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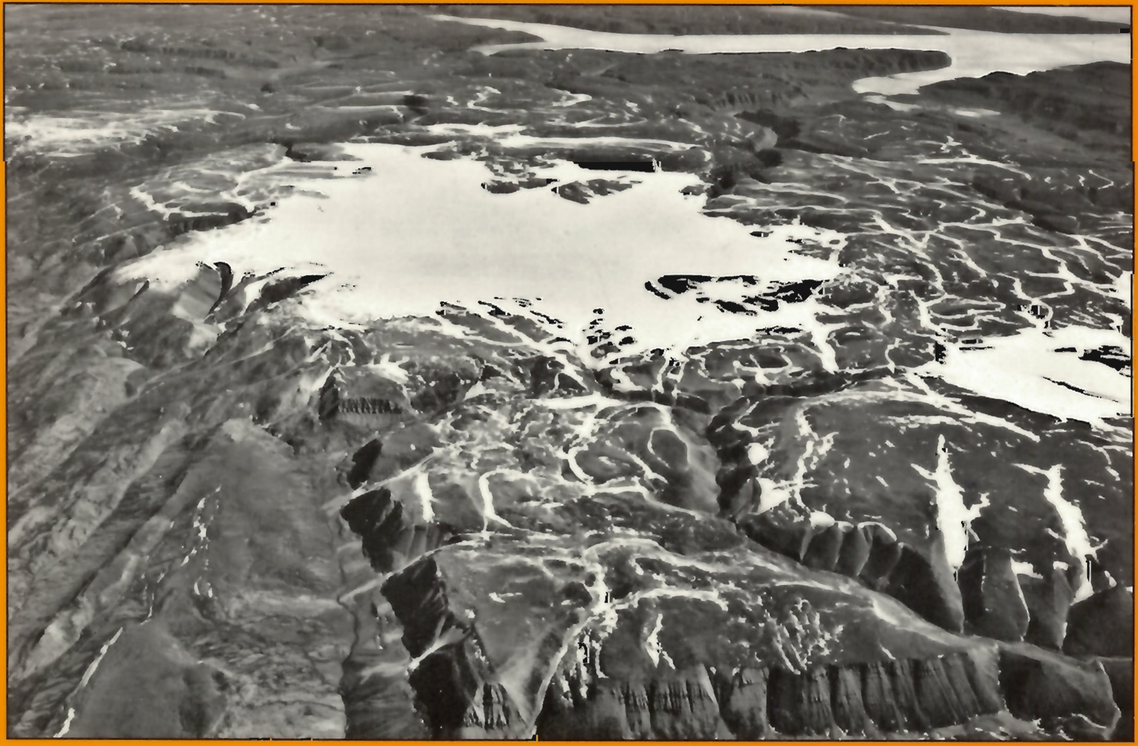
QUATERNARY GEOLOGY OF WESTERN MELVILLE ISLAND, NORTHWEST TERRITORIES

D.A. Hodgson



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Cover description

Southernmost Melville Island ice cap, 10 km diameter, draped over the highest (>700 m) planation surface of the Blue Hills; fault line scarps in the foreground. Snow filled channels drained final Late Wisconsinan regional ice sheet. View east towards Murray Inlet, part of the radial system of tectonic or glacial troughs. National Air Photo Library, T419R-17.

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QUATERNARY GEOLOGY OF WESTERN MELVILLE ISLAND, NORTHWEST TERRITORIES

Abstract

The western peninsula of Melville Island includes the highest elevations in the western Arctic Archipelago. At the centre are the Blue Hills plateaus, lying 400-750 m a.s.l., which are dissected on the margins and cut radially by cliffed sea inlets. The longest of several transecting scarps forms the border with northern lowlands. Some important morphological elements date from the Paleozoic; planation surfaces are likely Tertiary peneplains, but the origin of other such elements as the inlets, linear coastlines, and adjacent flat floored channels, is equivocal.

Most of the peninsula is mantled by up to several metres of frost disaggregated bedrock. This weathered rock, derived from a variety of clastic and calcareous sediments, includes discrete areas of fines, sand, mixed fines and rubble, and rubble. These materials bear no clear indicators of glaciation, other than marginal meltwater channels on coarse materials tracing retreat of local ice from some coasts to the interior.

Scattered patches of till, ice contact deposits, and undated raised glaciomarine deposits were left by a partial cover of local glacial ice, which was at least 300 m thick in places. Circumstantial evidence suggests a Late Wisconsinan age for this event; however, the highest evidence of marine overlap does not conform to the uplift pattern expected from an island ice cap.

Rare erratics of southern provenance at all elevations indicate inundation by continental ice, probably in early Quaternary time. The M'Clure glacier, at the northwest limit of the Late Wisconsinan Laurentide Ice Sheet, pushed onto the south coast earlier than 11.7 ka.

Modern and inactive fluvial sediments are the most widespread Quaternary deposits. Emergent shoreline deposits are rare. Static plateau glaciers are not relicts from the Pleistocene, but date from post-Hypsithermal cooling, when even more extensive areas were intermittently blanketed by perennial snow cover.

Résumé

La presqu'île ouest de l'île Melville comprend les altitudes les plus élevées de l'archipel Arctique occidental. On trouve, au centre, les plateaux des collines Blue, où l'altitude au-dessus du niveau de la mer est de 400 à 750 m; ces plateaux aux bordures disséquées sont coupés radialement par de petits bras de mer cernés de falaises. Le plus long des quelques escarpements transversaux borde les basses-terres du nord. Certains éléments morphologiques importants datent du Paléozoïque; les surfaces d'aplanissement sont probablement des pénéplaines du Tertiaire, mais l'origine d'autres éléments comme les petits bras de mer, les littoraux linéaires et les chenaux à fond plat contigus demeure incertaine.

La majeure partie de la presqu'île est recouverte de plusieurs mètres de socle décomposé par le gel. Cette roche désagrégée, qui provient de divers sédiments détritiques et calcaires, comprend des zones distinctes constituées de grains fins, de sable, d'un mélange de grains fins et de matériaux plus grossiers, et de blocaille. Ces matériaux ne présentent aucun signe manifeste de glaciation, sauf la présence de chenaux marginaux d'eau de fonte sous des matériaux grossiers, qui témoignent du retrait de la glace locale de certaines côtes vers l'intérieur.

Des bancs éparpillés de till, des dépôts de contacts glaciaires et des sédiments glacio-marins soulevés d'âge inconnu, ont été mis en place par une couverture partielle de glace de glacier locale, dont l'épaisseur atteignait par endroits au moins 300 m. Des indices indirects semblent indiquer que cet événement date du Wisconsinien supérieur; toutefois, la transgression marine la plus élevée qui ait été observée n'es pas conforme au modèle prévu du soulèvement d'une calotte glaciaire insulaire.

La présence de quelques blocs erratiques provenant du sud, à toutes les altitudes, indique qu'une inondation par un glacier continental a eu lieu, probablement au début du Quaternaire. Le glacier de M'Clure, situé à la limite nord-ouest de l'inlandsis Laurentidien du Wisconsinien supérieur, envahit la côte sud il y a plus de 11,7 ka.

Des sédiments fluviatiles et contemporains inactifs sont les dépôts du Quaternaire les plus répandus. Il y a peu de dépôts littoraux émergeant. Les glaciers tabulaires statiques ne sont pas des vestiges du Pléistocène, mais datent bien du refroidissement post-hypsithermal, période où de plus grandes étendues encore étaient recouvertes par intermittence d'une couverture de neige pérenne.

SUMMARY

Western Melville Island is significant to Quaternary studies as one of the few known centres of local ice in the western Arctic Islands, and by bordering the northernmost margin of the Laurentide Ice Sheet. This considerable landmass lies in an area where the cause and pattern of recent crustal movements are poorly understood. Field work reported here permits little more than further definition of these problems; explanatory stratigraphy and datable deposits, which underlie field methods, are uncommon.

Western Melville Island is a peninsula in the western Queen Elizabeth Islands, connected to the remainder of the island by a lowland isthmus (which lies beyond the 112° west meridian boundary of the map area). The southern portion is upland, cored by the Blue Hills plateaus, which lies between 400 and 700 m a.s.l. and which is increasingly dissected to the west and southwest. The elevation is sufficient to support the only ice caps in the western Arctic Archipelago. A radial system of sea inlets is cliffed where it intersects plateaus. Similarly steep scarps (to 500 m high) transect the uplands and a major bluff forms the northern margin of the uplands. Beyond lie rolling lowland and low scarpland, broken by outliers of upland at the dissected Canrobert Hills and inclined tableland of the Ragland Range. The seafloor generally falls away steeply from coasts into relatively even floored channels, 250 to 500 m deep.

About 95% of the land area is covered by weathered rock, disaggregated probably throughout the Quaternary. The four dominant units mapped are: 1) fine grained material of the lowlands; 2) rubble and fines mixed, mainly in uplands; 3) sand or silty sand, which occurs at all elevations; and 4) rubble upland. Fluvial and rapid mass movement processes characterize fine grained materials, slow mass movement such as solifluction lobes is most common on mixed deposits, and the most stable deposits are coarse grained, though they are subject to frost action.

Composition of weathered rock is related to the degree of induration and to component grains of underlying Paleozoic and Mesozoic sedimentary rocks. These are mainly quartzitic clastic rocks with neutral to slightly acid pH values, whereas carbonates and evaporites produce alkaline surface materials predominantly in the Canrobert Hills.

The only erosional landforms related to glaciation are concentrations of ice marginal meltwater channels preserved exclusively in coarse grained deposits, and extremely rare striations northwest of Raglan Range.

Small patches of till occur throughout the island, except on Sproule Peninsula in the extreme north. Most deposits appear to be of local provenance not only because of the local origin of most clasts, but because of their association with meltwater channels draining coastwards.

SOMMAIRE

La partie ouest de l'île Melville est importante à l'étude du Quaternaire d'une part parce qu'elle est un des rares centres connus de glace locale dans l'ouest de l'archipel Arctique et d'autre part parce qu'elle se situait sur la marge la plus septentrionale de l'inlandsis laurentidien. Cette énorme masse insulaire se trouve dans une région où l'origine et le type des mouvements récents de la croûte sont mal compris. Les travaux sur le terrain dont il est fait état dans le présent document permettent à peine de mieux définir ces problèmes; la rareté des données de stratigraphie explicative et de dépôts datables rend ces travaux difficiles.

La partie ouest de l'île Melville est une presqu'île située dans la partie ouest des îles Reine-Élisabeth et est liée au reste de l'île par un isthme bas (qui se trouve au-delà de 112° de longitude ouest, limite de la feuille). La partie sud est constituée de hautes terres, dont le coeur forme les plateaux des collines Blue à une altitude allant de 400 à 700 m au-dessus du niveau de la mer et qui présentent un aspect de plus en plus disséqué vers l'ouest et le sud-ouest. L'altitude est suffisante pour supporter les seules calottes glaciaires dans l'ouest de l'archipel Arctique. Un système radial de petits bras de mer forme des falaises là où il coupe des plateaux. De façon semblable, des escarpements abrupts (atteignant 500 m de haut) dissèquent transversalement les hautes terres; une falaise importante forme la marge nord de ces hautes terres. Au delà se trouvent des basses terres valonnées et des petits escarpements, dont l'harmonie est perturbée par des buttes témoins de hautes terres dans les collines Canrobert, relief fortement disséqué, et le haut plateau incliné de la crête Raglan. Le fond marin descend généralement rapidement à partir des côtes et finit par former des chenaux relativement plats de 250 à 500 m de profondeur.

Environ 95 % des terres sont couvertes de roches décomposées, probablement désagrégées pendant le Quaternaire. On a porté sur la carte les quatre unités prédominantes suivantes : 1) matériaux à grain fin des basses terres; 2) galets et grains fins mélangés, surtout dans les hautes terres; 3) sable ou sable silteux qu'on retrouve à toutes les altitudes; et 4) galets des hautes terres. Des processus fluviatiles et de rapides mouvements de masse caractérisent les matériaux à grain fin, les mouvements de masse lents, dont les lobes de solifluxion, sont plus fréquents sur les dépôts mélangés, et les dépôts les plus stables sont grossiers, bien que sujets aux effets du gel.

La composition des roches désagrégées est liée au degré de lithification et aux grains constitutifs des roches sédimentaires paléozoïques et mésozoïques sous-jacentes. Ces dernières sont principalement composées de roches détritiques quartzitiques dont le pH est neutre à légèrement acide, alors que des roches carbonatées et des évaporites produisent des matériaux superficiels alcalins, surtout dans les collines Canrobert.

Les seules fomes d'érosion associées à la glaciation sont des concentrations de chenaux d'eau de fonte creusés aux marges de glaciers, conservés exclusivement dans les dépôts à grain grossier.

Subglacial deposits are limited to a few eskers, kames and an area of equivocal drumlinoid ridges. Rare nonfossiliferous ice contact and valley train marine deltas, also associated with local ice, were deposited into a sea 45-76 m a.s.l. Even rarer banded silts, 60 to 220 m a.s.l., are likely glaciolacustrine. Fragments of marine pelecypods found on a silt deposit and likely eroded from adjacent till or outwash, yielded high alloisoleucine/isoleucine ratios, possibly indicating an early Quaternary or older age.

A scattering of more exotic erratics to at least 500 m a.s.l. includes lithologies of southerly origin, from Victoria Island or the mainland Canadian Shield. A silty calcareous till containing up to 5% southern erratics outcrops on south coast lowlands, adjacent to M'Clure Strait, particularly around Bailey Point and between Cape Russell and Comfort Cove. At the latter site, a till ridge possibly marks the inland limit of a glacier which pushed onshore from M'Clure Strait. Marine deposits directly overlying till at Comfort Cove dated 11.7 ka, and at Bailey Point 10.6 ka. Sea level was 40-60 m above present in that period.

Fine grained raised marine deposits are distributed discontinuously along lowland coasts. They rarely yield shells, which date 10-11 ka. Raised beaches are even scarcer, due to the existence of ice covered seas throughout the Late Pleistocene and Holocene. No deposits occur higher than 40 m elevation.

Fluvial sediments are the most widespread Quaternary deposits, other than weathered rock and colluvium. The extreme nival regime (except adjacent to ice caps) gives rise to sand and gravel braided channels in all units. Terraces, linked to prograding deltas, are confined mostly to the lowland north coast. Numerous fluvial fans and a few larger deltas border the upland coastline.

Permafrost in adjacent landmasses reaches depths of 300 to 600 m; however, the only subsurface information from western Melville Island is from a few shallow pits and natural exposures which show massive segregated ground ice present at least locally. The ice caps are thin and believed to be static.

Important elements of the morphology of western Melville Island were shaped prior to the Quaternary. Planation surfaces, which are widely present between 400 and 600 m a.s.l., are likely remnants of a Tertiary peneplain now inclined to the north. Inland and coast scarps originated by exhumation of Paleozoic fault-line scarps and subaerial erosion along fault lines. More speculative origins include fault scarps (i.e., direct tectonic origin) and glacial erosion.

The high elevation erratics of southerly provenance were deposited by a continental ice sheet preceding emplacement of Dundas Till (probably Early Pleistocene) on southern Melville Island.

On trouve répandus un peu partout dans l'île des petits bancs de till, sauf dans la presqu'île de Sproule située à l'extrême nord. La plupart des dépôts semblent être d'origine locale, non seulement à cause de l'origine locale de la plupart des dépôts détritiques, mais aussi à cause de leur association avec des chenaux d'eau de fonte drainant vers la côte. Les dépôts sous-glaciaires se limitent à quelques eskers, à quelques kames et à une région constituée de crêtes équivoques en forme de drumlins. De rares deltas marins non fossilifères formés par des matériaux de contact glaciaire et des traînées fluvio-glaciaires, et associés en outre à de la glace locale, ont été mis en place dans une mer s'élevant entre 45 et 76 m au-dessus de l'actuel niveau de la mer. Des silts rubannés encore plus rares, rencontrés 60 et 220 m au-dessus du niveau de la mer, sont probablement d'origine glacio-lacustre. Des fragments de pélécypodes marins, trouvés sur un dépôt silteux et provenant probablement de l'érosion d'un till ou d'un épandage fluvio-glaciaire adjacent, ont donné des rapports élevés allo-isoleucines à isoleucines, qui indiquent qu'ils dateraient du Quaternaire inférieur ou d'avant.

Un éparpillement de blocs erratiques exotiques pouvant atteindre au moins 500 m au-dessus du niveau de la mer renferme des lithologies d'origine sud, c'est-à-dire provenant de l'île Victoria ou du Bouclier canadien. On trouve un till calcaire silteux, renfermant jusqu'à 5 % de blocs erratiques du sud, sur les basses terres de la côte sud adjacentes au détroit de M'Clure, particulièrement autour de la pointe Bailey et entre le cap Russell et l'anse Comfort. À ce dernier endroit, une crête de till marque probablement la limite à l'intérieur des terres d'un glacier qui a avancé sur terre à partir du détroit de M'Clure. Des dépôts marins qui reposent directement sur les tills dans l'anse Comfort remontent à 11,7 ka et dans la pointe Bailey, à 10,6 ka. Le niveau de la mer se trouvait à cette époque entre 40 et 60 m au-dessus du niveau actuel.

Des dépôts marins soulevés, à grain fin, sont répandus le long des côtes basses. Ils renferment des coquilles qui remontent à 10-11 ka, mais rarement. Les plages soulevées sont encore plus rares, parce que les mers étaient couvertes de glace pendant tout le Pléistocène supérieur et tout l'Holocène. On ne trouve aucun dépôt au-dessus de 40 m.

Les sédiments fluviatiles sont les dépôts quaternaires les plus répandus, exception faite des roches désagrégées et des colluvions. Le régime nival extrême (sauf à proximité des calottes glaciaires) donne naissance à des chenaux anastomosés de sable et de gravier dans toutes les unités. Les terrasses, associées à des deltas en progression vers la mer, sont surtout confinées à la côte nord des basses terres. De nombreux cônes alluviaux et quelques deltas importants bordent le littoral des hautes terres.

Dans les masses insulaires voisines, le pergélisol atteint des profondeurs de 300 à 600 m; toutefois, les seuls renseignements de subsurface obtenus dans la partie ouest de l'île Melville proviennent de quelques thermokarsts peu profonds et de quelques affleurements naturels qui montrent, au moins par endroits, une glace dans le sol massive et de ségrégation. Les calottes glaciaires sont minces et on pense qu'il s'agit de calottes statiques.

Local ice left no indicator landforms while expanding in the Late Quaternary. The ice retreated towards the centre of the landmass leaving marginal channels encircling and perhaps overtopping the Raglan Range behind an outermost margin in Hecla and Griper Bay. Ice in the lowlands south of the Raglan Range was 300 m thick. The surface of thinner ice over the uplands conformed to relief. Glaciers occupied some sea inlets, but parts of the island may have remained ice free. Circumstantial evidence suggests a Late Wisconsinan age for this ice.

