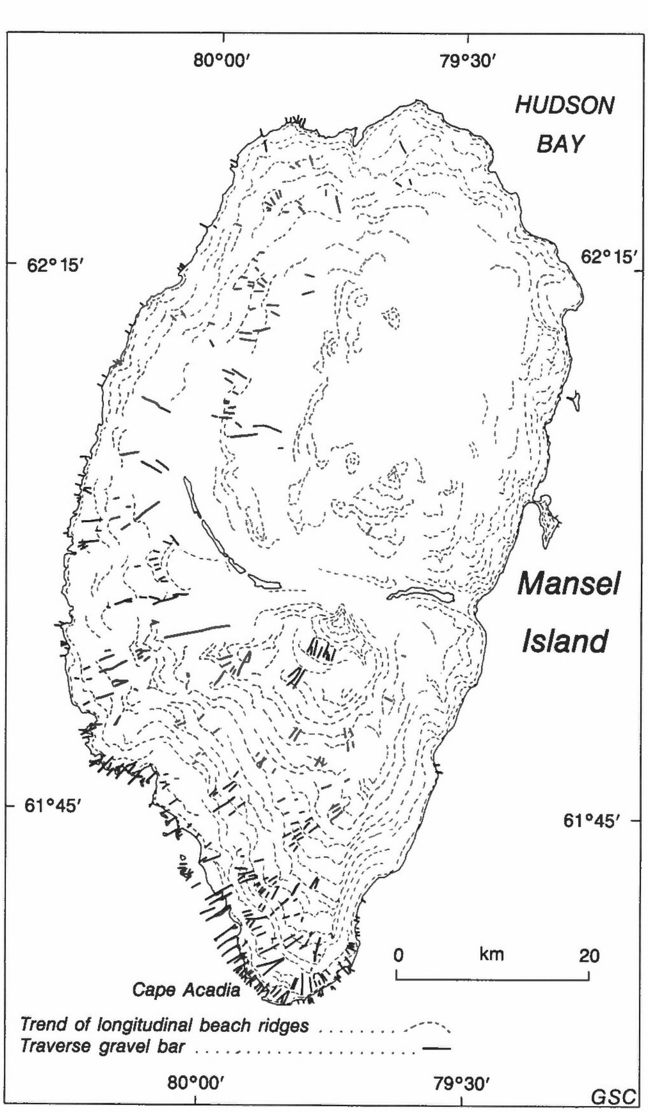

Figure 26. Transverse gravel bars and trend of beach ridges on Mansel Island.

name "strip delta". Where the stream is confined to a bedrock valley as on the south side of Cape Pembroke (Fig. 4, 25), the width of the "strip delta" is controlled by the width of the valley.

A strip delta may be covered with closely spaced strandlines, possibly formed by storms or by ice shove during breakup on its rapidly emerging foreslope; where these ridges form a distinctive chevron pattern curving back from the river on both banks, the unit has been designated Mdr (Fig. 20).

In summary, strip deltas can take several different morphologies, which may in turn exhibit characteristic modifications, depending on the nature of the surrounding terrain, sediment supply, and rate of isostatic uplift. They may have the form of long narrow strips of sediment filling the bottom of narrow bedrock valleys with the present river downcutting into them (Fig. 4, 25), or they may form sandy strips with no apparent confining sides. At the eastern end of the central valley and in Swaffield Harbour valley of Mansel Island and in several small valleys near Cape Pembroke, Coats Island (Fig. 25) strip deltas confined in bedrock valleys are developed. They may form broad, strandline-covered slopes infilling broad embayments in the steeper slopes of northeastern Coats Island, where they are deeply gullied and may grade laterally into true beach deposits (Fig. 4). Probably the most common form is a long narrow strip of sediment, sometimes with distinct beach ridges and intervening swampy areas, crossing the broad coastal plain which rings most of Coats Island (Fig. 20). These latter deltas grade laterally into other nearshore and offshore deposits and have no obvious confining walls. Some of the area mapped as MO, marine offshore deposits and organic cover, may have originated as a strip delta.