The M'Clure glacier, inferred to be a partially buoyant lobe at the northwest limit of the Late Wisconsinan Laurentide Ice Sheet, occupied at least eastern M'Clure Strait earlier than 11.7 ka. The glacier pushed onshore at several locations free of local ice. This event is correlated with deposition of Liddon and Bolduc tills on southern Melville Island. Vincent (1982) placed till deposition on the shores of northern Banks Island in the M'Clure Stade of the earlier part of the Wisconsinan Amundsen Glaciation.

Maximum known and speculative Late Pleistocene and Holocene sea levels, which generally lie at 40-70 m a.s.l., do not obviously record isostatic recovery from a local ice load. The Holocene relative sea level pattern has not been established, owing to the rarity of datable material.

Quartzitic sand to block size rubble is widely available for aggregate use from weathered rock units. Coarse grained glacigene and marine deposits are rare. Fine grained materials are particularly susceptible to gullying, and where silty sand is dominant, to skin flows. Though close to clusters of earthquake epicentres, there is no conspicuous evidence of landslides.

Les éléments importants de la morphologie de la partie ouest de l'île Melville ont été façonnés avant le Quaternaire. Les surfaces d'aplanissement, abondantes entre 400 et 600 m au-dessus du niveau de la mer, sont probablement des vestiges d'une pénéplaine tertiaire, actuellement inclinée vers le nord. Les escarpements intérieurs et côtiers se sont formés suite à l'exhumation d'escarpements de lignes de failles paléozoïques et à l'érosion subaérienne le long de ces lignes de faille. Il est possible, mais l'hypothèse est spéculative, que ces escarpements aient comme origine des escarpements de faille (c'est-à-dire d'origine tectonique directe) et une érosion glaciaire.

Les blocs erratiques juchés à haute altitude et provenant du sud ont été déposés par un inlandsis précédant la mise en place du till de Dundas (probablement au Pléistocène inférieur) sur la partie sud de l'île Melville.

La glace locale n'a laissé aucune forme de relief révélatrice pendant son expansion au Quaternaire supérieur. La glace s'est retirée vers le centre de la masse insulaire, laissant des chenaux marginaux qui entourent et peut-être dominent la crête Raglan derrière une marge périphérique dans la baie Hécla et Griper. La glace des basses terres au sud de la crête Raglan, atteignait une épaisseur de 300 m. La surface d'une glace plus mince, au-dessus des hautes terres, épousait la forme du relief. Des glaciers occupaient quelques petits bras de mer, mais certaines parties de l'île pourraient n'avoir pas été couvertes de glace. Des indices indirects semblent indiquer que cette glace datait du Wisconsinien supérieur.

Le glacier de M'Clure, qu'on suppose être un lobe partiellement flottant à la limite nord-ouest de l'inlandsis laurentidien du Wisconsinien supérieur, occupait au moins la partie est du détroit de M'Clure il y a plus de 11,7 ka. Le glacier a avancé sur la côte en plusieurs endroits libres de glace locale. Cet événement correspond au dépôt des tills de Liddon et de Bolduc sur la partie sud de l'île Melville. D'après Vincent (1982), le dépôt du till sur les rivages de la partie nord de l'île Banks date du stade de M'Clure de la partie inférieure de la glaciation d'Amundsen du Wisconsinien.

Les niveaux maximaux, connus et supposés, de la mer au Pléistocène supérieur et à l'Holocène, qui se situent généralement de 40 à 70 m au-dessus du niveau actuel, ne montrent aucun signe de compensation isostatique manifeste après la disparition de la charge de glace locale. On n'a pas établi la configuration du niveau de la mer relatif à l'Holocène à cause de la rareté de matériaux datables.

On peut facilement obtenir, à partir des roches désagrégées, des galets quartzitiques de la taille du grain de sable à celle du bloc pouvant servir d'aggrégats. Les dépôts d'origine glaciaire et marine à grain grossier sont rares. Les matériaux à grain fin sont particulièrement sensibles au ravinement et, lorsque les sables silteux sont les matériaux les plus répandus, aux écoulements superficiels. Bien qu'on soit à proximité d'esssaims d'épicentres sismiques, il n'existe aucun indice apparent de glissements de terrain.

INTRODUCTION

This report describes Quaternary deposits and geomorphic processes on Melville Island, Northwest Territories, north of Liddon Gulf and west of the 112°w meridian (Fig. 1). It complements concurrent bedrock and vegetation studies of western Melville Island (Christie, in press; Edlund, in press) and extends an earlier study of the Quaternary geology of central Melville Island (Hodgson et al., 1984). There are some differences in map legend numbers (Table 1) and content between the latter study and this one, although the basic mapping method and approach are the same.

There are four parts to this report. First surficial deposits are described using a genetic-textural classification, following the chronological order established in the accompanying surficial geology map legend (Map 1753A); notes on originating and modifying processes and stratigraphy are included with the unit description. Second, the difficult question of the development of physiography is approached — some major elements of the landscape are pre-Quaternary in age. Third is a synthesis of Quaternary events. Finally, potential land use hazards and other geotechnical applications are reviewed.

Preliminary airphoto interpretation (1:60 000) of the study area was followed by four weeks of fieldwork in 1985, comprising foot and helicopter traverses (Fig. 2). Access to southeastern and northwestern sectors of the mapped area was severely limited by poor weather; this was partly redressed in 1989 by four days of ground traverses between the head of Marie Bay and Grassy Point. Observations made by J.G. Fyles during a reconnaissance in 1964 are included.

Previous Work

Few regional or topical Quaternary studies have been conducted in western Melville Island; thus, generally only speculative comments have been published. Field studies of Phanerozoic deposits during the 1950s (Thorsteinsson and Tozer, 1960; Tozer and Thorsteinsson, 1964) contributed several significant observations. Firstly, they reported that the drift boulders of southerly provenance noted by a number of explorers from the mid 19th to early 20th centuries (e.g., McMillan, 1910, p. 461), occur at all elevations and record a previous inundation by continental ice. The absence of fresh glacial landforms characteristic of southern islands indicates a relatively early Pleistocene event. Nonetheless, though Prest (1957) reported the erratics, Wilson et al. (1958) showed glaciers with local centres, only ever covering half of western Melville Island. Craig and Fyles (1960) published a figure substantially illustrating Tozer and Thorsteinsson's field observations, though they suggested erratics also might have been emplaced by rivers prior to formation of the archipelago.

The second major contribution of Tozer and Thorsteinsson was a commentary on the origin of the gross physiography. They suggested that a peneplain developed across the western islands, probably during the Tertiary. Subsequent uplift, perhaps even Pleistocene, elevated this surface in southwest Melville Island (cf. Fig. 3). Prominent linear cliffs, thus, follow weak fault line or perhaps, in places, even fault (i.e., directly tectonic) scarps. Furthermore, following the initial idea of McMillan (1910, p. 448), they suggested that the general form of the archipelago had been determined by late Tertiary faulting, involving differential vertical movement of the whole or parts of islands. A tectonic origin now is rejected by Thorsteinsson (personal communication, 1988). Kerr (1981) provided a plate tectonic framework for such an event, embracing crustal stretching, rifting and fragmentation continuing into the Tertiary, although Harrison et al. (1985) place completion of the most active period of northwest-southeast extension locally in the Cretaceous. Notwithstanding this possible tectonic origin of islands and channels, Tozer and Thorsteinsson (1964) ascribed the radiating pattern of inlets in western Melville Island to fluvial erosion followed in the Late Pleistocene by erosion by local glaciers. Perhaps this was the influence of Fortier and Morley's (1956) drainage system hypothesis for the origin of the archipelago; it certainly anticipated Pelletier's (1966) suggestion that interisland channels were glacially modified.

In 1964, J.G. Fyles conducted a more detailed survey of Quaternary deposits; his unpublished field notes were consulted extensively for this report. Some unique observations, including those of numerous deglacial meltwater channels, and the possibility that the dichotomy between areas of abundant and sparse glacial landforms in the archipelago reflects either age of glaciation or thickness of ice in a single glaciation, were published in Fyles (1965) and Craig and Fyles (1965). Prest et al. (1968) show the degree of emergence of north and northeast coasts, measured by Fyles. The overlap of Laurentide ice onto the south coast of Melville Island is discussed by Fyles (1967).

Speculative portrayals of timing and extent of glaciation have been more widely circulated than the above observations. These include Prest's (1969) depiction of a complete last glaciation of the archipelago, contracting to an ice cap bounded by the present shoreline of western Melville Island by 11.5 ka. Dyke and Prest (1987) showed the maximum extent of ice in the last glaciation covering the central 50% of the land area, and disintegrating between 13 ka and 11 ka. Most authors (e.g., Koerner, 1989, p. 16) agree with Tozer and Thorsteinsson's (1964) suggestion that the present small ice caps were regenerated in the Holocene.

The only topical (as opposed to regional) Quaternary studies have been Henoch's (1964) dating of a paleoeskimo site in McCormick Inlet, which indicated no more than 1.8 m of emergence, and likely 1 m, in the last 1.7 ka; gravity and radio depth-sounding on Leopold Glacier (Spector, 1966; Paterson and Koerner, 1974) and unpublished mass balance measurements on the southern ice cap; and determinations of Neoglacial perennial snow cover using lichen-free zones (Koerner, 1980; Edlund, 1985).

Pre-Quaternary geological provinces

Three geological provinces extend into western Melville Island (Fig. 4): (1) the Arctic Platform consisting of undeformed carbonate and siliciclastic rocks, bounded at a hinge line by (2) the Parry Islands Fold Belt (a) mostly composed of platform and basinal facies, deformed in the middle to late Paleozoic Ellesmerian Orogeny (b) succeeded by redbeds

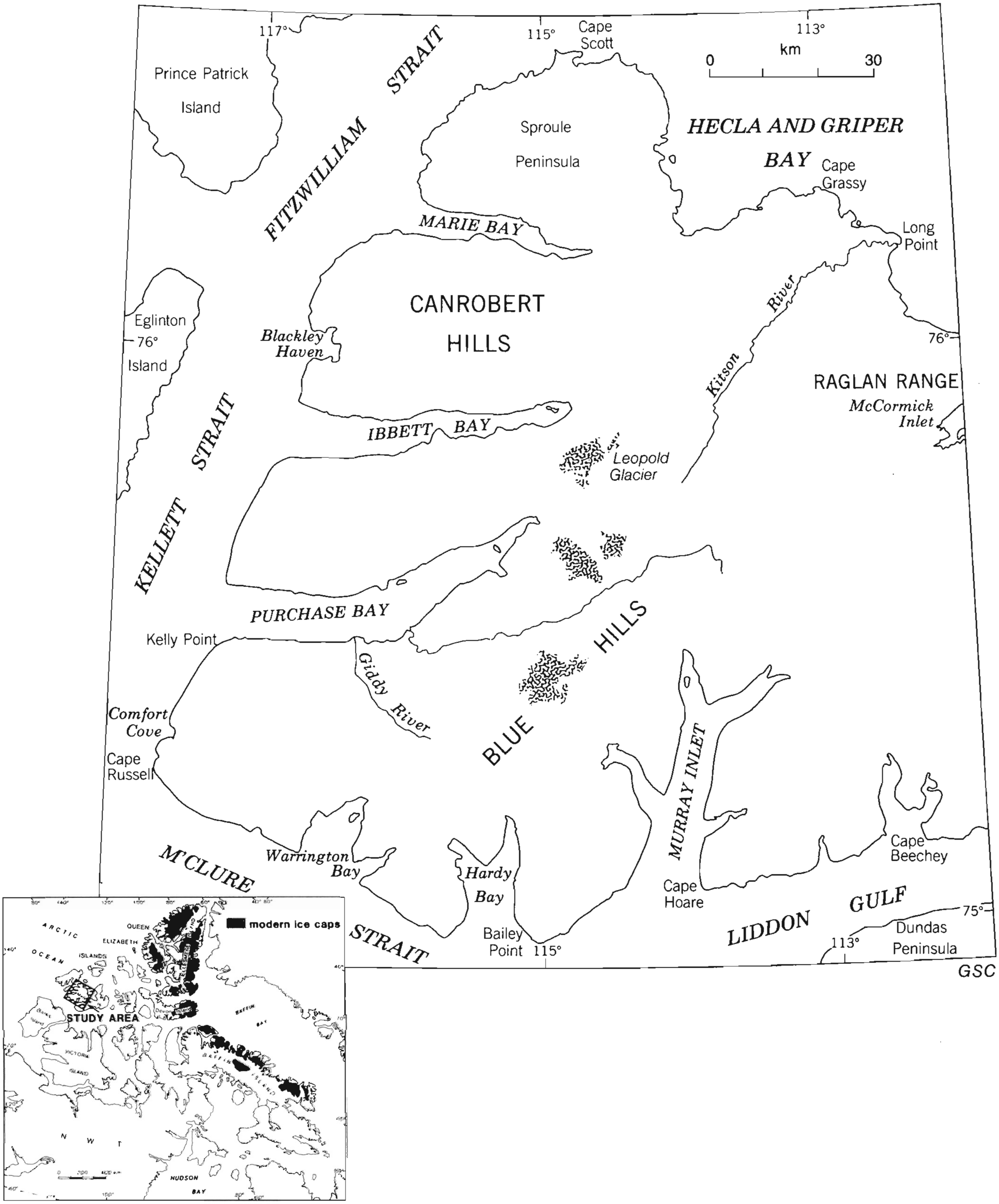
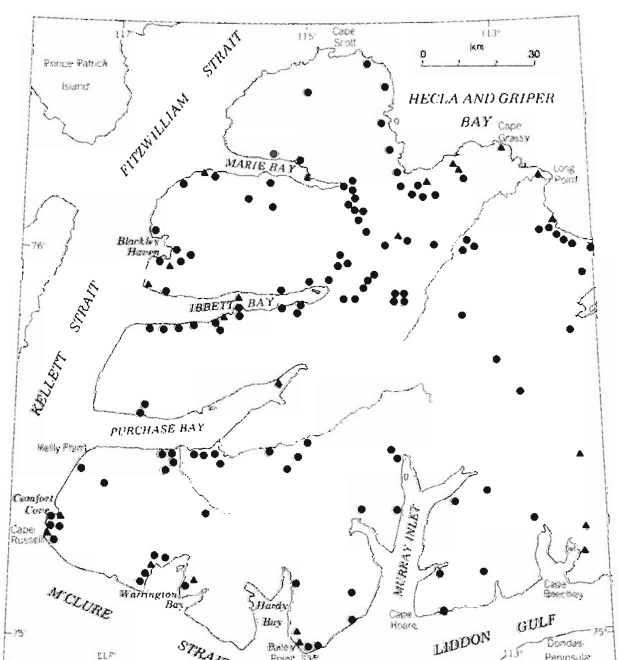


Figure 1. Western Melville Island location map and place names.

Table 1. Equivalence of genetic-textural surficial units used in western Melville Island (this report) with those used in central Melville Island (Hodgson et al., 1984)

Western Melville Island (this report)	Central Melville Island (Hodgson et al., 1984)
8	—
7	8
6b	7b
6a	7a
6	—
5b	6b
5a	6a
—	5
5a	4
4	—
3b	3
3a	—
2a	2e
—	2d
2b	2c
2b	2b
—	2a
3a	1
1d	D
1c	C
1b	B
1a	A



Ground Observations

Hodgson, 1985.............•

Fyles, 1964...............▲

Figure 2. Ground observations of Quaternary deposits.

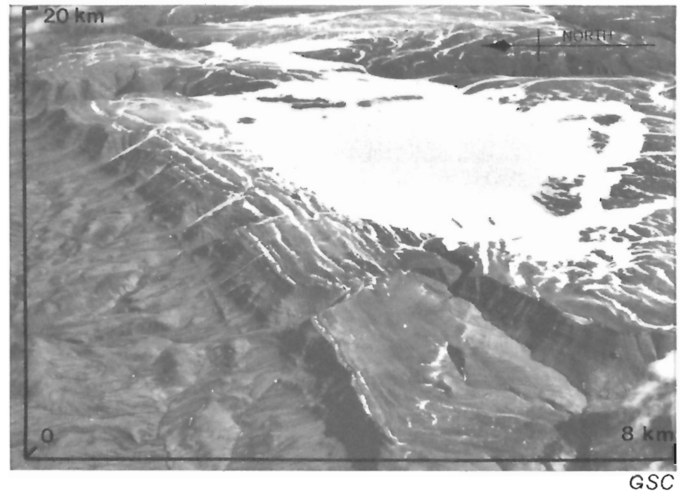


Figure 3. Leopold Glacier overlying planated inclined strata of Blue Hills plateau, south of the head of Ibbett Bay; the northern lowlands lie below 350 m fault-line scarp. National Air Photo Library, T419R-29.

deformed in the late Paleozoic Melvillian Disturbance, overlapped by (3) Sverdrup Basin clastics involved in the mid-Cenozoic Eurekan Orogeny (Thorsteinsson and Tozer, 1970). Rocks of geological provinces 1 and 2a are relatively more resistant and thus much more topographically prominent than 2b and 3.

Geomorphological provinces

A major physiographic division lies within Paleozoic strata at the scarp running east and southeast from Ibbett Bay (Fig. 3 and 5). To the south, uplands are underlain by strata including much resistant sandstone; to the north, rolling lowlands and low scarplands have developed on generally weaker clastic rocks, except for the resistant Canrobert Hills inlier and the Raglan Range outlier. The uplands rise to much the highest elevations in the western Queen Elizabeth Islands about a summit axis over 600 m in elevation (maximum 762 m) aligned north-south at 115°W meridian. This summit supports the only ice caps in the archipelago west of a line joining Meighen to Devon islands. Extensive plateaus within the uplands lie at 400 to 600 m elevation; in places the plateaus may have a structural origin, but elsewhere planation cuts geological structures. Linear segments of cliffs border inlets and the outer coast, as well as traversing the interior of the uplands. Bathymetry, where available, indicates that the seafloor falls away from most coasts to generally even-floored channels 250 to 500 m in depth (Canadian Hydrographic Service, 1971, 1972, 1984, 1986). No soundings have been taken in inlets in the southern half of the area.

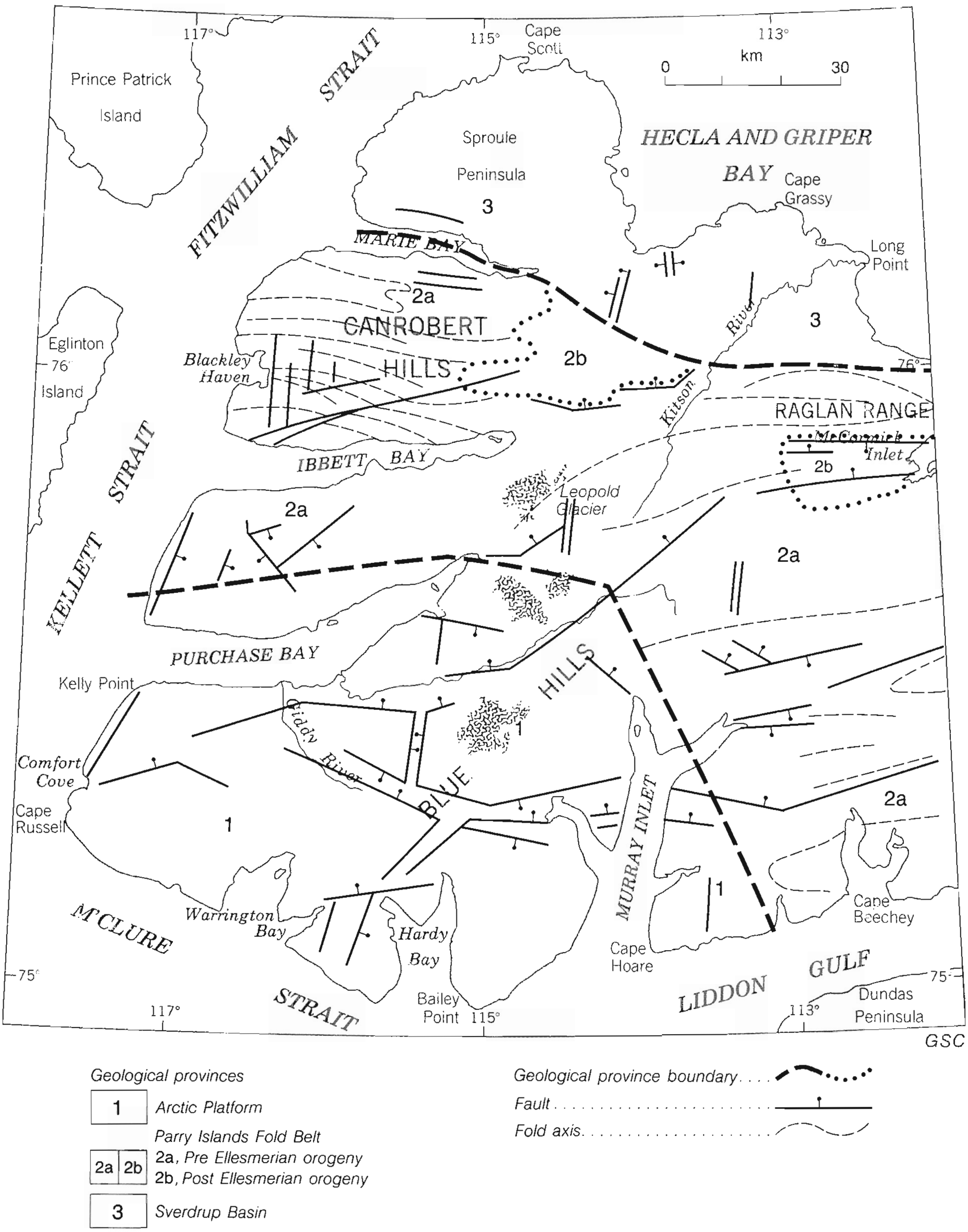
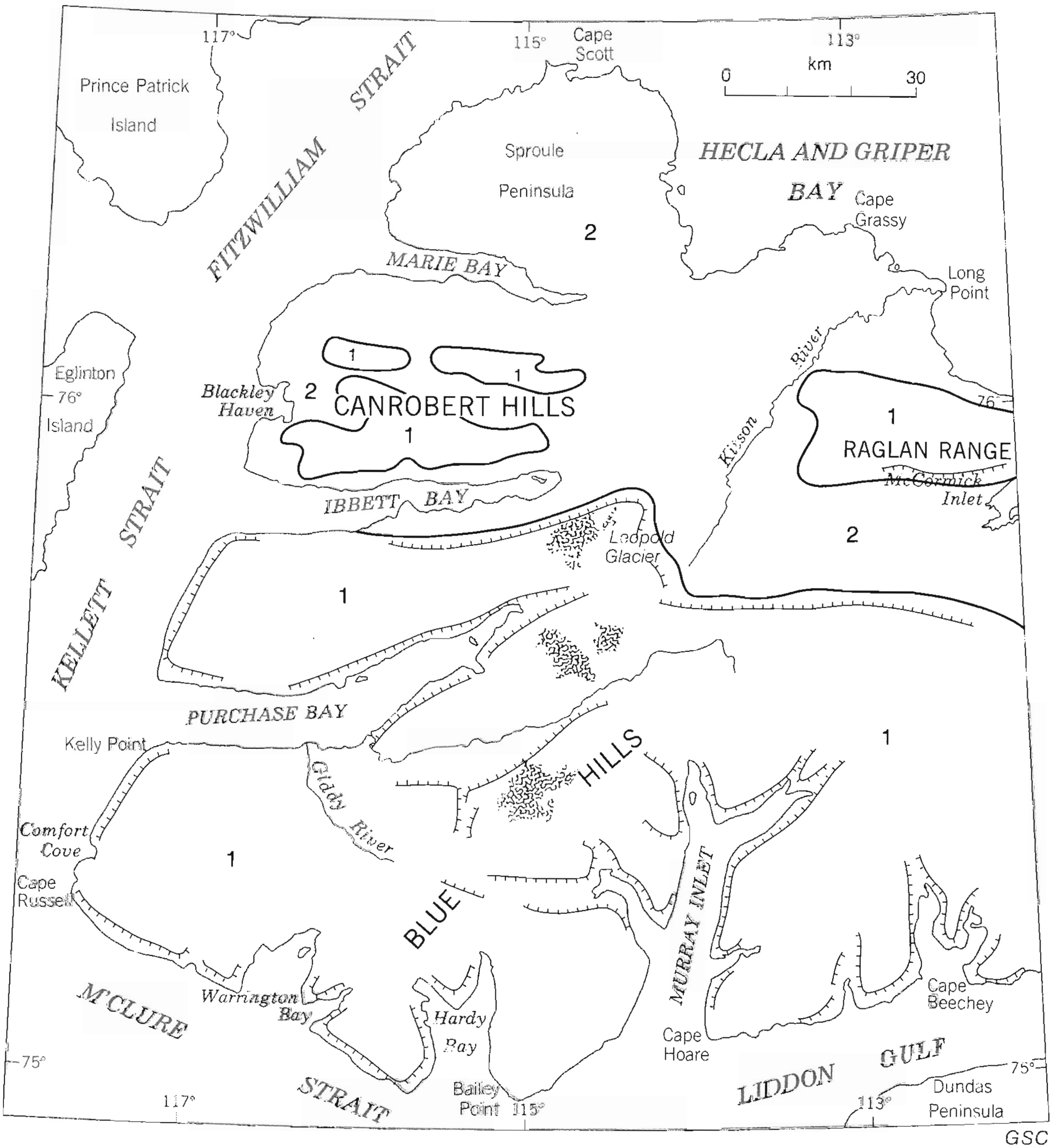


Figure 4. Geological provinces and structure of western Melville Island.



1 Upland

2 Lowland, low scarpland

Sea cliffs and major scarps. . . .

Figure 5. Geomorphological provinces.

SURFICIAL MATERIALS

Pre-Quaternary and Quaternary

Bedrock

Four weathered rock units (rubble, mixed rubble to fines, sand, fines) are derived from a variety of clastic rocks, described in the Appendix by the most recently recognized lithostratigraphic units (Harrison, in press). Weathered units are outlined by these bedrock stratigraphic boundaries in places, but diverge elsewhere according to strictly textural differences.

Two major cyles of sedimentation are recorded in western Melville Island (Tozer and Thorsteinsson, 1964). Firstly, in the Paleozoic, clastic deposition prograded from the northeast into the Franklinian geosyncline, an equatorial foreland basin (Embry and Klovan, 1976). Sediments in this clastic wedge underlie surficial deposits of the south and centre (Fig. 6).

Those deposits within the Parry Island Fold Belt, north of the hinge line (Fig. 4), were deformed increasingly with depth, hence the oldest deposits, in the Canrobert Hills, are the most tightly folded. Conversely, the Arctic Platform now underlying the Blue Hills was little disturbed, thus permitting Hecla Bay sandstone and the relatively minor but resistant sandstone units in the Beverly Inlet Formation to outcrop widely as a capping rock.

In the second cycle of sedimentation, from the late Paleozoic through the Mesozoic, the Sverdrup Basin overlapped the northern part of the present peninsula (Fig. 6), and a generally alternating series of nonmarine and marine sandstone and shale was deposited (Tozer and Thorsteinsson, 1964). Evidence of Tertiary deposits has not been found in the map area.

Weathered rock

Bedrock is assumed to have disaggregated as much as several metres in depth (i.e. into permafrost) by mechanical weathering, chiefly frost action (French, 1976; Washburn, 1980). The process is sufficiently slow to preserve the walls of small-scale drainage channels dating from the last glaciation (11 ka) cut into resistant rocks, but perhaps not in fine grained rocks. If, as appears likely, little chemical weathering has occurred, superjacent material should have a similar mineral composition to source rocks, which have been subjected to analysis (c.f. Embry and Klovan, 1976; Embry, 1984; and Appendix). The dominant mineral in Paleozoic and Mesozoic rocks is quartz; chert pebbles are common, and calcite and siderite are abundant in some formations. The most common clay minerals are kaolinite and illite.

Weathered rock units were partly differentiated using lithostratigraphic units from bedrock maps; the two classifications are correlated in Table 2. Most materials were recognized from airphotos, where the chief characteristic used was the surface expression of certain active geomorphic processes (not necessarily those most dominant); these processes are described for each unit. A more complex characteristic is albedo, in which lithology and vegetation are factors. For example, coarse, stable materials are commonly dark because of lichen cover. Lichens are less common on toxic calcareous materials and on relatively less stable fines, which, however, may support other types of vegetation which reduce reflectivity.

Fines (1a, 1a′)

This recessive, low rolling unit is composed predominantly of silt and fine sand; clayey silt is abundant on black deepwater shale, especially Cape de Bray Formation (Fig. 7a). Clasts, chiefly local shale fragments, some erratics, form a discontinuous lag cover. These are concentrated to armour river and stream courses. Fines were not mapped separately in the southern half of the map area, where they are generally intermixed with clasts from more resistant interbedded sandstone or siltstone. Materials are approximately neutral, except on alkaline Canyon Fiord and Ibbett Bay formations, which are separately identified as unit 1a′.

The primary agent of erosion — and clearly visible on airphotos — is snowmelt drainage via fine networks of shallow to deep rills and gullies; erosion is accelerated by numerous skin flows.

No ground ice was observed, though studies of similar deposits elsewhere in the Queen Elizabeth Islands indicate high ice content (Hodgson, 1982). Polygonally patterned frost-fissure troughs are probably masked by slopewash and are only conspicuous on level areas. It is not known why this pattern is picked out by thermokarst ponds locally on the Sproule Peninsula. A calcareous shale member, unit 5, within the Ibbett Bay Formation (Harrison, in press), which is densely vegetated, may have a high ice content providing excess surface moisture in the summer (S.A. Edlund, personal communication, 1985).

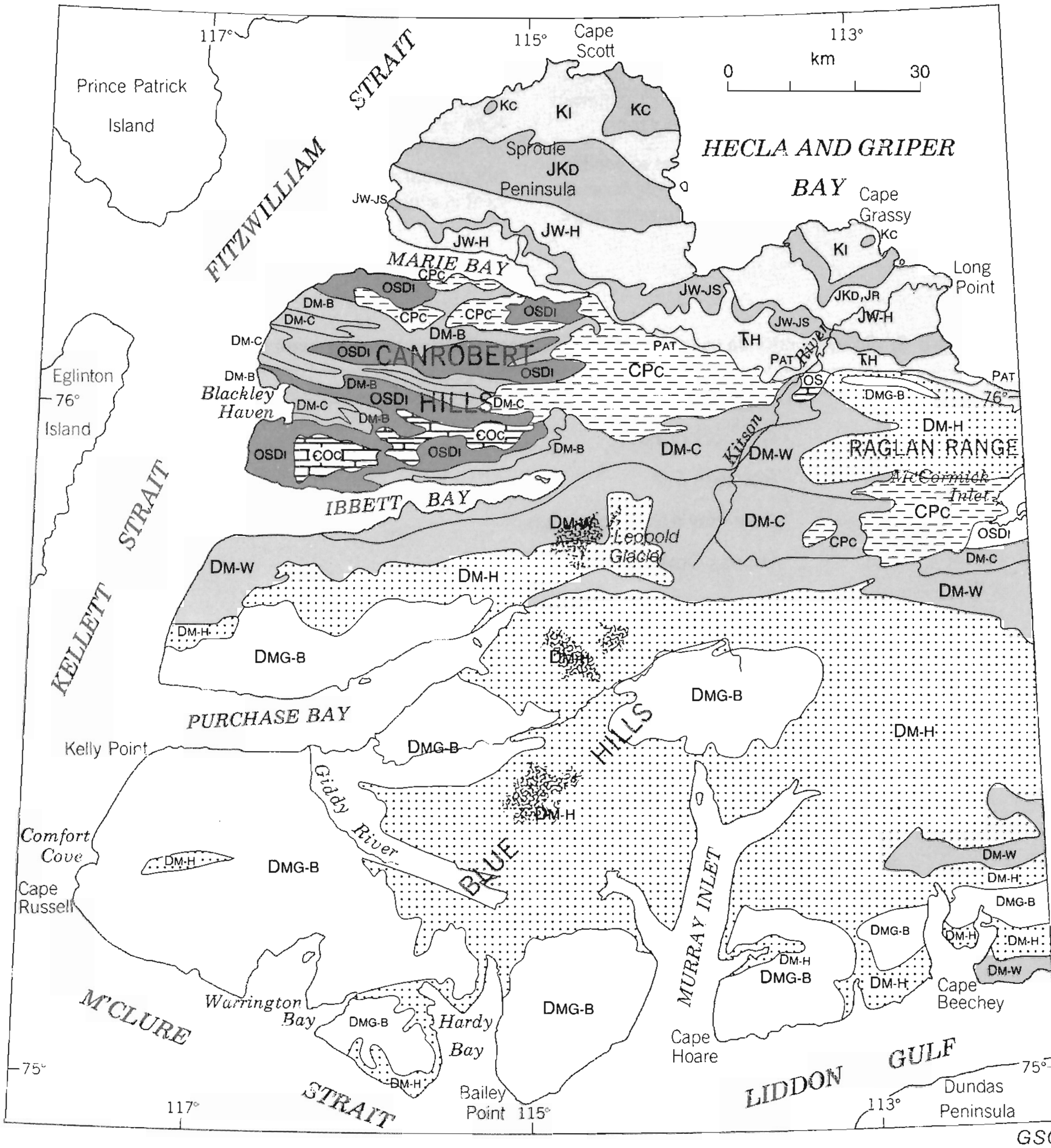
Rubble to fines (1b, 1b′)

This unit is composed of materials derived from resistant and recessive Paleozoic rocks. Areas of rubble, sand, silt and clayey silt are not easily divisible at the map scale (Fig. 7b). Source rocks, though predominantly composed of quartz, include calcareous beds; thus pH varies from weakly acid to weakly alkaline.

The generally rugged relief includes much fluvially dissected terrain with local relief up to 500 m, cliffs of 250 m in places fault-aligned, and plateaus buttressed by resistant rocks underlying unit 1d. The variations in materials, slope angles, and snow accumulation encourage a variety of mass wasting and fluvial processes. Long, steep slopes and intermixed coarse and fine material produces characteristically elongated solifluction lobes and dark (vegetated) seepage rills as well as patterns characteristic of 1a and 1d.

Sand (1c)

Sandstone weathers preferentially to sand in two geographical areas (Fig. 7c).



Sverdrup Basin

KC	*Christopher Formation*
KI	*Isachsen Formation*
JKD	*Deer Bay Formation*
JR	*Ringnes Formation*
JW-H	*Hiccles Cove Formation*
JW-JS	*Jameson Bay and Sandy Point formations*
TH	*Heiberg Formation*
PAT	*Assistance and Trold Fiord formations*
CPC	*Canyon Fiord Formation*
DMG-B	*Beverly Inlet Formation*

Clastic wedge

DM-H	*Hecla Bay Formation*
DM-W	*Weatherall Formation*
DM-C	*Cape de Bray Formation*
DM-B	*Blackley Formation*
OSDI	*Ibbett Bay Formation*
OS	*unamed*
€OC	*Canrobert Formation*

Indurated sandstone

Sandstone

Sandstone, siltstone, shale

Siltstone, sandstone, shale

Siltstone, shale

Carbonate

Carbonate, siltstone, shale

Figure 6. Generalized bedrock lithostratigraphic units (after Harrison, in press).

(1) In the southeast, where Paleozoic rocks, mainly Hecla Bay Formation (Appendix), disintegrate to weakly acid very fine to medium grained sand or silt and rubble. The low rolling plateau, 300 to 600 m a.s.l. has few distinct patterns other than extensive networks of frost-fissure polygons.

(2) In the north, Mesozoic sandstone weathers to weakly acid to alkaline sand, silt, and pea gravel, commonly bearing a discontinuous gravel lag. This unit is only slightly more topographically prominent than adjacent shale or siltstone, but is better drained. It also has a prominent frost-fissure pattern, which is similar to thick till, and has led to equivocal mapping in south-central Sproule Peninsula and adjacent to Kitson River. In the latter area, a network of ice marginal drainage channels corresponds closely with the unit. Where not armoured by a lag cover or by vegetation, the sand may drift in a thin veneer and, in extreme cases, develop blow outs.