Transverse gravel bars

Distinctive transverse gravel bars occur along the western side of Mansel Island, both inland and in shallow water offshore (Fig. 26, 27). These long, narrow, ridges are oriented perpendicular to past and present shorelines. Their lengths are 0.5 to 7 km and they may extend up to 3 km into the sea. These ridges are best developed on the southern half of the island, where they radiate mainly westward and southward from the local height of land (95 m). They extend discontinuously from near the height of land to the present shore and beyond. Small, secondary beaches flare out laterally from some of the ridges and, where linked with those of neighbouring ridges, may form a cuspate beach parallel to the shore. The transverse pattern is interrupted on steeper slopes, where closely spaced, normal strandlines are parallel to the local contours.

Brief mention was made of Mansel Island's transverse ridges by King (1969), who referred to them as chevron beach ridges. Although she was unable to explain their origin, she did not discount reworking of crevasse fillings as a possibility. Similar transverse features have been observed along the west coast of Hudson Bay and in other Arctic locations. A variety of possible origins, ranging from wave reworked glacial landforms to true wave constructed landforms, have been suggested (Bird, 1967; King, 1969; Martini et al., 1980).

The formation of the transverse ridges of Mansel Island is thought to be initiated at shoals formed by local bedrock protuberances in the generally smooth, gently sloping, offshore bottom. It may be that these protuberances are the relatively erosion resistant pinnacle and patch reefs contained in the limestones of the Ekwan River and Attawapiskat Formations (Heywood and Sanford, 1976). Other features with positive relief, whether of bedrock or surficial materials, should produce the same results (Martini et al., 1980).

Because storm waves approach Mansel Island from the west and southwest, direction of wave movement is approximately perpendicular to the western coast. A shoal would intercept wave base first, focusing wave energy at the shoal and causing waves to refract around it. Where the refracted waves meet, the coarser fractions of the glacial substrate are reworked and heaped up into a transverse gravel bar extending from the shoal towards the shore (Fig. 28). The refracted waves converge and cross along the axis of the bar, gradually building the sediment up above sea level and toward the shore as described for similar features by Niedoroda and Tanner (1970). Their "transverse bars" were formed of sand. Therefore we have named the features on Mansel Island "transverse gravel bars" to emphasize the compositional difference.

Tidal changes increase the area affected by these waves. Once established, the process becomes self-perpetuating. Refraction apparently causes all waves to converge along the spit, expending their constructive energy on the spit rather than on the shore. Water returns offshore in the zone between the spits, moving parallel to them. No significant longshore currents can exist where these features are well developed.