Table 2. Correspondence of bedrock and overlying surficial units (dominant units underlined)

A.		Bedrock unit	underlies	Surficial unit
	Kc	Christopher Fm		1a
	Ki	Isachsen Fm		1c
	JKd + Jr	Deer Bay and Ringnes fms		1a
	Jwh	Hiccles Cove Fm		1c
	Jwjs	Jameson Bay and Sandy Point fms		1a
	Tb	Bjorne Fm		1c
	Pat	Assistance Bay and Trold Fiord fms		1c
	CPc	Canyon Fiord Fm		1a
	Dmgb	Beverly Inlet Fm		1a, <u>1b</u>, 1c, 1d
	Dmh	Hecla Bay Fm		1b, <u>1c, 1d</u>
	Dmw	Weatherall Fm		<u>1a</u>, 1b, 1d
	Dmc	Cape de Bray Fm		1a
	Dmb	Blackley Fm		1a
	OSDi	Ibbett Bay Fm		<u>1a'</u>, 1b', 1d'
	OS	unnamed		1d'
	COc	Canrobert Fm		1d'
B.		Surficial Unit	overlies	Bedrock Unit
		1d		<u>Dmgb, Dmh,</u> Dmw
		1d'		OSDi, Os, COc
		1c		Ki, Jwh, Tb, Pat, Dmgb, Dmh
		1b		<u>Dmgb</u>, Dmh, Dmw
		1b'		OSDi
		1a		Kc, JKD + Jr, Jwjs, Cpc, <u>Dmgb</u>, Dmw, Dmc, Dmb
		1a'		OSDi

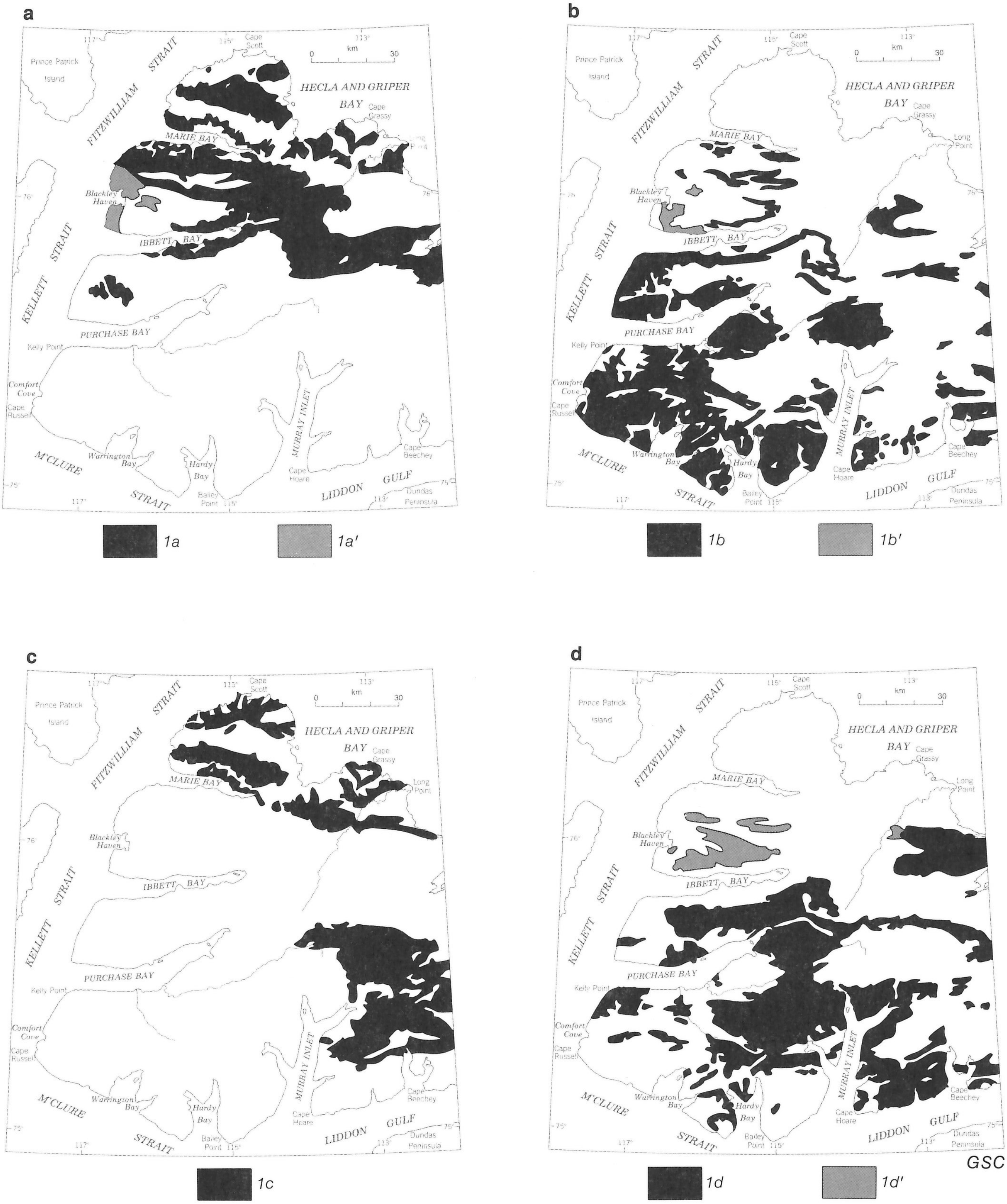


Figure 7. Distribution of weathered rock: a. fines; b. mixed rubble to fines; c. sand; d. rubble.

Rubble (1d, 1d')

The most resistant Paleozoic bedrock at least fractures by frost action along joints and bedding planes and more commonly disaggregates to angular boulder to granule size clasts with some sand and silt. Most of this unit is derived from quartzose Hecla Bay Formation sandstone and thus is weakly acidic; however, the early Paleozoic carbonate rocks in the Canrobert Hills, which produce alkaline material, are separately identified as unit 1d' (Fig. 7d).

This is the most topographically prominent unit, and includes much of the Blue Hills dissected plateau (maximum elevation 762 m), spectacular bordering cliffs up to 600 m high, the independent massif of the Raglan Range (500 m), and the ranges of the Canrobert Hills (550 m). Only major drainage lines are incised. Many slopes of relatively stable blocks are moulded into distinctive compact solifluction lobes, steeper slopes are talus covered, and scattered large lobes (rock glaciers?) were observed. Frost-fissure wedges occur on flat areas, even where rubble covered, indicating disaggregation to at least several metres in depth. The majority of abandoned ice marginal channels occur on this unit.

Rock-cut glacial landforms

Nivation hollows

Classic bowl-shaped cirques, let alone moraines, were not recognized. The landforms most resembling cirques are several hundred amphitheatres of varying aspect at the head of steeply graded streams. In most cases, they are cut in weaker rocks underlying resistant capping rocks and are more likely a variation of the more common V-notch stream head. The result is scalloping of the perimeter of the Blue Hills plateau and, in places (especially the Canrobert Hills), complete elimination of any planation surfaces, leaving a fretted landscape (c.f. Dyke et al., 1982). Rather than recording former independent glaciers, they likely result from a combination of fluvial, mass wasting and nival processes. The V-notches rather than the ampitheatres provide the best conditions for snow accumulation and are, indeed, the preferential location for the numerous small glacierettes that exist today at high elevations.

Ice marginal meltwater channels

Abandoned sidehill and ice front channels are found exclusively cut in coarse grained weathered rock and bedrock. Two concentrations of channel systems were identified.

(1) A belt of north flowing proglacial channels, lying between Marie Bay and McCormick Inlet, records wasting of ice more than 300 m thick in the lowland centred on Kitson River; sidehill channels on the west side of Raglan Range are incised 100 m in places (Fig. 8).

(2) The most notable of several systems in the Blue Hills lies between the existing (unnamed) central and southern ice caps, where ice wasted within a southwestward draining valley. Scattered channels elsewhere in the Blue Hills record a deglaciation pattern radiating from an upland north of Murray Inlet.

Channels are rare near the southern and western coasts, and in the Canrobert Hills. Smaller channels scattered in the bottoms of high elevation valleys in the Blue Hills and Raglan Range are Neoglacial in age.

No channels continue from coarse grained material onto fines (Fig. 9). For example, the extensive system cut in pea gravel and sand over sandstone on gently inclined terrain west of Kitson River ends abruptly, commonly at a collector channel, at the contact with silty sand over mudstone and siltstone. It certainly appeared in the field that the system never continued onto the fines, where, admittedly, mass wasting is more active. Similar examples were noted in the eastern Queen Elizabeth Islands by Hodgson (1985, p. 366), who suggested this dichotomy resulted from subglacial processes (e.g., bed permeability), not unequal postglacial degradation.

No absolute age has been obtained for meltwater drainage; however, in the northern belt, colluvium has barely encroached on the sides of flat channel floors, suggesting channel abandonment at 10-20 ka, (i.e. Late Wisconsinan) rather than 50 ka or older.

Glacial troughs

The pattern of glacial meltwater channels, and, in one case, of glacial deposits (see glaciomarine), shows that the three largest inlets (Murray Inlet, and Purchase and Ibbett bays) have been occupied by glaciers. But glaciation was not necessarily the cause of trough erosion. Insufficient soundings have been taken to determine bathymetry.

Striations

Striations were observed in Western Melville Island on scattered, mostly recently uncovered boulders of local sandstone in till. A striated bedrock pavement was found only on Jurassic (Hiccles Cove Formation) sandstone at one coastal location, northwest of Raglan Range. Orientations were northwards. The absence on bedrock is possibly due to the general sparsity of protective till. A more likely explanation is that basal ice was maintained below the pressure melting point (i.e., was non-erosive) by cold air temperatures acting on a thin static or slow flowing ice cover.

Pleistocene

Till

Local provenance till (2a)

Till, composed mostly of silty sand and clasts of quartzitic sandstone (rarely striated), was recognized over only 1% of western Melville Island (Fig. 10). Deposits lie chiefly on the flanks of the Blue Hills which provide the dominant clast lithology, though some southern erratics are present on the north and east sides. Much of the till has a relatively flat surface and was identified only where it masks bedrock structures that normally show on airphotos through

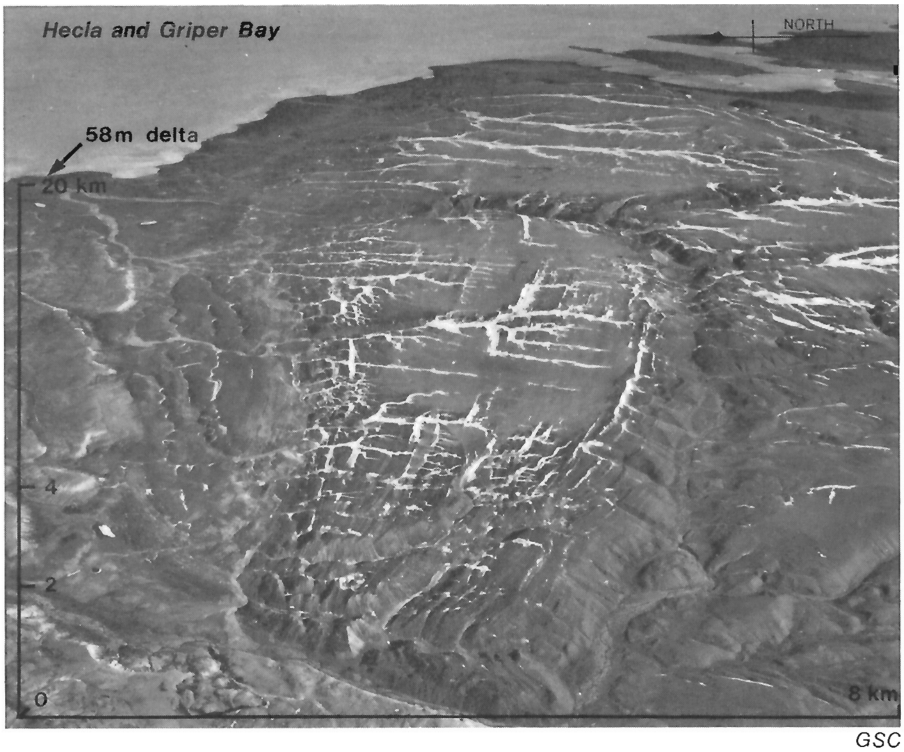


Figure 8. Raglan Range — an outlier of planated quartzose sandstone upland, dissected by north draining meltwater channels of last glaciation; light toned areas are lichen-free zones which lay under perennial snow or ice in the Little Ice Age. National Air Photo Library, T416L-75.

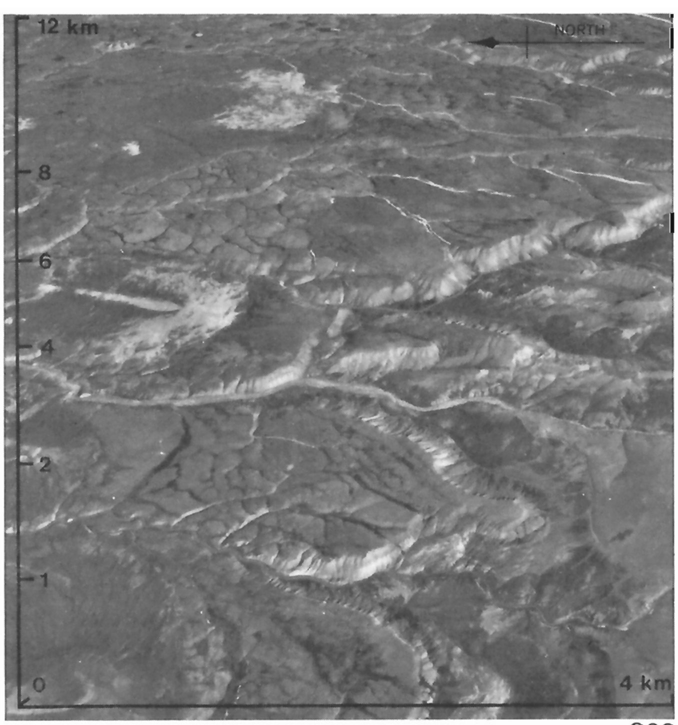


Figure 9. Northern belt of ice marginal channels from last glaciation; channels are cut exclusively in weathered coarse grained rock and are absent from flanking fines. National Air Photo Library, T414R-53.

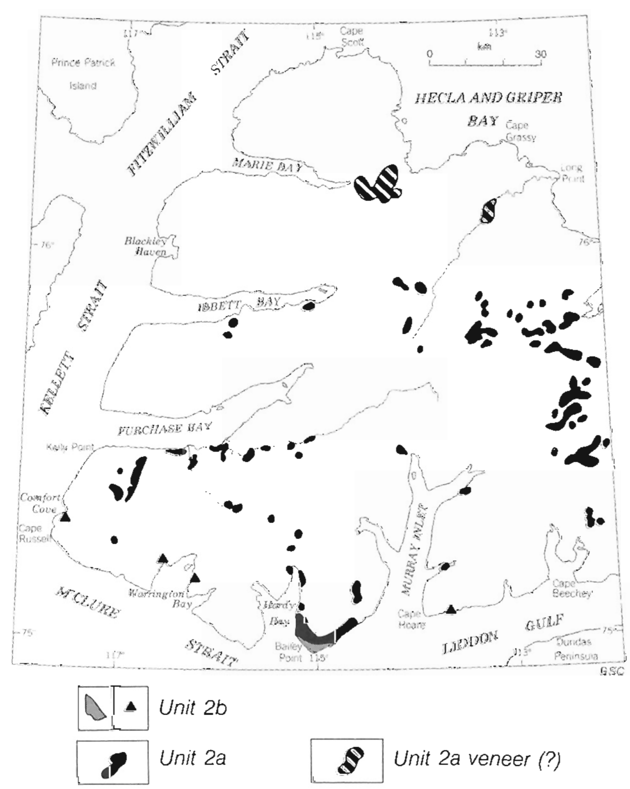


Figure 10. the distribution of till of local (2a) and Laurentide (2b) provenance.

Table 3. Radiocarbon ages, western Melville Island and vicinity

^{14}C age (years BP)	Laboratory No. field sample No.	Material	Location	Elevation of sample (m)	Related sea level (m)	Geological environment	Comments	Collector	References
A. Western Melville Island									
11 700 ± 110	**GSC-4167** HCA-85-9-7-3a	*Hiatella arctica*	1 km S of Comfort Cove 75°18.3'N, 117°35'W (88G)	6	>15	In marine silt directly overlying till of southern provenance	Immediately postdates withdrawl of Laurentide ice	D.A. Hodgson, 1985	This report
10 600 ± 150	**GSC-324** FG-64-143a (site 8/4H)	*Hiatella arctica*	NW of Bailey Point; 75°01'N, 115°10'W (88E)	40	>40	Surface of till containing some southern erratics	Likely Liddon till	J.G. Fyles, 1964	Lowdon et al. (1967, p. 192) Hodgson et al. (1984)
10 520 ± 150	**GSC-340** FG-64-229a (site 8/14K)	*Hiatella arctica*	S shore Ibbett Bay; 75°51'N, 115°46'W (88H/13)	13	>13	Surface marine diamict		J.G. Fyles, 1964	Blake, 1972 (p. 81)
10 430 ± 150	**GSC-368** FG-64-40a (site 7/17H)	*Hiatella arctica*	N shore Marie Bay; 76°11'N, 114°58'W (89A)	18	>18	Surface of shingle beach flight rising to 23 m		J.G. Fyles, 1964	Blake, 1972 (p. 81)
10 300 ± 100	**GSC-4958** HCA-89-9-8-4	*Hiatella arctica*	13 km NE of head of Marie Bay; 76°13.6'N, 114°12.5'W (89A/3)	5-15	>20	Surface of glaciomarine rhythmites		D.A. Hodgson, 1989	This report
10 200 ± 120	**GSC-5002** HCA-89-11-8-4	Twigs, *Salix* sp.	25 km W of Cape Grassy; 76°11.3'N, 113°50'W (89A/2)	22	>30?	Organic mat within fluvial (deltaic?) sand	Predates 30 m terrace - possibly outwash delta	D.A. Hodgson, 1989	This report
7890 ± 70	**GSC-4187** HCA-85-10-7-1c	Peat	South central Purchase Bay 75°28'N, 115°53'W (88H)	70		Basal 15 cm of 2-3 m peat over >5 m silty sand containing massive segregated ice body	Minimum age of any local ice	D.A. Hodgson, 1985	This report
1740 ± 190	**I-840**	Peat (moss)	S shore McCormick Inlet; 75°49'N, 112°07'W (88H)	1.8	<1.8	Moss under hearthstones in prehistoric dwelling	Any positive land movement apprecialy less than 1.8 m in last 1.7 ka	W.E.S. Henoch (1962)	Henoch (1964) Trautman (1964, p. 270)
1150 ± 160	**GSC-148**	Charred moss	S shore McCormick Inlet; 75°49'N, 112°07'W (88H)	1.8	<1.8	Fuel on heartstone of prehistoric dwelling	See I-840	W.E.S. Henoch (1962)	Dyck and Fyles (1964, p. 180)
B. Areas adjacent to western Melville Island									
11 500 ± 260	**GSC-3113** HCA-80-7-7-3	*Hiatella arctica*	13 km WSW of Shellabear Point 74°49'N, 113°42'W (88E)	56	>56	Surface of littoral deposits close to limit of late Pleistocene marine transgression; overlying Liddon Till (contains southern erratics).	Possible marine limit on Liddon Gulf. Minimum age of Liddon Till.	D.A. Hodgson and J.-S. Vincent, 1980	Hodgsoon et al. (1984, p. 25)
11 160 ± 150	**GSC-260** FG-64-27a (site 7/14A)	*Hiatella arctica*	18 km NW of Wilkie Point, Prince Patrick Island 76°21'N, 117°46'W (89B)	up to 18 m	>26	In diamicton below stratified silt and sand deltaic deposits, delta surface >24 m	Elevations revised by D.A.H. (1985)	J.G. Fyles (1964)	Lowdon et al. (1967, p. 193)
10 380 ± 160	**GSC-338** FG-64-51b (site 7-/21l)	*Hiatella arctica*	9.5 km SE of Nias Point; 75°30.4'N, 110°15'W (78G)	44	>49	In fine silty sand of a marine delta, 5 m below delta surface (49 m)	Dates 49 m waterplane, possibly 55 m which is the height of the highest delta remnant	J.G. Fyles, 1964	Blake (1972, p. 81) Hodgson et al. (1984) Blake (1984, p. 26)

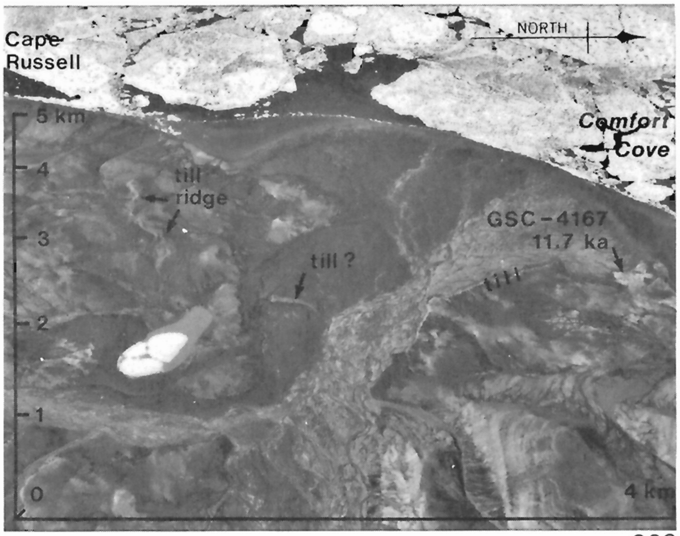


Figure 11. Area of overlap of M'Clure glacier, the northwesternmost lobe of the Late Wisconsinan Laurentide Ice Sheet, at the southwest extremity of Melville Island. National Air Photo Library, T430R-132.

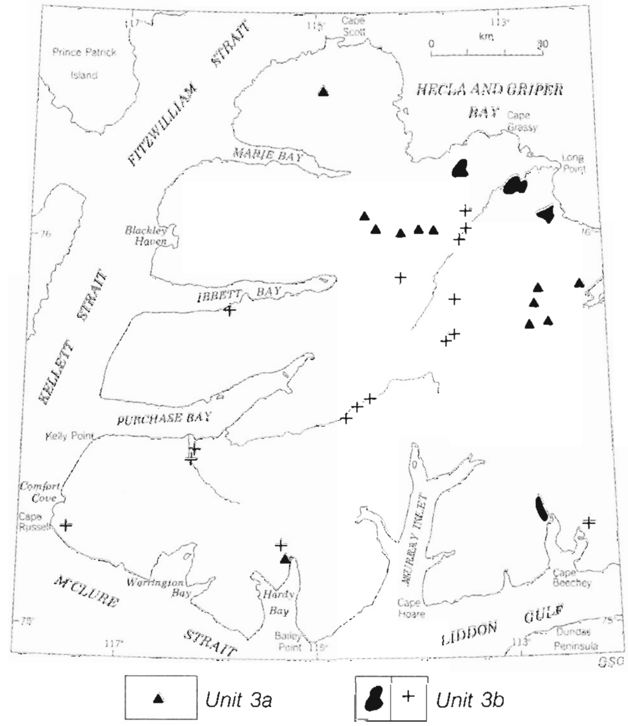


Figure 12. The distribution of glaciofluvial deposits (3a, kames and eskers; 3b, outwash: ice contact sediments and valley train deltas).

weathered rock. The patchy distribution may result from limited deposition of till or from degradation of a more extensive cover. Skin flows occur in places, similar to those on weathered Canyon Fiord Formation (unit 1a). No absolute or relative age determinations were made, though some deposits are associated with generally nonfossiliferous fluvial, lacustrine, or marine deposits discussed below.

An area showing a distinctive quadrangular pattern of deep frost-fissure troughs has developed on deposits masking bedrock structure between the head of Marie Bay and the Kitson River (Fig. 10). Several low relief drumlinoid ridges trend north-northeast. The few ground observations showed red silt or fine sand incorporating clasts of Hecla Bay Formation sandstone and rare striated carbonate rocks.

The extensive deposit of till north of Bailey Point included in this unit was not examined in the field. It is identified as local till on the basis of apparent southward decline of its inland margin and meltwater drainage channels, especially on the Hardy Bay side of the peninsula. An overlapping till described below is of southerly provenance.

Southerly provenance indicator erratics

Granule to boulder size erratics transported from the south of Parry Channel include quartzites, gneisses, diabases and gabbros; carbonate rocks likely originated in Victoria Island rather than the Canrobert Hills or Raglan Range (Tozer and Thorsteinsson, 1964). These erratics are most common on coasts: those adjacent to M'Clure Strait are discussed below; on western and northern shorelines, erratics possibly melted out of floating ice which originated in the Late Wisconsinan Laurentide Ice Sheet. Above marine limit (i.e., approximately 50 m a.s.l.), erratics occur rarely in till on the northern and eastern flanks of the Blue Hills. Elsewhere, on weathered rock, they are exceedingly rare. None were observed among readily identifiable quartzitic sandstone clasts at a number of lichen-free sites on summits of the Blue Hills and Raglan Range. They have been reported from the highest elevations of the Canrobert Hills (Tozer and Thorsteinsson, 1964).

Laurentide till (2b)

A silty calcareous till, containing numerous (0.1-5%) erratics of southerly provenance, overlaps Bailey Point and a promontory 8 km east of Cape Hoare on the south coast (Fig. 10). These deposits, which provide a distinctive light tone on airphotos, were described first by Hodgson et al., 1984 (p. 15). The till at Bailey Point is older than overlapping marine deposits from which J.G. Fyles collected shells, 40 m a.s.l., dating 10 600 150 BP (GSC-324; Table 3).

No new observations were made at Bailey Point in 1985, but fieldwork extended the limits of similar till to the southwest corner of Melville Island. There, between Cape Russell and Comfort Cover, the glacier that abutted high rock cliffs along most of the coast encroached onto a small lowland now occupied by a large delta (Fig. 11). The Comfort Cove ice lobe deposited on its southern margin, 3 km inland, a sinuous ridge about 1 km long and 20 m high, with a maximum elevation 96 m a.s.l. It is composed of subround to angular pebbles and granules and some boulders, in a calcareous silty sand calcareous matrix. Clast lithologies are chiefly sandstone, but several dozen crystalline and carbonate rocks were noted (including a 2 m diameter dolomite boulder). Nearby,

Figure 13. Gravel ridge, probably a degraded esker recording northward ice flow over Sproule Peninsula. GSC 204768-A.

a 4 m high ridge of gravel-sized local clasts, which projects above (or perhaps through) a modern floodplain, 13 m a.s.l., possibly records an ice margin. Nevertheless, the lake immediately inland is likely a kettle (lakes are rare features on the island). Bedrock structure is partially masked on airphotos still farther inland to at least 100 m a.s.l., though only local clasts were found in what appeared in the field to be weathered rock.

On the north side of the delta, a number of poor exposures suggest that three glacial units flank the modern channel. At the base is 5 m of stratified silty sand or sandy gravel, possibly deposited ahead of an advancing glacier. This unit is overlain by up to 5 m of structureless silty till, containing up to 1% crystalline and carbonate rocks (some of the latter are striated). The uppermost unit, also at least 5 m thick in places, is a silty diamicton deposited in the postglacial sea, possibly up to 60 m a.s.l. Numerous whole valves, some paired, of the marine pelecypod *Hiatella arctica* collected from silt 1-2 m above unweathered till dated 11 700±110 (GSC-4167; Table 3). Thus, it appears that the sedimentation underway by 11.7 ka commenced immediately upon deglaciation. Sea level at 11.7 ka was at least 15 m higher and possibly 60 m higher than that at present.

There is nothing to indicate that Laurentide ice met local Melville Island ice at this location — or, indeed, that there was ever local ice in the extreme southwest. Thus, during the last glaciation, surface drainage should have continued towards the present delta, where it either flowed under or into a grounded or floating ice sheet. Alternatively, it flowed east to Warrington Bay (or vice versa) via a series of col channels, all at 180 m a.s.l., though there are no shorelines indicating impounded water. Airphotos show possible embayment moraines in two small valleys draining to Kellett Strait between Comfort Cove and Kelly Point, but a cursory field check suggested that the ridges are bedrock cored.

Grounded or floating Laurentide ice entered Warrington Bay and left several small deposits of till, bearing southern erratics. Stratigraphy is similar to Comfort Cove. On the east side of the main bay, till is underlain by 20 m of stratified sand, whereas on the west side, till is overlain by 4 m of stratified nonfossiliferous silt. The highest silt or delta terraces are 40 m a.s.l.

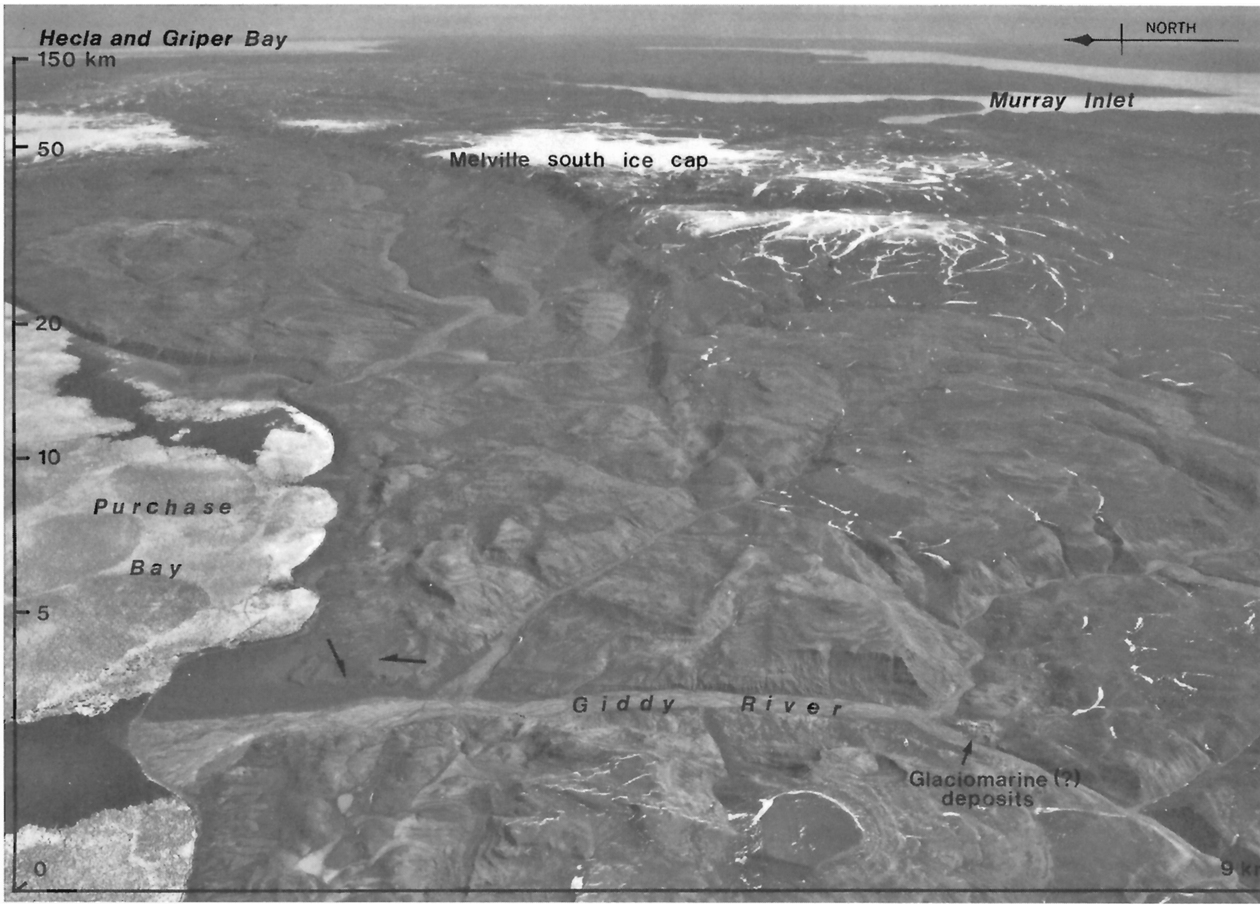
Glaciofluvial deposits

Kames and eskers (3a)

Three main clusters of kame and esker deposits are shown in Figure 12.

(1) In north-central Sproule Peninsula, several short segments of a degraded esker-like ridge trend due north, over a 2.5 km distance. The ridge, up to 50 m wide, is composed of Paleozoic sandstone clasts in a silty sand matrix, though it overlies weathered Mesozoic rock (Fig. 13). It resembles ridges in the Ringnes islands described by Hodgson (1982, p. 17).

(2) In the lowland, east of the Canrobert Hills, short segments of an esker-like ridge extend over 25 km. This ridge has a sharper crest, and is in places much wider (to several hundred metres) than the Sproule Peninsula ridge but, nonetheless, appears to have been substantially eroded by subaerial processes. The ridge is composed of granule to boulder size, dominantly Paleozoic sandstone clasts in a sand matrix. No internal structure was exposed; the protected underlying recessive weathered rock may largely core the ridges, as was suspected in the Ringnes islands to the north. Much of the ridge is transverse to the direction of flow in the complex of meltwater channels just to the north, as might be expected of a moraine ridge; however no trace of other ridges or till was



GSC

Figure 14. Relationship of glaciolacustrine (?) rhythmites to margin of retreating (?) Purchase Bay glacier, in lower Giddy River valley. Arrow indicates paleocurrent in kame delta. National Air Photo Library, T428L-210.

found, and the west end of the ridge segments trends north in a valley as an esker might do.

(3) West of McCormick Inlet, gravelly knolls in places cap the generally recessive fine grained weathered rock deposits. One exposure showed 10 m of inclined interstratified sand and gravel. Some southern erratics occur with generally quartzic sandstone clasts like adjacent till patches.

Outwash: Ice contact sediments and valley train deltas (3b)

Identifiable outwash deposits are rare, especially in the Blue Hills where the number of rock-cut channels indicates a formerly large flow of meltwater. Most of the scattered outwash can be placed into two morphogenetic groups (Fig. 12).

(1) In the westward draining bays, several bouldery gravel kame deltas were deposited at margins of glaciers occupying the bays. At Giddy River, deltas 76 m and 70 m a.s.l. and coeval meltwater channels and minor lateral moraines (up to 144 m a.s.l.) outline west-flowing ice in Purchase Bay (Fig. 14). Lower Giddy River valley was ice free at this time, though likely inundated by water into which stratified silt was deposited earlier (see below). Deltas 69 m a.s.l. are believed to be coeval with marginal channels on the south shore of Ibbett Bay. More numerous minor deltas and terraces lie between 50 and 60 m a.s.l. Here, silts also are found in a north-flowing river, similar to Giddy River, though inland ice appears to have advanced down the valley over the silt.

(2) Valley trains terminating in marine deltas lead from the northern belt of north flowing meltwater channels to Hecla and Griper Bay. The easternmost deposit, north of the Raglan Range, is composed of 1 to 5 m of pebble to cobble size subround clasts, over 10 to 20 m of sand. The well defined delta front lies 60 m a.s.l. Outwash further west flowed from Mesozoic rocks and thus is finer grained — mainly pea gravel and sand. The original channel surfaces, which lay at least 30 m a.s.l.and as high as 65 m for one clifftop deposit, are pitted by kettles and thermokarst ponds, and are gullied and undercut by later fluvial erosion. A stream cut at the seawardmost limit of a 30 m a.s.l. surface at the head of the northwesternmost embayment of Hecla and Griper Bay exposed organic mats >1cm thick in reduced sand and silt strata 8 m below the top. Twigs and possibly roots of *Salix* sp., including buds and intact bark, were identified in the plant material by R.J. Mott (unpublished GSC Wood

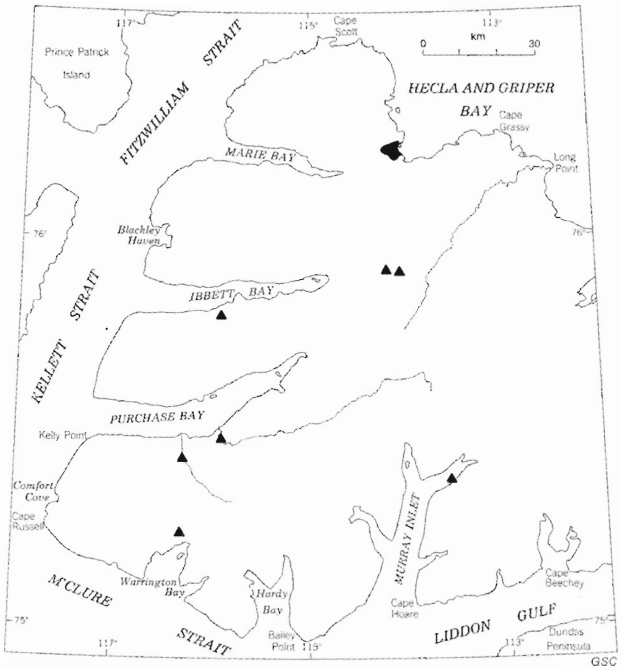


Figure 15. The distribution of glaciolacustrine or emerged glaciomarine deposits.

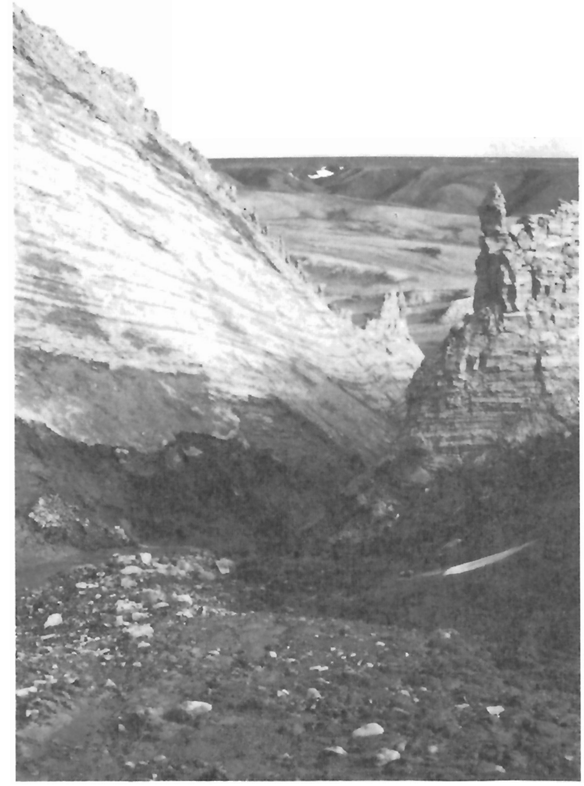


Figure 16. Silty glaciolacustrine (?) rhythmites overlying till, west of Ibbett Bay. GSC 204768.

Identification Report No. 90.22, 1990). These yielded a radiocarbon age of 10 200±120 BP (GSC-5002; Table 3A). They may lie in an outwash delta or in nonglacial fluvial sediments; whichever, it is likely that the contemporary sea level was at least 30 m higher than present. Plant material yielding finite ages up to several hundred years older has been collected to the south of Banks Island (Vincent, 1983, Appendix D), whereas the oldest plant material collected from an adjacent island (Bathurst) at a similar latitude is 1 000 years younger (Blake, 1964, Table 1).

Glaciolacustrine or emerged glaciomarine deposits (4)

In addition to glaciomarine deposits associated with Laurentide till, discussed above, four other assemblages (Fig. 15) of thick, stratified silt deposits first were identified by the characteristic fine fluting that results from gullying.