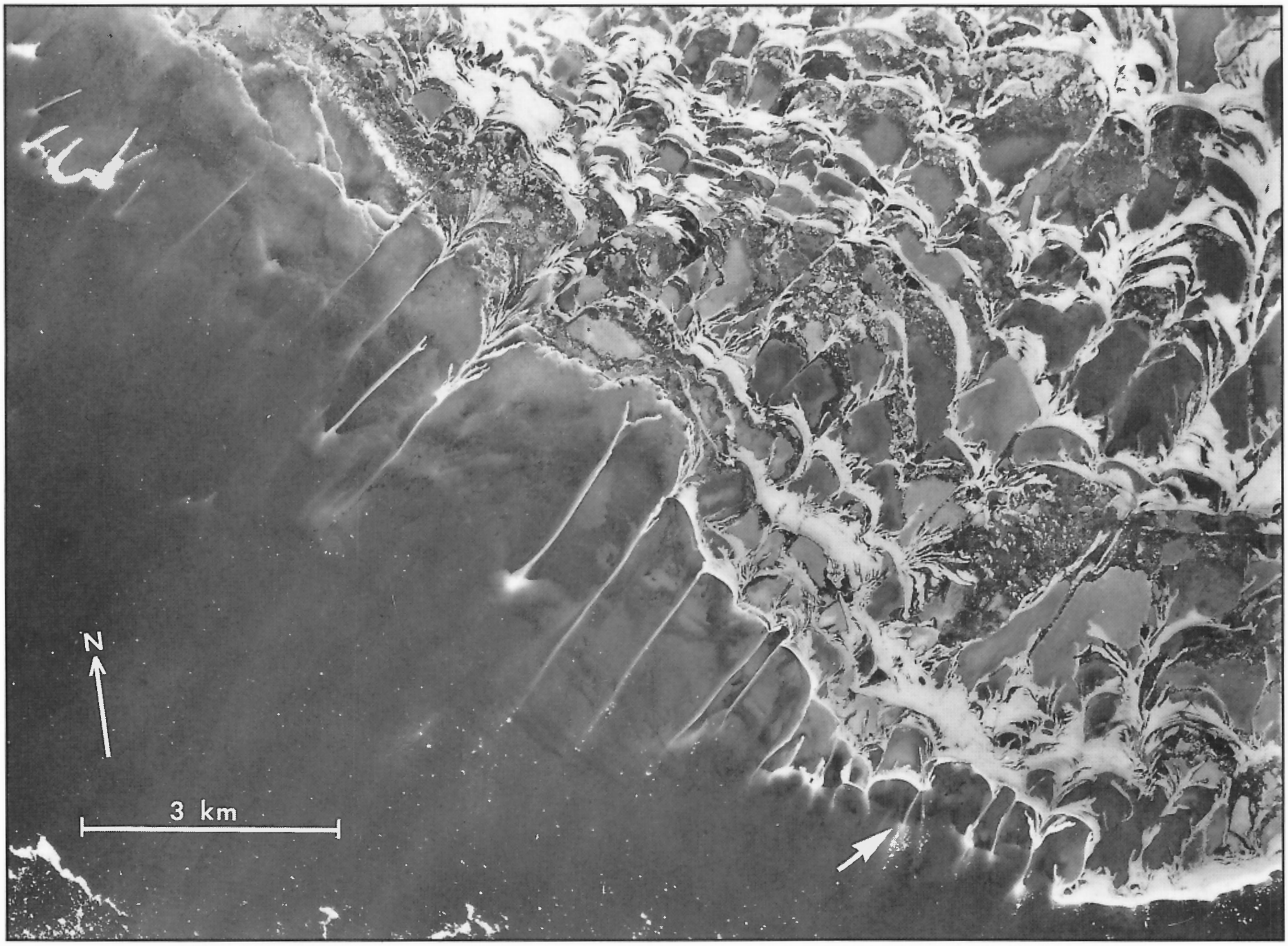

Figure 27. Southwestern shore of Mansel Island. Cape Acadia is on right. Transverse gravel bars extend up to 3 km from shore. Note small islands or shallow areas at offshore end of many transverse gravel bars. Offshore are examples of transverse gravel bars with and without secondary beaches which flare out from the bars like barbs on an arrow. NAPL A 25026-37

Figure 28. Wave refraction causing waves to converge and cross over crest of submerged transverse gravel bars, Cape Acadia, Mansel Island. GSC 203538-G

Figure 29. Raised beaches, eastern Mansel Island. Note small alluvial fans (photo centre), associated with short streams, issuing from springs in underlying bedrock. GSC 203538

Because the land as a whole is emerging from the sea, the landward parts of the bars rise progressively above sea level, making them a conspicuous feature of the onshore landscape. The fact that many offshore transverse gravel bars are continuous with raised ones onshore suggests that the submarine process is self perpetuating for some as yet poorly understood reason.

Alluvial deposits

The youngest sediments on these islands were deposited by streams, which eroded, transported, and redeposited glacial and marine materials following retreat of the sea.

Silt, sand, gravel, cobbles, and boulders were deposited as alluvium (Ac) on floodplains and in channels. Except for a small region of northwest Mansel Island, areas of alluvium of mappable size are restricted to the outer slopes of Coats Island, where the unit is commonly, although not exclusively, associated with channels cut into strip deltas by their depositing stream. In addition, on both islands small deposits of alluvium occur within areas mapped as strip delta (Md) and marine deepwater sediments and postdepositional organic cover, undifferentiated (MO, MrO).

In many locales, generally at a break of slope or downstream from a catastrophically drained lake, sand, gravel, or boulders were deposited as a fan. A few large alluvial fans (Af) occur along active stream channels on the eastern slope of Coats Island. Numerous small alluvial fans occur along the steeper eastern slopes of Coats and Mansel islands and in places on other steep slopes. Some are associated with short intermittent streams or dry gullies, which start abruptly on beach covered slopes and may be related to groundwater flowing through taliks (Fig. 29). However, evidence of former small lakes dammed behind the ridge suggests that the majority are the result of the breaching of a beach ridge and catastrophic draining of the lake. The resulting torrent may strip a channel to bedrock and the former beach sediments are redeposited in a small fan at the bottom of the slope.

Peat

Poorly drained surfaces are commonly covered by sedge meadows and peat. An organic mat is characteristic of much of unit MO, which is an undifferentiated unit of marine deepwater sediments and postdepositional organic cover, and of the intervening flat areas between strandlines of unit MrO. Areas of peat cover are characterized commonly by frost polygons and extensive areas of tundra ponds. Permafrost lies at a shallow depth (50 cm or less) beneath the insulating organic mat.

Small mounds

Various types of small mounds occur on Coats and Mansel islands. On southwestern Coats Island surfaces of three areas characterized by swamps and tundra ponds (MO) are broken by clusters of small low mounds, each approximately 150 m diameter. These features were not visited in the field but were mapped from airphotos; their light tone on the airphotos suggests that they are either composed of sand or reflect the locally improved drainage and depletion of aquatic plants as an organic mound grew. Although they are mapped as "small mounds of unknown origin" (Map 1633A), they resemble pingo-like features mapped near the mouth of Maguse River on the west coast of Hudson Bay (Arsenault et al., 1982), and we feel that they are more likely to be pingo-like features than palsa-like features.

In the shallow water off the southern coast of Coats Island, other features, which seemed on airphotos to be spring-like features on the seafloor, were found to be bouldery gravel mounds on the bottom with fines washing seaward.

On Mansel Island small mounds and cratered mounds were observed in cobbly gravels and in shallow lakes overlying gravels. Possibly these gravels merely mantle frost heaved bedrock. Ice lensing along subhorizontal fractures within the rock is known to heave bedrock into small mounds with central craters (DiLabio, 1978).

Several unusual features that resemble small bomb craters, are found scattered along beach-covered slopes of eastern Mansel Island (Map 1632A). Isolated hummocky gravel deposits occur immediately downslope of a hollow in the beach sediments. In some cases a dry gully extends downslope from the hollow and terminates in a small alluvial fan, suggesting the presence of an intermittent spring. In other places there is no evidence of water movement, although a light flow may trickle through the undisturbed gravels. The hummocky deposit is thought to be caused by the near surface freezing of periodic outflows of groundwater through subterranean conduits in the underlying limestone. Buildup of ice on the surface of the bedrock would result in a doming of the overlying frozen beach sediments. When the sides of the dome became steep enough, the covering gravel may have slumped downslope exposing ice of the dome's core, which subsequently, without an insulating cover, melted and collapsed.

GLACIAL HISTORY

Ice flow directions

Fluting and striae

Fields of large scale glacial flutings are common on Coats Island, particularly in the depressed central plain which was sheltered from the destructive action of waves. Where flutes were examined on the ground, the frost shattered nature of the bedrock made it difficult to differentiate between muddy limestone residue and till. It is difficult to determine in many cases whether flutings are primarily cut in bedrock or formed of till.

Some flutings are prominent parallel ridges, 0.5 to 2.0 km long (Fig. 15, 16), but others, such as those south of the central lakes on Coats Island (Fig. 17), are faint, irregular or discontinuous features that, although obvious on airphotos, are barely discernable on the ground. In the protected central plain of Coats Island a small field of drumlins, oriented parallel to the flutings, has been protected from the destructive force of wave action.

On both islands the major ice flow, recorded by the prominent fluting fields, was northerly reflecting the evacuation of Laurentide ice northward out of Hudson Bay into Hudson Strait during most of the glaciation. Although the dominant direction of ice flow across Coats Island was northeastward, parallel with the long axis of the island, a wide range of fluting orientations exist, particularly among the fainter and shorter flutings (Fig. 30). Fields of flutings commonly truncate or intersect the trend of other fields on Coats Island, and, in a few locations, cross other fluting orientations. The early northeastward ice flow that formed the most prominent flutings was apparently followed by weaker easterly and southeasterly flow, which is thought to have occurred as areas of drawdown toward a nearby and growing marine reentrant between Coats and Mansel islands. The shift in ice flow direction is also reflected by striation measurements which indicate an older northeastward flow crossed by a younger southeastward flow (Fig. 30).

Flutings on Mansel Island are restricted to the northeastern quarter of the island. With the exception of a minor area of southwest-northeast trending flutings in the centre of the island, only a northward ice movement is recorded (Fig. 31). The minor southwest-northeast trend probably represents reorientation of ice flow towards the marine incursion between Coats and Mansel islands. No striae were found on Mansel Island.