(1) Several square kilometres of silt is draped over valley sides 20 km east of the head of Ibbett Bay (Fig. 15). The deposit, which lies between 180 m and 220 m a.s.l. is uniquely high for the western Queen Elizabeth Islands. The silt and fine sand rhythmites, mostly 2-10 cm thick, give way rarely to other structures, including small (1 m wide) channel fills, striated dropstones to 1 m diameter and associated deformed strata, debris flows to 20 cm thick incorporating gravel and silt clasts, load structures in beds to 15 cm thick, and climbing ripples (Fig. 16). Up to 15 m of stacked sediment was observed. The silt is underlain by shale bedrock. Cobbles and boulders of striated quartzose sandstone and rare crystalline and carbonate clasts, including a striated ultrabasic boulder, which occur in the bottoms of gullies cut in the silt probably rolled from above it. The very poorly exposed till is overlain by up to 6 m of round to subangular granules to boulders in a sand or silt matrix. These fluvial or glaciofluvial deposits cap areas adjacent to the silt, at elevations of 230-240 m. Pelecypod fragments found scattered over 100 m^2 of silt may be in situ, or transported in and recently eroded from till or outwash. The following ratios of alloisoleucine to isoleucine (aIle/Ile) in a single shell fragment believed to be from *Mya truncata* were determined by Laboratoire de Géochronologie par les Acide Aminés (GEOTOP at UQAM).

Lab no.	aIle/Ile (free)	aIle/Ile (total)
UQA-633-1	0.349	0.211
UQA-633-2	0.997	1.183
UQA-633-3	0.746	0.353
Mean	0.697	0.592

The mean values are higher (i.e., closer to racemic equilibrium ratio and thus older) than any ratios published for Queen Elizabeth Islands (cf. Retelle, 1986), including in situ shells from assumed Miocene or Early Pliocene deposits (Brigham-Grette et al., 1987). However, if these shells are

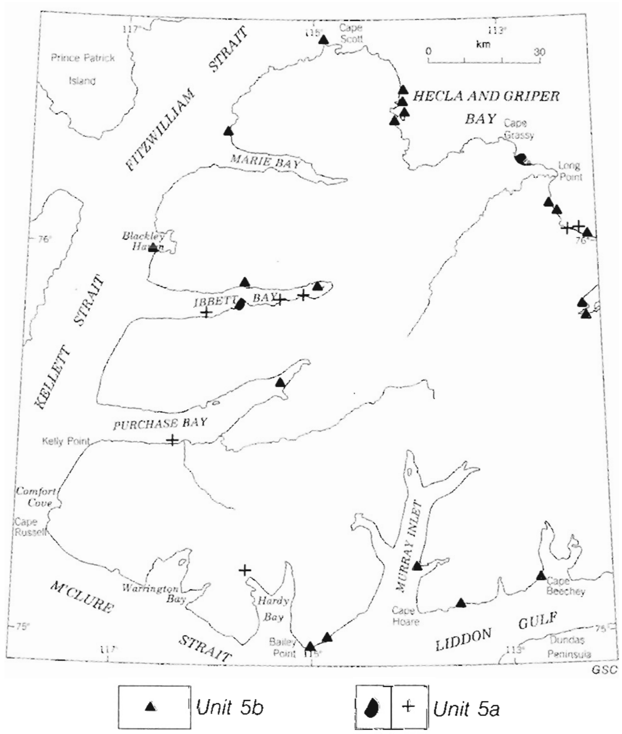


Figure 17. The distribution of marine deposits (5a, emerged neritic; 5b, raised beaches).

not in situ, then they may have had a variable thermal history and not be as old as the ratios suggest.

(2) Rhythmically bedded unfossiliferous silt occurs between 60 and 130 m a.s.l. in several valleys tributary to Purchase and Ibbett bays. The Ibbett Bay and Giddy River (Purchase Bay, Fig. 14) deposits were shown above to be likely lacustrine sediments deposited into water bodies impounded by glaciers filling the bays. The well exposed deposit south of Ibbett Bay shows up to 20 m of otherwise structureless stratified silt, overlying 1 m of diamicton which may be a flow till, which in turn rests on very weak but undeformed shale. Here, as in the other deposits, the silt appears to be overlain by or perhaps coeval with till and outwash.

(3) The largest deposit, perhaps 20 km^2, lies downstream of outwash and equivocal streamlined till at the northeast margin of Hecla and Griper Bay. The highest recorded elevation is 43 m a.s.l.; no shells were found in the vicinity. Laminations are rarely visible in the greater than 20 m thickness of silt and fine sand exposed. The reddish colour presumably is derived from Canyon Fiord Formation red bed sediments that occur to the south.

(4) Stratified fine sand flanks a lateral moraine ridge on the eastern shore of Murray Inlet to 68 m a.s.l. These unfossiliferous deposits were probably deposited in a marine environment at least on the seaward side of the ridge.

Pleistocene and Holocene

Marine deposits

Emerged neritic marine deposits (5a)

Clayey silt to fine sand, generally in a thin veneer but locally observed to 6 m thick, is discontinuously distributed along lowland coasts. Only the largest deposits were identified (Fig. 17). Sediments in places are rhythmically stratified or contain clasts, including striated quartzitic sandstone, and crystalline rocks of southern provenance. These erratics, as described previously, chiefly occur at low elevations and were likely rafted in bergs derived from Laurentide ice. Silt surfaces commonly show efforescence typical of marine sediments, but the deposits rarely contain marine shells. Most shells were observed on outer coasts; they are extremely rare in the inlets. They also lie well above modern shorelines and appear to have been most abundant at the end of the Pleistocene during late glacial and deglacial times. Remember, however, the usual bias of collectors towards the highest shells.

The two shell collections from the south coast, dating 10.6 ka and 11.7 ka were described above. On the west coast, shells observed north of Blackley Haven at elevations of 13 to 36 m are probably contemporaneous with shells collected by J.G. Fyles on the opposite shore of Prince Patrick Island, 18 m a.s.l., dating 11 160±150 BP (GSC-260; Table 3B). On the south shore of Ibbett Bay J.G. Fyles collected shells at 13 m elevation which yielded an age of 10 520±150 BP (GSC-340; Table 3A). In 1985, this conspicuous deposit of marine silt was the only location where shells were found during ground traverses of 40 km of the adjacent coast. In Marie Bay, J.G. Fyles collected shells at 18 m which yielded an age of 10 430±150 BP (GSC-368; Table 3A); shells 20 km to the east at 5-15 m dated 10 300±100 BP (GSC-4958; Table 3A).

The limit of late Pleistocene marine inundation in western Melville Island is conjectural. Along southern coasts and inlets, it has already been shown that sea level was at least 40 m in elevation at Bailey Point at 10.6 ka and 15 m at Comfort Cove at 11.7 ka, where glaciomarine deposits rise to possibly 60 m. In the northeast arm of Murray Inlet, undated probably glaciomarine sediments were deposited up to 68 m a.s.l., whereas in the northwest arm what appears to be a washing limit lies 55 m a.s.l. On the west coast, at Blackley Haven, assumed Late Pleistocene shells were found up to 36 m elevation, and deltas extend to 51 m. No unequivocal marine deposits have been observed above 25 m in Purchase Bay (a delta at Giddy River); possible glaciomarine silt rises to 50 m a.s.l. The record is clearer in Ibbett Bay, where scattered benches and terraces lying between 50 and 60 m a.s.l. appear to be marine rather than ice marginal. The 10.5 ka shells at 13 m a.s.l. lie in deposits that rise to 38 m. A (marine?) kame delta on the south shore lies 36 m a.s.l. On Sproule Peninsula, shells were observed up to 17 m elevation in deltaic silt rising to at least 25 m a.s.l. Indicators of raised sea levels are relatively abundant along the northwest shore of Hecla and Griper Bay, though no absolute ages of features were determined other than 10.2 ka for a sea level likely higher than 30 m (see above and Table 3A). They include glaciomarine silt to at least 43 m a.s.l. and several deltas lying as high as 65 m a.s.l. Deltas at these elevations occur at the south end of the bay, where sea level was at least 49 m in elevation at 10.5 ka (Table 3B; Hodgson et al., 1984). Why a bluff was eroded presumably by marine processes 20 m a.s.l. at several locations southeast of Cape Grassy is not known.

Raised beaches (5b)

Unlike the southern and eastern Arctic Islands, the modern beach is only intermittently developed in western Melville Island, and raised beach flights are rare (Fig. 17). This is inferred to be a function of climate; abundant sand and coarser particles are available for reworking. Even in favourable summers, most surrounding waters are 9/10 or more covered by sea ice; this means there is little open water for waves or currents to operate in, and ice push frequently disturbs littoral sediments. Furthermore, low coasts suitable for beach development are commonly underlain by weak rocks subject to detachment slides and flows which eradicate older landforms. Where it exists, the modern beach is normally composed of a low sand or sandy gravel berm.

Holocene

Fluvial deposits (6)

These most widespread of Quaternary deposits (Fig. 18) were rarely examined in the field; however, observations made by Hodgson (1982, p. 22) and Hodgson et al. (1984, p. 14) are believed to be relevant here. Only linear deposits more than 100 m wide and other forms greater than 1 km^2 are shown on Map 1753A, eliminating many of the alluvial fans developed at the coast and at other major inflections in stream thalwegs. Sediment composition is dominated by the coarser fraction of subjacent and adjacent materials (i.e., mainly weathered rock). Hence fluvial deposits on units 1b, 1c, and 1d are mostly gravel and sand, and unit 1a and unit 1c on Sproule Peninsula are silty to gravelly.

Inactive (6a)

Terraces are minor features in rugged areas which compose two thirds of the map area. There, valleys are confined and periodically swept by active channels. Most fluvial deposits are not being actively reworked along the north coast, where deltas have prograded as much as 15 km while sea level has fallen. Frost fissure patterns are commonly well developed on terraces, but thermokarst erosion, ponds and peat growth uncommon.

Active (6b)

Most rivers have an extreme nival regime in which channel flow is greatly reduced after the snowmelt freshet. There is a near total absence of lakes to regulate flow. Rivers draining the glaciers which are present on the highest Blue Hills have a glacial regimen which extends the season of flow. Multiple braided channels are common in all parts of the map area.

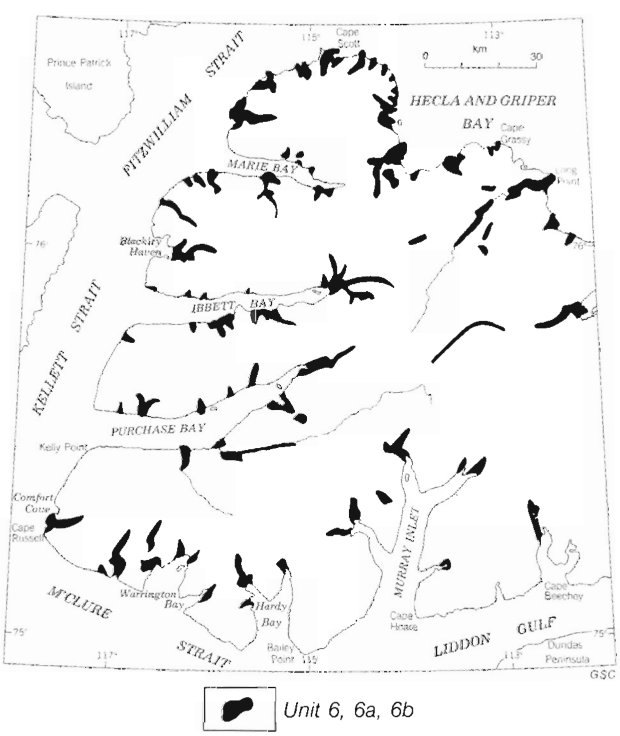


Figure 18. The distribution of fluvial deposits (6, undifferentiated; 6a, inactive; 6b, active).

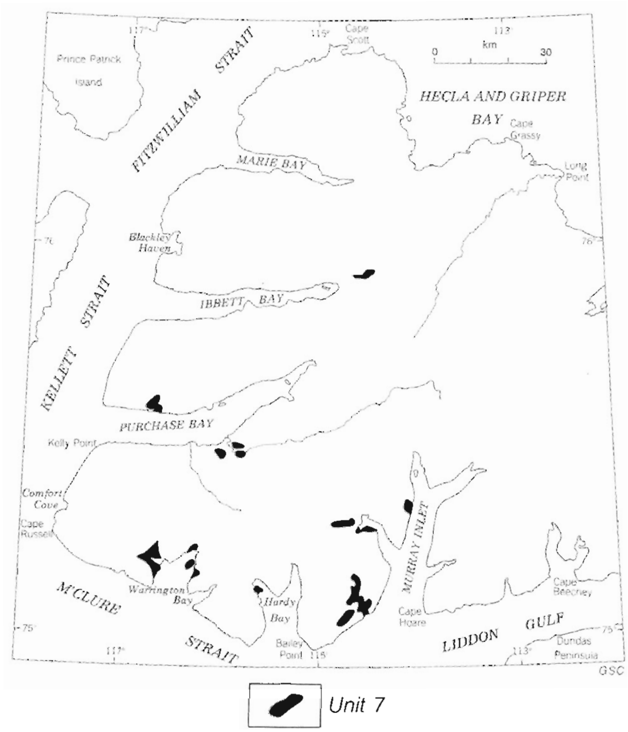


Figure 19. The distribution of colluvial deposits (7).

Colluvial deposits (7)

Colluvium is considered here as material transported or altered by mass wasting processes, especially slopewash, rillwash, and solifluction, to such a degree that it markedly differs in composition or structure from its subjacent source material. Although such deposits occur both on and at the foot of slopes, they are rarely extensive enough to be mapped separately from weathered rock (Fig. 19). This unit occurs mostly where weathered rock and till have been reworked and intermixed below the limit of previous marine inundations.

Ice (8)

Ground ice

All of western Melville Island is underlain by permafrost which in adjacent landmasses reaches depths of 300 to 600 m (Taylor et al., 1982), but is less where the thermal profile was disturbed by overlap of late Quaternary seas (Taylor et al., 1983). The seasonally fluctuating upper ground temperatures stabilize at about 10 m depth, at a similar temperature to the mean annual air temperature (-18°C at Mould Bay). The annual thaw never penetrates more than 1 m. As noted above, frost fissure patterns are widespread, possibly indicating much underlying wedge ice, though Hodgson (1982, p. 27) noted examples of coarse mineral soil filling wedges in the Ringnes islands. Cores taken from weathered Paleozoic rock on Dundas Peninsula of Melville Island generally showed much segregated ice down to 2 m depth, and a decline to no visible ice in the 1 to 8 m below (Stangl et al., 1982). The well vegetated clayey silt overlying the black shale unit 5 of the Ibbett Bay Formation contains an unknown thickness of segregated ice (Dyke, personal communication, 1986). Segregated ice was observed exposed in late Quaternary deposits at three sites. At the head of Ibbett Bay, a thermoerosional niche in a river bank exposed 1 m of structureless ice overlain by silt and peat. Several 5 m(?) high pingos are present in the adjacent floodplain (pingos were not observed anywhere else). Two bodies of ice, at least 20 m wide and 3 m thick, were exposed behind flowslides in the large laminated glaciomarine silt deposit at the northwest corner of Hecla and Griper Bay. Inclined thin strata of silty sediment in the ice were crosscut by the subhorizontal lamination of the overlying silt. And south of Purchase Bay, in the next valley east from Giddy River, a massive volume of ice was exposed over a face up to 100 m long and 20 m high within glacigene sediments (Fig. 20). The ice is subhorizontal, slightly deformed, and could be buried glacier ice, for it lies within or at the base of a silty bouldery diamicton, likely a till, underlain by stratified fluvial or glaciofluvial sand.

Glaciers (8)

The only ice caps in the western Arctic Archipelago are the four draped over summit plateaus of the Blue Hills at an elevation of 650±100 m (Fig. 21). They range in area from 55 to 15 km^2, and as Tozer and Thorsteinsson (1964) estimated, are no thicker than 60 m (Spector, 1966). Mass balance measurements show the ice caps to be static (i.e., stagnant, Koerner, 1989). Ice cap margins in places overrun marginal drainage channel systems dating from much older and more extensive glacier ice (Fig. 22), indicating expansion to present forms — perhaps even establishment after the hypsithermal mid Holocene (cf. Blake, 1981). Numerous glacierettes, which accumulated by drifting, lie in ravines and on lee slopes down at least to 300 m (in Raglan Range). Small (i.e., tens of square metres) perennial snowpatches, probably truly glaciers have been recorded in southeast Melville Island down to 50 m a.s.l. (Young and Lewkowicz, 1990). Some ravine glaciers show solution and collapse features resulting

Figure 20. Massive ground ice within or underlying glaciogene deposits, east of Giddy River, Purchase Bay. GSC 204768-B.

Figure 21. The distribution of glaciers (8).

from surface and subsurface runoff. Perennial snow (ice?) cover was probably more extensive 300-100 years ago, as discussed below.

Vegetation superstrate

Melville Island lies in the generally impoverished High Arctic vegetation region yet offers considerable diversity (Fig. 23) due to variation of both surficial materials and climate (Edlund, in press). Materials control availability of nutrients, toxicity to certain species, moisture retention, and ease of rooting. Climate is not simply a matter of temperature variation with elevation, or moisture availability; at these latitudes, shelter, aspect, and proximity to cold ice-covered seas are critical. Peat is a rare surficial deposit, and a thick deposit was observed at only one site. A channel cut adjacent to (in?) the Purchase Bay icy sediments described above is filled with up to 3 m of peat; the basal 15 cm was sampled and yielded a radiocarbon age of 7890±70 (GSC-4187; Table 3A). Peat accumulation was well established in the western archipelago by this time (Ovenden, 1988).

Quartzose sandstone of the summit plateaus provides few nutrients and poor rooting for vascular plants but is capable of supporting cryptogams, especially crustose lichens. Parts of these uplands were observed to be lichen-free by Koerner (1980) who argued that the reason these and other such areas are not colonized is due to late-persisting snowfields, rather than the former presence of perennial (Neoglacial) icefields, which had been proposed for the eastern Arctic (Ives, 1962). Edlund (1985) outlined lichen-free areas of western Melville Island for the first time (Fig. 24) and accepted the original Neoglacial icefield origin. The occurrence of small, recent ice marginal meltwater channels in these zones gives support to the icefield hypothesis.

DEVELOPMENT OF QUATERNARY LANDSCAPE

Important elements of the morphology of western Melville Island were shaped prior to the Quaternary. The contributions of Tozer and Thorsteinsson (1964) and others were discussed earlier in this report. There are not, unfortunately, any known terrestrial Tertiary deposits to record the most significant events (the more continuous record probably present in offshore channels yet has to be investigated). Therefore, it is necessary to interpret events through erosional landforms. Plateaus or planation surfaces and scarps or cliffs are the most noticeable eroded elements of the landscape and historically probably the most significant.