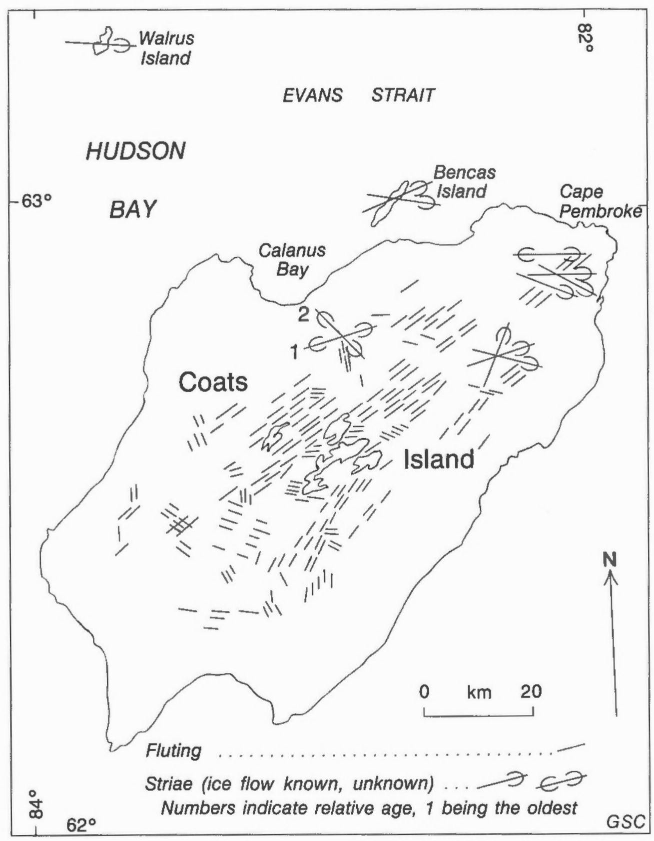

Figure 30. Orientation of flutings and striae, Coats Island. Daily change of the North Magnetic Pole causes erratic declination deflections in this area, and magnetic declination varies widely across Coats Island. Declination settings were neither adjusted nor recorded at each striation site. Therefore, there may be some errors in striation measurement, a situation suggested by the apparent lack of correspondence between striations and flute orientations representing main sustained direction of ice flow parallel to island's axis.

Dispersal trains

On both islands most of the Precambrian erratics are granitic and basic gneissic or igneous intrusive rocks which, because of their ubiquitous occurrence within the Canadian Shield on either side of Hudson Bay, cannot be assigned to any specific source area. The remainder of the Precambrian erratics of all sizes on both islands comprise mostly sedimentary and volcanogenic types that can be traced to fairly specific source areas within the Proterozoic depositional basins that occur both east and west of Hudson Bay.

The nongneissic component of the erratics of Mansel Island was glacially transported from the Circum-Ungava geosyncline which lies 100 to 150 km south and east of Mansel Island. They include distinctive black to grey greywacke metasandstones and shales, ultramafic and basic volcanic clasts, and various types of iron formation. The presence of these "dark" erratics (Shilts, 1980b, 1982) and lack of "red" erratics suggest that, throughout its glacial history, Mansel Island was under the influence of ice flow from Quebec.

Red volcanogenic erratics found on Coats Island are derived from the Dubawnt Group in the Baker Lake area, west of Hudson Bay and close to the centre of the Keewatin ice. At the end of the glacial stage, the Keewatin Ice Divide lay across or just to the west of the main outcrop areas of hard, red to grey volcanogenic lithologies of the Dubawnt Group. The Dubawnt Group erratics and associated Proterozoic metaorthoquartzitic erratics were dispersed in a well defined train southeastward from these outcrops into Hudson Bay. The train was deflected sharply to the northeast to cross over Coats Island where the Dubawnt erratics, which were transported 600 to 700 km from their source outcrops, make up approximately 1-2% of pebble sized erratics in the till. By the time the dispersal train crossed Coats Island, it had been constricted to less than a 100 km wide swath, as evidenced by the general paucity of red erratics on Walrus Island and southeastern Coats Island.