Planation surfaces

Plateau elements occur to 700 m elevation and are particularly common between 600 m and 400 m. Elevations decline eastwards to 300 m at 112°W and there appears to be a northerly tilt to the highest summit plane (Fig. 25A). The degree of dissection in the west of the map area hinders correlation of levels there or determination of any inclination. The 500 to 600 m element concords with the highest summit of the lithologically varied and dissected Canrobert Hills. The more homogeneous sandstone Raglan Range bears a planar surface that declines northward from almost 500 m elevation (Fig. 25B).

Summit surfaces in the south accord with subhorizontal strata of the Arctic Platform, however, inclined strata are planed in the fold belt north of the hinge line. These strata were last folded during the mid Paleozoic Ellesmerian Orogeny, and arguably during the late Paleozoic Melvillian Disturbance (Tozer and Thorsteinsson, 1964; Harrison et al., 1985). In the north, Mesozoic Sverdrup Basin sediments were considerably uplifted as a result of compression during the early Tertiary Eurekan Orogeny. Uplift of the resultant plain is suggested by Tozer and Thorsteinsson (1964) to have occurred in the Tertiary and possibly into the Quaternary by differential displacement of blocks of western Melville Island. This is the latest event likely to have initiated a cycle of erosion responsible for widespread peneplanation. Elevation is explained by Trettin (in press) as compensation for isostatic disequilibrium resulting from erosion following the Eurekan Orogeny and may have occurred as doming without faulting. Reliable reconstruction of planation surfaces from island to island must await collection of information on the age and origin of the channels. Nevertheless, Tozer and Thorsteinsson (1964) speculated that the surface underlying the fluvial Neogene Beaufort Formation of Prince Patrick Island may be contemporaneous with planation surfaces of Melville Island.

Scarps and cliffs

Scarps up to 400 m high transect upland and lowland western Melville Island; coastal cliffs in places 600 m high, border much of Kellet Strait, M'Clure Strait, and Liddon Gulf, as well as inlets south of the latitude of Ibbett Bay. These features originated by one or a combination of (1) backwasting by subaerial erosion of flat or inclined strata capped by resistant beds (mainly Hecla Bay Formation sandstone); (2) erosion along fault lines of various ages, as suggested by Thorsteinsson and Tozer (1970, p. 588), who noted the linear or arcuate pattern of most scarps and speculated some might be (3) fault (i.e., tectonic) scarps of Tertiary or even Quaternary age, an idea discussed by Tozer and Thorsteinsson (1964) and most recently expounded by England (1987). Tozer and Thorsteinsson (1964) also suggested (4) a glacial origin for the inlets, which radiate from the centre of the landmass (centre of local ice?). Thorsteinsson has since rejected the tectonic origin hypothesis (personal communication, 1988).

The oldest landforms recognized are exhumed structural features that originated during the Paleozoic. The 300 m high sandstone-capped scarp, which forms the northern border of the main upland plateau (Fig. 3), predates the lower lying but unconformably overlapping upper Paleozoic Canyon Fiord Formation. These and younger Sverdrup Basin sediments must have filled the present lowland at least to the scarp crest during subsequent planation. The similarly ancient Canrobert Hills are fold and thrust relief landforms also overlapped by Canyon Fiord beds. The low cuestas widespread in the northern lowlands obviously were initiated later than the Tertiary Eurekan Orogeny by subaerial or perhaps glacial processes.

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Figure 22. Stagnant ice cap straddling snow-filled marginal meltwater channels left by ice of last glaciation retreating into Blue Hills, southeast of Purchase Bay. Arrows show side hill channels with barb on distal side. National Air Photo Library, T414L-34.

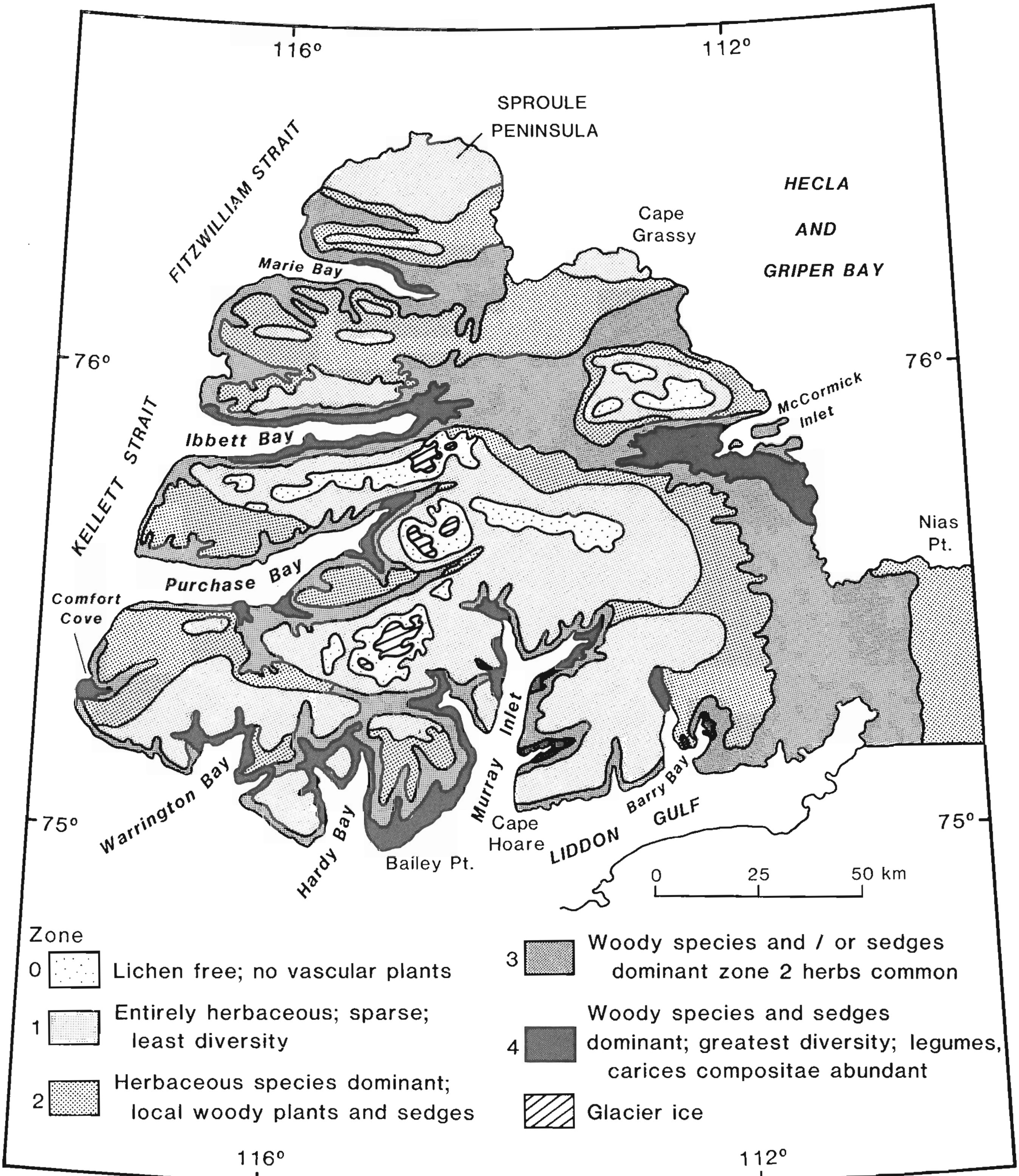

Figure 23. Plant communities on western Melville Island (from Edlund, 1986, Fig. 86.3).

Most of that faulting which controls the alignment of inland scarps is believed by Harrison et al. (1985) on stratigraphic evidence, to have been completed in Paleozoic and Mesozoic eras, whereas Tozer and Thorsteinsson (1964, p. 188) suggested that the "youthful physical expression" of many scarps within and bordering the Blue Hills results from their being fault scarps of late Tertiary age. Geomorphological evidence, however, shows that a number of prominent scarps are fault line in origin. For example, the 50 km x 5 km x 300 m graben linking the Giddy River with Murray Inlet (bounded on the south side by the Murray Inlet Fault of Tozer and Thorsteinsson, 1964) is crossed by drainage lines superimposed from a postfaulting planation surface (Fig. 26). (Superimposed rivers also cut the northern Canrobert Hills). Around other scarps, too, there is no evidence of the deranged drainage expected to accompany tectonically displaced land surfaces.

Figure 24. The distribution of lichen-free zones.

The origin of coastal cliffs is more open to speculation. The linear east shore of Kellett Strait parallels Eglinton Graben, which was believed by Miall (1975, p. 561) to have existed in Mesozoic time; but whereas faultline scarps in the Blue Hills are normally capped by resistant sandstone, the Kellett Strait coast cuts across lithologies ranging from sandstone to weak shale. It is surprising that such a linear coast could be maintained after formation (by glacial or reactivated tectonic processes?) in sediments so susceptible to erosion.

M'Clure Strait has been concluded to be a graben formed in the late Tertiary (Tozer and Thorsteinsson, 1964, p. 188) or Quaternary (Miall, 1975, p. 561). Kerr (1981) and Sobczak (1982) placed the graben at the west end of a rift or shear zone system linking Arctic and Atlantic oceans along Parry Channel. They suggested that faults propagated upwards during early and mid Tertiary time die out below the present surface. Why, then, such a system should have a clear geomorphic expression is not clear. Dyke (1983, p. 5) has suggested beheaded streams were evidence of a fault scarp origin for cliffs in eastern Parry Channel. These events are placed later than the most active period of faulting recognized

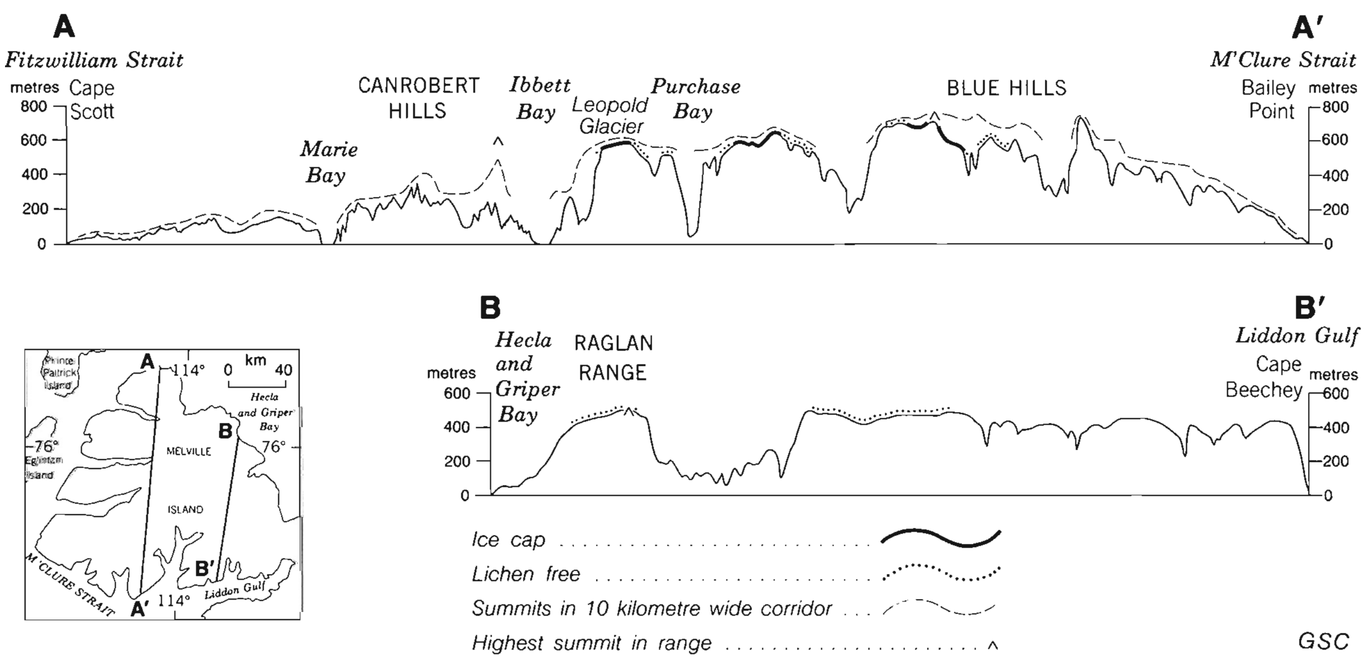

Figure 25. Topographic profiles, north-south, across Melville Island.

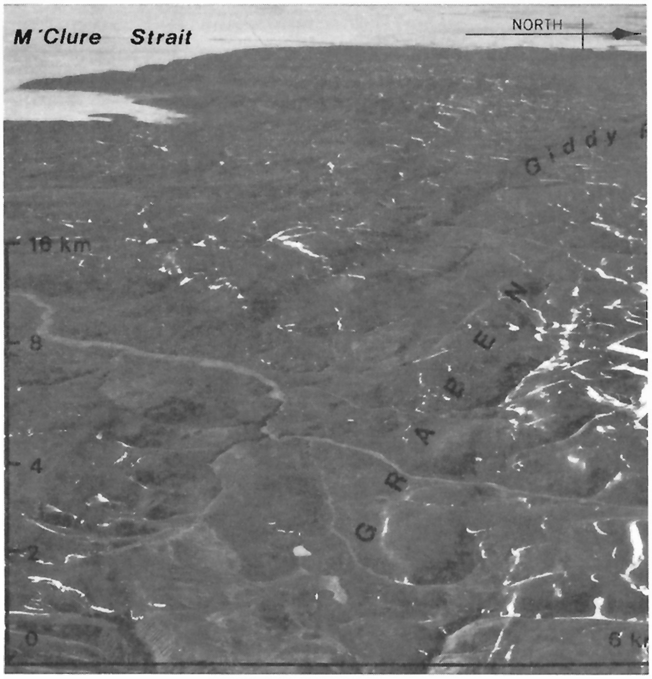

Figure 26. Superimposed drainage crossing Giddy River-Murray Inlet graben. National Air Photo Library, T414L-24.

by Harrison et al. (1985). Looked at geomorphologically, the cliffs bordering M'Clure Strait on Melville Island, which include resistant lithologies, could be fault-line scarps of subaerial, marine, or glacial origin (M'Clure Strait was likely filled with ice a number of times).

Within Melville Island, Harrison (in press) showed no faults closely paralleling southern inlets, nor extending inland from their heads. No terrestrial grabens occur on the scale of the major inlets. Nevertheless, no geomorphological evidence of glacial erosion was found, nor is there a record of deposition of a large volume of sediment eroded by glacial action. Much of the detail in the landscape of western Melville Island appears to have been shaped by subaerial processes, chiefly fluvial, aided by mass wasting. Indicators of glacial scouring, such as lakes, are almost completely absent.

QUATERNARY HISTORY

The description of surficial materials showed the sparse distribution and equivocal age of Quaternary deposits; hence the occurrence and age of most Quaternary events remains speculative.

Early Pleistocene glaciation

An inundation by one or more early Quaternary continental ice sheets, and subsequent erosion of till by mass wasting or by local glaciation is suggested by the rare erratics of southern provenance that can be found at all elevations, together with the absence of identifiable till above 450 m elevation. The single remnant landform may be the esker on Sproule Peninsula (Fig. 13). The esker may be coeval with similar landforms on the Ringnes islands (Hodgson, 1982). The glaciomarine or glaciolacustrine deposit at 200 m elevation east of Ibbett Bay, may be early Quaternary in age if it is the deposit of origin for overlying "old" shells.

Correlation

Hodgson et al. (1984) stated that dissected kame-like landforms at the limit of Dundas Till, up to 300 m elevation on the Dundas Peninsula, "mark the unequivocal maximum limit of continental ice on central Melville Island." This refers to the extent of Dundas Till because, of course, the occurrence of erratics indicating ice flow from the south over the western Queen Elizabeth Islands had long been known (see above). Dundas Till was tentatively correlated with deposits on Banks Island from the Early Pleistocene Banks Glaciation or less extensive, Middle Pleistocene, Thomsen Glaciation. Vincent (1984, p. 96, 97) acknowledged that the northern Melville Island erratics may be remnants of an even older advance of continental ice. Based on existing observations, England's (1987) speculation that the oldest glacial event was late Tertiary in age, and preceded tectonic uplift and dissection, must remain just that for Melville Island. Many other glacial landforms, except glacial troughs — if inlets were glacially eroded — are attributed to Late Pleistocene events.

Late Pleistocene glaciations and sea level changes

Local ice

Most areas of western Melville Island bear evidence of glacier ice retreating towards the centre of the landmass (Fig. 27). Occurrence of ice is recorded mostly by rock-cut meltwater channels and less commonly by glaciomarine or glaciolacustrine deposits, and by outwash trains. In the general absence of ice flow indicators, it is assumed that the preceding expansion took place from local ice centres; only at the western extremity of Hecla and Griper Bay is there evidence for such flow. Here, north moving ice deposited till coloured red by material from the Canyon Fiord Formation, which lies immediately to the south. Numerous quartzose sandstone boulders in the till originated in the Hecla Bay Formation in the centre of the island.

In a few areas, landforms permit the shape of a retreating glacier to be determined: 1) Northward flow, which possibly topped the Raglan Range, broke into streams to the east and west of the range after a lowering of the ice surface (Fig. 8). Ice was at least 300 m thick in adjacent lowlands. The 58 m marine delta north of the range lies in an area previously overrun by several hundred metres of ice; outwash leading to the delta may record retreating ice, or the maximum stand of a later event. 2) An east-west ice front retreated southwards between Raglan Range and Marie Bay (Fig. 9). 3) Glaciers contained by the inlets retreated east within the entrances of Ibbett and Purchase bays (Fig. 14). 4) Southward flow from Hardy Bay and probably Murray Inlet is recorded by till at Bailey Point. The point was overlapped later by the M'Clure glacier (see below). 5) Ice retreated up the east slope of the Blue Hills, from as far east as the head of Liddon Gulf

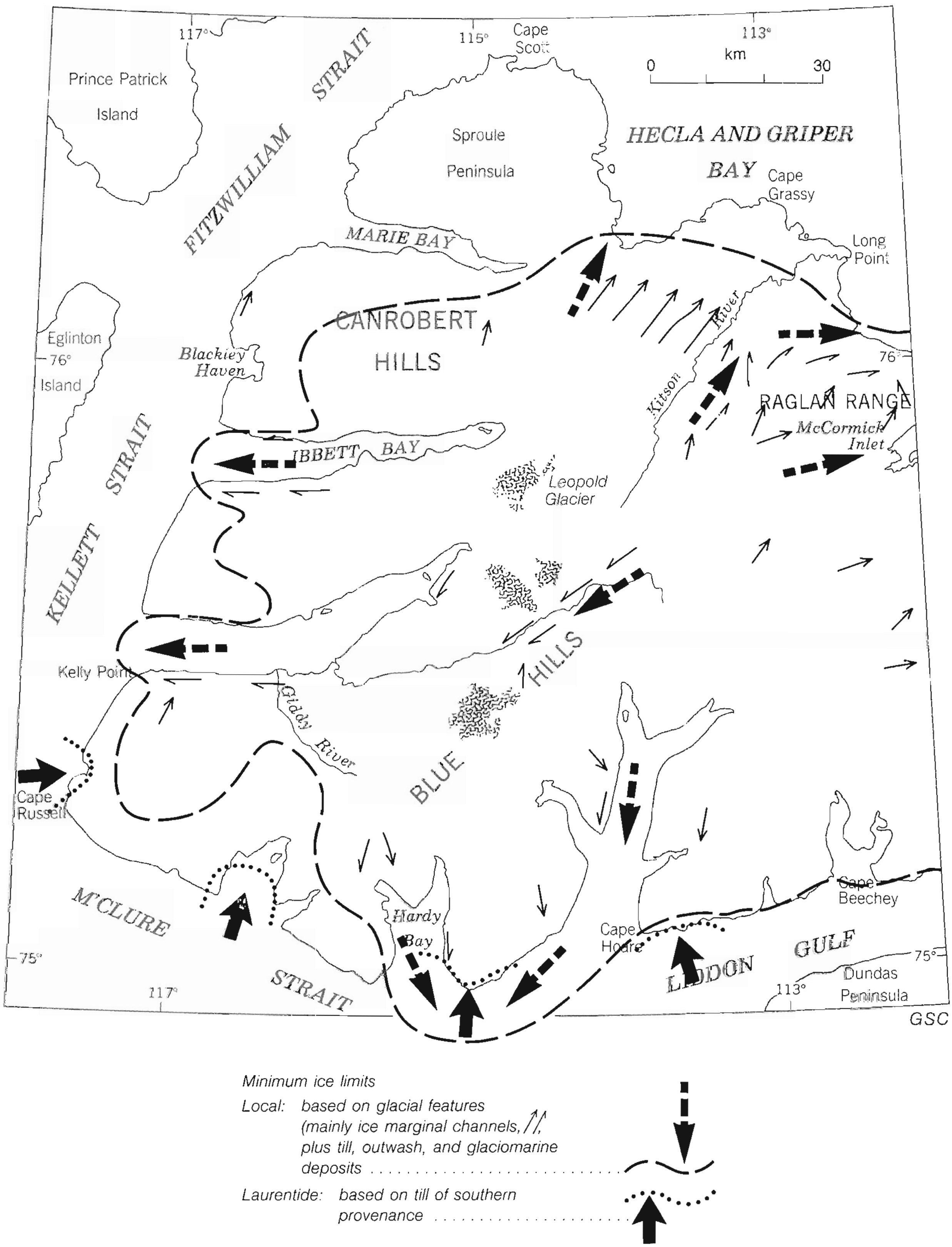

Figure 27. Minimum extent of last glaciation.

(Hodgson et al., 1984, p. 23). 6) Sidehill channels show that ice wasted in the major southwest draining valley between Purchase Bay and Murray Inlet, and between two existing ice caps, towards the northern scarp of the Blue Hills and the headwaters of the north draining Kitson River (Fig. 22). 7) Channels elsewhere in the Blue Hills indicate retreating ice tongues conformed to topography. Murray Inlet contained south-flowing ice to at least 300 m a.s.l. east of Mount Joy. The absence of kame deltas at inlet heads, which are completely occupied by recent fluvial sediments, is unusual in the Arctic Islands; it suggests a debris-free retreating ice cover.

It is not known whether these suites of landforms are coeval, or even from the same stade or glaciation, hence the speculative minimum limit shown in Figure 27 is unlikely to be synchronous. The following circumstantial evidence of age is available: 1) Till deposited by inland ice at Bailey Point, is overlapped by, and thus predates the probably Late Wisconsinan Liddon Till. 2) The central reach of Ibbett Bay was occupied by the sea from at least 10.5 ka (GSC-340, Table 3A). 3) Marine deltas terminating valley trains on Hecla and Griper Bay, and at the head of Liddon Gulf accord with a 50-60 m water plane traced to a 10.4 ka delta (GSC-338, Table 3B) at 49 m in southern Hecla and Griper Bay and to Shellabear Point on Liddon Gulf where 56 m shells dated 11.5 ka (GSC-3113, Table 3B). As noted above, many meltwater channels appear Late Wisconsinan in age. Similarly, deltas north of the Raglan Range look unweathered, though well preserved kame deltas of pre-Late Wisconsinan age are known elsewhere (e.g., Retelle, 1986, p. 1005).

Correlation

Ice retreat towards the centre of landmass has been reported from other large Queen Elizabeth islands (Hodgson, 1989). These glaciers, too, were only locally erosive, and left scattered deposits of commonly featureless till. On northern Ellesmere Island, limits of the last advance of ice, established mostly from glaciomarine deposits including kame deltas, are ca. 8 ka old in the northeast (England, 1978, 1983) and 10 ka on the north coast facing the Arctic Ocean (Bednarski, 1986). Blake (1964) observed indicators of radial flow on Bathurst Island, but no ice margins were determined, however no finite dates older than 10 ka have been obtained from terrestrial or marine deposits in clearly glaciated areas.

Continental (Laurentide) ice

Till composition and distribution indicate that ice of southerly provenance overlapped the shores of M'Clure Strait to not more than 100 m a.s.l. at Comfort Cove/Cape Russell, Bailey Point, Cape Hoare and, possibly, Warrington Bay. Underlying fluvial deposits, (subaerial or subaqueous?), probably deposited before advancing ice, are undated. There is no evidence of a hiatus between deposition of till and of overlying conformable marine deposits. Shells from these deposits, which yielded ages of 11.7 ka at Comfort Cove (Fig. 11) and 10.6 ka at Bailey Point, provide a minimum date for deglaciation (Table 3A). The postglacial marine limit lies at least 15 m a.s.l. and possibly 60 m at Comfort Cove, and at least 40 m at Bailey Point. No landforms indicate any interaction between continental and local ice.

The horizontal nature of the till limit, sparsity of marginal landforms, and small postglacial rebound from isostatic depression suggest that at least eastern M'Clure Strait, which is presently almost entirely about 400 m deep, was occupied by an ice shelf or partial buoyant glacier, rather than filled by grounded ice (c.f. Hodgson et al., 1984; Hodgson and Vincent, 1984). Calving from this Laurentide ice likely transported the relatively abundant shield erratics to the shores of Kellett and Fitzwilliam straits.

Correlation

Hodgson et al. (1984) suggested correlation of Bailey Point till with Liddon Till, which was deposited on the outer south shore of Liddon Gulf prior to 11.5 ka. (Table 3B). That till could be coeval with Bolduc Till (11.7 ka) on the south shore of Dundas Peninsula. All these tills have similar lithologies and lack prominent landforms. The postglacial marine overlap is at least 56 m in Liddon Gulf and at least 90 m on the northwest shore of Viscount Melville Sound.

On the Banks Island (i.e., south) shore of M'Clure Strait, Vincent (1982) found tills similar to those described above up to 130 m a.s.l. He, too (1982, p. 227), believed they could have been deposited by floating glacial ice. Nevertheless, massive distal meltwater channels have no counterparts on Melville Island shores. The tills (Mercy Bay Till and Bar Harbour Till) were deposited by the Prince Albert Lobe in the M'Clure Stade. This was assigned by Vincent, on the basis of circumstantial dating, to the earlier part of the Wisconsinan Amundsen Glaciation. Dyke (1987) argued that this event was Late Wisconsinan in age, and Dyke and Prest (1987) showed all M'Clure Strait occupied by an ice shelf which reach a maximum extent between 18 ka and 13 ka. Observations from western Melville Island support a concept of glacial ice filling or floating in eastern M'Clure Strait. The ice from this maximum northwestward thrust of the Late Wisconsinan Laurentide Ice Sheet is referred to informally here as the M'Clure glacier. Evidence that the 10 ka Viscount Melville Sound Ice Shelf (Hodgson and Vincent, 1984) extended onto the shore of M'Clure Strait has not been found.

Late Pleistocene and Holocene sea levels

A specific raised marine water plane was identified only at the undated 58 m outwash delta north of the Raglan Range (Fig. 8) and the 65 m delta to the northwest. Undated deltas and washing limits at 68 m and 55 m proximal to moraines in Murray Inlet, 70 m at Giddy River (Purchase Bay), and 69 m in Ibbett Bay are probably ice contact marine features, but could be glaciolacustrine. Sea level at Bailey Point was at least 40 m above present at 10.6 ka.

These elevations do not directly indicate recovery from the saucer shaped crustal depression expected under a local ice cap. Possible interpretations include: 1) Higher marine features were not found up inlets, due to steep talus-covered flanking slopes, and simply inadequate time spent in field investigation. 2) Rebound was in phase with ice margin retreat and establishment of marine limit, hence a subhorizontal diachronous limit registered between outer coasts and heads of inlets. 3) A large thin ice cap extended beyond coasts, producing uniform emergence throughout the region. 4) The ice cap was too small to significantly depress the crust, and observed emergence results from tectonism or from external ice loads. The symmetry of emergence on north and south coasts, however, suggests the M'Clure glacier had little influence. Perhaps the reverse occurred, that is, the forebulge from the Laurentide Ice Sheet reduced rebound.

Whatever explanations apply, the result is much less emergence than measured on Bathurst Island (over 150 m in the north), or even from some central Queen Elizabeth islands which bear no indicators of local ice, for example, Cornwall Island (110 m).

The relative abundance of marine pelecypods (dominantly *Hiatella arctica*) at 12-10 ka could result from increased nutrients supplied by a disintegrating local ice cap or M'Clure glacier, or from a temporary decrease in the summer sea ice cover. No younger material was found which could be related to a water plane. The rarity of raised beaches indicates a year round sea ice cover through the Holocene — or perhaps occasional open seas with an ice foot or floes protecting shores from wave action. Moss collected by W.E.S. Henoch at the head of McCormick Inlet from a paleoeskimo site on a beach 1.8 m a.s.l. dated 1740±190 BP (I-840; Table 3A; Henoch, 1964, p. 119). This restricts any emergence of the site to <1m in the last 1.7 ka, and leaves open the question of whether recent submergence has occurred. A.S. Dyke (personal communication, 1989) has speculated that rapid initial emergence, when there was little time for beach development, was followed by a period of slower uplift during which beaches may have been built. Subsequent submergence through much of the Holocene has drowned those beaches.

Holocene terrestrial events

Koerner (1989) suggested that thin stagnant ice caps began to grow in the Queen Elizabeth Islands 4 to 1 ka ago in the Neoglacial following the Hypsithermal. This may be when the Leopold Glacier and the other ice caps of western Melville Island originated (Fig. 3 and 22). There is no evidence of glacial erosion or deposition related to the present plateau ice caps. Much smaller niche glaciers occupied valleys incised in high planation surfaces. They are flanked by marginal drainage channels magnitudes smaller than those cut in the Late Pleistocene. Those few channels examined in the field are not colonized by lichens, unlike upslope materials. Thus they appear to be of similar age to the broad lichen-free areas described above (vegetation superstrates), which likely developed during the 16th to 19th century Little Ice Age climatic deterioration.

LAND USE AND GEOTECHNICAL APPLICATIONS

Engineering geology and land use concerns are summarized and keyed to surficial geology map units in Table 4.

Foundation conditions and aggregate sources

All but a few percent of the surface of the landmass is composed of rock weathered to a wide range of clast and grain sizes (Table 4). The unweathered rock, present 1-5 m below the surface, varies from poorly lithified shale to well consolidated sandstone or carbonate rocks. Grains are dominantly quartz; clay minerals are mainly illite and kaolinite.

Hazardous processes

Processes have not been systematically studied in the map area. Comments on processes and hazards on weathered Mesozoic rocks are included in Hodgson (1982).

Fine grained deposits (units 1a,a′, parts 1b,b′, 2,4,5,8) are particularly sensitive to disturbance which concentrates surface drainage and results in gullying and possibly thermal erosion. Skin flows were observed widely on silt and fine sand. Segregated ice is an unknown quantity in western Melville Island because of the rarity of natural exposures (Fig. 20) and absence of any other subsurface information apart from the observation by L. Dyke (personal communication, 1986) of massive ice in one particular bedrock unit. It is assumed to be present below the frost fissures which pattern many materials units. Ice is possibly present in protalus ramparts and rock glaciers(?) on the coarsest materials.

Western Melville Island lies within a few hundred kilometres of several clusters of earthquake epicentres (Basham et al., 1977); nonetheless, no landslides were identified on the cliffs and steep scarps.

Sensitivity to disturbance

Disturbance is considered to be man-initiated change; sensitivity is the degree to which the terrain responds. In Table 4, a low sensitivity or minor disturbance may be locally moderate or high during snowmelt or heavy rain. A moderate sensitivity is present throughout the area disturbed by activity. In a highly sensitive area, natural processes will likely expand the disturbance beyond the area of activity, as well as hindering these activities.

Table 4. Geotechnical Considerations

Unit	Foundations and Aggregates	Hazardous Processes	Sensitivity
1a, a' Fines: weathered rock	Discontinuous lag gravel over fine sand to clayey silt, some clasts; weathered rock 1-5 m thick. Underlain by generally weak, fine grained bedrock. Quartzitic; some illite, kaolinite. Unit 1a' is calcareous.	Active layer may remain saturated. Segregated ice likely widespread, especially in frost fissure. Skin flows (detachment) widespread. Gullying on fine materials. Frost heave where poorly drained.	High
1b, b' Rubble to fines, undivided: weathered rock	Rubble to clayey silt; weathered rock over consolidated quartzitic sandstone or carbonates (see 1d, d') to weak fine grained rock (see 1a, a'). Unit 1b' is calcareous. Fill or rip rap from coarser deposits.	Mass movement widespread; especially solifluction lobes. Much snowbank seepage on irregular terrain.	Low to high
1c Sand: weathered rock	Lag clast veneer over sand or silty sand and clasts; weathered rock 1-3 m thick over resistant to weak quartzitic sandstone. Good fill, some rip rap.	Ice-filled (?) frost fissures widespread. Frost heave where drainage poor.	Low in uplands Moderate in lowlands
1d, d' Rubble: weathered rock	Rubbe, minor sand or fines, minor fissured outcrop; weathered rock 1-3 m thick over consolidated quartzitic sandstone. Unit 1d' is carbonate. Rip rap.	Unstable talus, rare ice cored (?) rock glacier. Frost heave where drainage poor and fines concentrated.	Low
2a Till - local	Poorly sorted silty sand diamicton, 1-10 m thick. Clasts chiefly granule to boulder size quartzitic sandstone.	Ice content possibly high, in frost fissure and other massive bodies. Skin flows common in unit 2a in eastern Blue Hills.	Moderate
2b Till - Laurentide	Poorly sorted calcareous silty diamicton, 1-10 m thick. Clasts of sandstone with some crystalline and carbonate lithologies.		
3a, b Glaciofluvial	Granule to boulder size, subround quartzitic sandstone clasts in silty sand matrix, 1-20 m thick. Locally silty sand.	Ice in frost fissures.	Low
4 Glaciolacustrine/ marine	Silt and fine sand, 1-20 m thick.	Gullying. Massive ice at least locally.	Moderate
5a Marine - neritic	Silt and fine sand, 1-10 m thick, local gravel veneer.	Gullying.	Moderate
5b Marine - beaches	Sand, silty gravel, 1-2 m thick.	Frost fissures.	Low
6a Fluvial - inactive	Gravelly sand or silt terraces, 1-10 m; mainly silty sand on Sproule Peninsula.	Frost fissures, possibly massive ice. Poorly drained ponds subject to thermal enlargement, especially on Sproule Peninsula.	Moderate
6b Fluvial - active	Boulder, gravel shifting channels in gravelly sand or silt floodplain, 1-3 m thick. Coarse stream bed, even within larger fine grained units.	Liable to inundation by spring freshest. Scouring below normal frost table in fluctuating channels.	Low
7 Colluvium	Silty clay to rubble diamicton.	Gullying, solifluction lobes, talus.	Moderate

FUTURE STUDIES

Western Melville Island is significant to Quaternary studies as one of the few known centres of local ice in the western Arctic Islands, and because it borders the northernmost margin of the Laurentide Ice Sheet. This considerable landmass lies in an area where the cause and pattern of recent crustal movements are poorly understood. Field work reported here permits little more than further definition of these problems; explanatory stratigraphy and datable deposits, which underlie field methods, are uncommon. Areas that may prove productive for future studies are:

-Bailey Point, where local till appears to be overlapped by Laurentide till, which was later transgressed by Late Pleistocene/early Holocene seas.

-northwest shore of Hecla and Griper Bay, where fluvial deposits draining the last local ice sheet may interfinger with (datable?) marine deposits.

Great hopes rest on any future inshore or offshore studies of bottom morphology and underlying sediments. These could reveal the age and extent of continental and local ice sheets and resolve the argument of tectonic versus erosional (glacial or subaerial) origin of the landscape.

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APPENDIX

Summary of rock-stratigraphic units and their weathering products in western Melville Island; bedrock after Harrison (in press).

Canrobert Formation (COc); unamed (OS): calcareous dolomite, deposited in carbonate banks; resistant, weathers to rubble.

Ibbett Bay Formation (OSDi): shale, siltstone, limestone dolomite, deposited in the outer margin of the basin; resistant to recessive, weathers to rubble to silt.

Blackley Formation (Dmb): shale, siltstone, sandstone, mainly quartz and illite, deposited in a submarine fan; recessive, weathers to silt, clayey silt and shale clasts.

Cape de Bray Formation (Dmc): silty and clayey shale, mainly quartz, kaolinite, illite, from a continental slope; recessive, weathers to silt, clayey silt.

Weatherall Formation (Dmw): sandstone, siltstone and shale, dominantly quartz, lesser kaolinite, minor illite, from a deltaic-marine environment; relatively recessive, weathers to sandy silt, shale clasts, rubble.

Hecla Bay Formation (Dmh): Quartz sandstone, minor siltstone and shale, mainly deposited by braided streams; much of the unit in western Melville Island weathers to resistant rubble and sand, but in the southeast, it breaks down directly to sand. Embry and Klovan (1976, p. 540) suggested that kaolinite content controls the degree of weathering — that 10% or more kaolinite is present in rubble, and less than 2% in the unconsolidated sand.

Beverly Inlet Formation (Dmgb): Sandstone, siltstone and shale, mainly quartz, with chert and kaolinite, deposited by meandering streams; resistant to recessive, weathers to sandy silt, rubble.

Canyon Fiord Formation (CPc): sandstone, conglomerate, siltstone, clayey shale, limestone; recessive, characteristically weathers to reddish sandy silt, silty sand, some gravel.

Assistance and Trold Fiord Formation (Pat): sandstone, in part calcareous, minor limestone, shale, mainly glauconitic quartz; recessive, weathers to silty sand, some fine gravel.

Bjorne Formation (Tb): sandstone, conglomerate; relatively resistant, weathers to fine gravel and sand.

Jameson Bay and Sandy Point formations (Jwjs): sandstone, siltstone, shale; recessive, weathers to sandy to clayey silt.

Hiccles Cove Formation (Jwh): quartz sandstone; relatively recessive, weathers to sand, silt.

Ringnes and Deer Bay formations (Jr, JKd): siltstone, shale, sandstone; recessive weathers to sand and clayey silt.