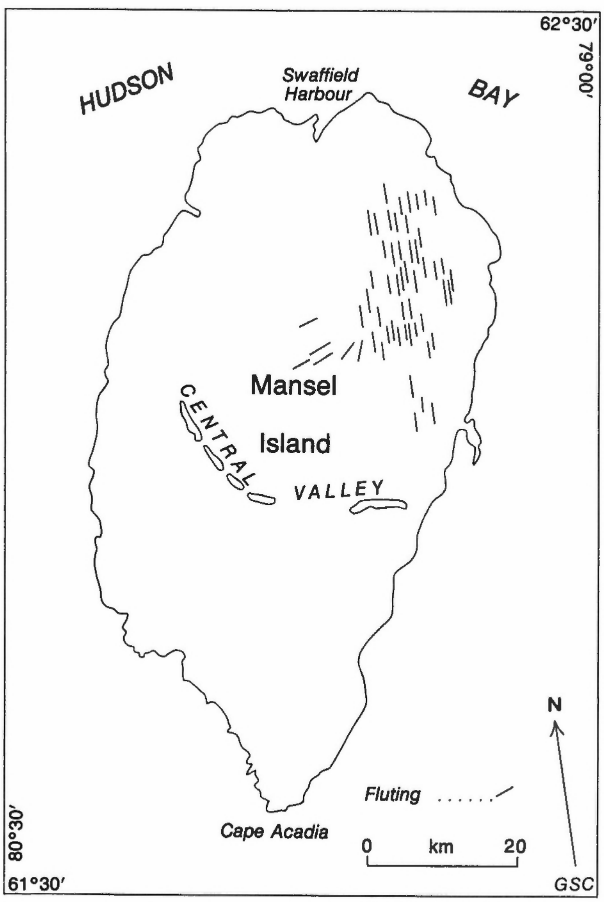

Figure 31. Orientation of flutings, Mansel Island.

The presence of "dark" erratics on eastern Coats Island proves that, unlike Mansel Island, Coats Island was influenced by both ice masses.

Glaciation

Coats and Mansel islands occupy a strategic location for the determination of the glacial history of the area surrounding Hudson Bay, as they lie near the outlet of Hudson Bay where that portion of the Laurentide Ice Sheet that occupied the bay flowed northward and northeastward out into Hudson Strait.

In recent years two opposing schools of thought concerning the nature of the Laurentide Ice Sheet have emerged. One, based on a theory championed by Flint (1943), proposes a stable central ice dome over Hudson Bay for most of the Wisconsinan with retreat to two late ice divides on land in Keewatin and Quebec-Labrador in the last 2000 years of the glaciation. (For discussion of this theory see Denton and Hughes, 1981). The other model, first suggested by Tyrrell (1898), interprets the Laurentide Ice Sheet as being composed of coalescing multiple ice centres, situated on land, and subject to as many as six major glacial pulses which reduced ice volume of these centres to such a significant degree that Hudson Bay was open to the sea once or twice during the Wisconsinan (Andrews et al., 1983; Shilts, 1985). The latter theory is supported by evidence from detailed mapping of the surficial geology of the areas surrounding Hudson Bay, by patterns of glacial drift dispersal, of which this reconnaissance plays a part, and by geochronological dating of shells in interglacial, interstadial, and postglacial sediments, using the amino acid technique.

Ice flow centres, actually elongated ridges called ice divides in this report, developed in Keewatin and Quebec-Labrador. From these centres, ice flowed radially outward until flow was diverted by flow from another centre. In the northern part of Hudson Bay the coalescing ice flowed northward out into the area of Hudson Strait. The zone of convergence probably shifted with changes in the relative strength of each ice sheet.

The dissimilarity in erratic composition on Coats and Mansel islands prove that ice from two ice flow centres, positioned east and west of Hudson Bay merged between the islands to flow through the narrow mouth of Hudson Bay (Shilts, 1982). The interface between these two ice masses lay off the east shore of Coats Island and fluctuated somewhat, depending on the relative strength of the two ice masses at any specific time.

Because of the distance of transport undergone by the red Dubawnt erratics, and the significant period of time inferred for this transport under normal glacial conditions, it is probable that the above pattern of ice flow existed throughout much of the last glaciation (Shilts et al., 1979; Shilts, 1980b, 1982). Because of the lack of exceptions to the dispersal patterns so clearly expressed by deposits of the last glacial events (for example, although easy to identify, not a single Dubawnt erratic was observed on Mansel Island), it is thought that ice flow patterns for earlier events in this part of Hudson Bay were similar.

Deglaciation and isostatic rebound

It is probable that the ice sheet profile was relatively flat by the time Hudson Bay was penetrated and that deglaciation of the remaining ice sheet occurred largely by stagnation (Shilts, 1985; Shilts et al., 1987). Certainly landforms on these islands suggest a style of deglaciation that is consistent with the idea of a largely stagnant ice body. Hummocky till is found above marine limit on Coats Island and in protected locales on both islands. In addition, hummocky, unconsolidated sediments, as interpreted from sonar records, are reported from Mansel Bank, south of Mansel Island (Josenhans et al., 1988). Hummocky till is thought to result from the release of debris from the basal part of an essentially stagnant ice mass and is common throughout the region of the Keewatin Ice Divide where widespread stagnation is inferred (Shilts et al., 1987).

Deglaciation of this area began with the incursion of marine water into Hudson Bay at about 8 Ka (Skinner, 1973; Hardy, 1977). The presence and growth of a marine reentrant between the islands is reflected in the shifting orientation of flutings and striae on Coats Island. By following the 200-240 m deep trough that separates Coats and Mansel islands, the reentrant eventually split the two ice sheets at or very near their actual zone of confluence.

Josenhans et al. (1988) established from side-scan sonar records that the original reentrant extended towards the Manitoba-Ontario border and not along the eastern side of Hudson Bay as earlier postulated (Andrews and Falconer, 1969). They also suggested that the initial incursion was rapid, followed by a time of relative stability. They point to the high resolution seismic evidence for the existence of a large subaqueous moraine, extending between Mansel Island and Quebec mainland, with thick, laminated, glaciomarine sediments lying to the north of the moraine. South of the moraine the sediment cover is thin, as is the case over much of the rest of Hudson Bay and on the islands themselves.

A second calving bay grew towards James Bay, reaching the James Bay Lowlands about 7.8 Ka, and most of the rest of Hudson Bay was glacier-free by 7.3 Ka (Craig, 1969). The last glacial ice retreated to the vicinity of the Keewatin and Quebec-Labrador ice divides and disappeared completely before 6 Ka.

Wagner (1967) collected shells from three sites on Mansel Island and two sites on Coats Island. The radiocarbon ages range from 5440 to 7115 BP. Unfortunately there is no information to relate these dates to specific shorelines. The oldest date, 7115 ± 100 BP (GX-1070), was obtained from a site at 95 m a.s.l. on Mansel Island, well below maximum marine level. It provides a minimum date for deglaciation.

With the exception of a small area of northeastern Coats Island, the sea submerged both islands upon deglaciation. It is significant that marine limit is relatively low (124 m) on Coats Island, one of the first parts of Hudson Bay to be deglaciated, compared with marine limits elsewhere around Hudson Bay. The same holds true for nearby Bell Peninsula of Southampton Island where marine limit lies at various elevations between 124 m and 157 m (Bird, 1953). In contrast, marine limit lies at 158 m in the Ottawa Islands (Andrews and Falconer, 1969) and varies from 192 m near the coast of mainland Keewatin to 152 m near the Keewatin Ice Divide (Shilts, 1986). West of Baker Lake a last remnant of the Keewatin ice blocked entry by the sea into a small basin until sufficient restrained rebound had occurred to establish marine limit at 123 m (McDonald and Skinner, 1969). Low elevation of marine limit in areas subject to earliest deglaciation requires that the ice sheet was thinner over Coats Island than in areas with similar marine limits but much later dates of deglaciation (Shilts, 1986). Alternatively, sufficient time elapsed between development of a marine reentrant and deglaciation of Coats Island to allow substantial restrained rebound to occur. A combination of both explanations is likely.

As the crust rebounded from the weight of the ice sheet and the land emerged through wave base, the surficial sediments and bedrock itself were reworked into the extensive flights of raised beaches described earlier in the text. The presence of unshattered stones in nearshore deposits just above present high tide suggests that isostatic rebound is continuing because only short periods of subaerial exposure are required to cause carbonate clasts to corrode and split from the action of salt air and frost.

ACKNOWLEDGMENTS

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