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CONTENTS

Figures

Tables

MARINE GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS IN WELLINGTON, BYAM MARTIN, AUSTIN, AND ADJACENT CHANNELS, CANADIAN ARCTIC ARCHIPELAGO

Abstract

Marine geological and geophysical investigations were carried out in Wellington Channel, Byam Martin and Austin channels, and in eastern Barrow Strait-western Lancaster Sound from CSS HUDSON in 1986. These investigations provided information on the distribution, thickness, composition, depositional environments, geotechnical properties, and regional geological setting of the surficial sediments, and on the structure of the near surface bedrock.

The data indicate the widespread occurrence of sediments of apparent glacial origin (glacial drift) which overlie variably dipping sedimentary bedrock, and which are in turn locally overlain by up to a few metres of acoustically stratified and acoustically transparent sediments, interpreted to represent glaciomarine and postglacial sediments respectively. The drift unit locally forms constructional features interpreted to be moraines, and in places contains multiple sequences. Surficial sediment thicknesses in Wellington Channel commonly are less than 10 m but locally reach 25 m, are somewhat greater in Byam Martin and Austin channels (up to 50 m), and are generally greater in eastern Barrow Strait, where they locally reach 100 m.

Geotechnical, foraminiferal, and textural data show consistent correlations with one another and with the acoustic stratigraphic units. The postglacial sediments have a high water content, low bulk density, and low shear strength; the converse applies to the glaciomarine and glacial drift sediments. Foraminifera are relatively diverse in the postglacial sediments, less diverse in the glaciomarine sediments, and are absent in the glacial drift.

Magnetic susceptibility data suggest that most of the sediments probably were derived from Paleozoic rocks of the Arctic Islands, but that glacial drift in northern Prince Regent Inlet and glaciomarine sediments in eastern Barrow Strait-western Lancaster Sound may have been derived partly from Precambrian rocks bordering part of the Gulf of Boothia, south of Prince Regent Inlet.

Some seafloor sediments, particularly the glacial drift, have been modified by ice scour.

Résumé

Des études géologiques et géophysiques marines ont été effectuées dans les chevaux de Wellington, de Byam Martin et d'Austin, ainsi que dans le détroit de Barrow — partie ouest du détroit de Lancaster à partir du CSS HUDSON en 1986. Elles ont permis d'obtenir des renseignements sur la distribution, l'épaisseur, la composition, les milieux des dépôts, les propriétés géotechniques et le cadre géologique des sédiments de surface, ainsi que sur la structure du socle situé près de la surface.

Les données indiquent la présence généralisée de sédiments d'origine glaciaire apparente (drift glaciaire), qui recouvrent un socle sédimentaire à pendange variable et qui sont recouverts à leur tour de sédiments stratifiés acoustiquement et de sédiments acoustiquement transparents, qui d'après les auteurs seraient respectivement des sédiments glaciomarins et des sédiments postglaciaires. L'unité de drift forme par endroits des constructions qui seraient des moraines; elle renferme par endroits plusieurs séquences. Les épaisseurs des sédiments de surface dans le chenal de Wellington sont généralement inférieures à 10 m, mais atteignent parfois 25 m; elles sont un peu plus grandes dans les chenaux de Byam Martin et d'Austin (jusqu'à 50 m) et sont habituellement supérieures dans la partie est du détroit de Barrow, où elles atteignent par endroits 100 m.

Des données géotechniques, des données texturales et des données sur les foraminifères montrent des corrélations constantes entre elles, ainsi qu'avec les unités stratigraphiques acoustiques. Les sédiments postglaciaires ont une teneur plus élevée en eau, une faible densité apparente et une faible résistance au cisaillement; l'inverse s'applique aux sédiments glaciomarins et au drift glaciaire. Les foraminifères sont assez variés dans les sédiments posglaciaires, moins variés dans les sédiments glaciomarins et absents dans le drift glaciaire.

Les données sur la susceptibilité magnétique laissent supposer que la pluspart des sédiments proviennent de roches paléozoïques des îles de l'Arctique, mais que les dépôts glaciaires du bras de mer du Prince-Régent, ainsi que les sédiments glaciomarins de la partie orientale du détroit de Barrow et ceux de la partie occidentale du détroit de Lancaster peuvent avoir comme origine, en partie, des roches précambriennens bordant une partie du golfe de Boothia, au sud du bras de mer du Prince-Régent.

Certains sédiments du fond marin, particulièrement les dépôts glaciaires, ont été affouillés par les glaces.

SUMMARY

Wellington, Byam Martin, Austin, and adjacent channels were investigated in 1986 from CSS HUDSON using marine geological and geophysical methods. These methods provided information on the distribution, composition, thickness, geotechnical properties, magnetic susceptibility, paleo-oceanography, and depositional environments of the unconsolidated seabed sediments, and on the near surface structure of the underlying bedrock. This work was conducted as part of the Northern Oil and Gas Action Program.

Three main unconsolidated sediment units are recognized throughout the region. These are interpreted to represent glacial drift, glaciomarine sediments, and postglacial sediments. The glacial drift is the most widespread and thickest of the surficial sediments, whereas the glaciomarine and postglacial sediments are much more localized in their occurrence.

Glacial drift, the lowermost unit, is an unstratified unsorted diamict, variable in thickness and relief, which locally forms positive constructional features as well as infilling bedrock depressions.

Glaciomarine sediments are stratified acoustically and are composed of laminated mud and sandy mud with granules and pebbles.

Postglacial sediments are acoustically transparent nonlaminated muds which locally display some mottling. Drop stones are absent throughout most of this unit and where present locally, as in Wellington and Byam Martin channels, usually are confined to the upper 30-40 cm of sediment. A date of 7970 ± 70 BP (TO-752) was obtained from contained pelecypod valves at a subbottom depth of approximately 4 m in eastern Barrow Strait.

A very thin veneer, up to a few centimetres thick, of soupy, silty, clayey, sandy, gravelly sediment overlies the main sediment units at the immediate seabed in many areas.

SOMMAIRE

En 1986, on a exploré les détroits de Wellington, de Byam Martin, d'Austin et les chenaux adjacents, à partir du navire océanographique CSS HUDSON, à l'aide de méthodes géologiques et géophysiques applicables en milieu marin. On a ainsi obtenu de l'information sur la répartition, la composition, l'épaisseur, les propriétés géotechniques, la susceptibilité magnétique, la paléo-océanographie et les milieux de formation des sédiments non consolidés du fond marin, et sur la structure de subsurface de la roche en place sous-jacente. On a realisé ces travaux dans la cadre du Programme d'initiatives pétrolières et gazières dans le Nord.

Les travaux ont établi que la région se divise en trois grandes unités sédimentaires non consolidées. On les a interprétées comme étant des matériaux de transport glaciaire et des sédiments glaciomarins et post-glaciaires. Les matériaux de transport glaciaire constituent les sédiments superficiels les plus étendus et les plus épais, tandis que les sédiments glaciomarins et post-glaciaires ont une répartition beaucoup plus localisée.

Les matériaux de transport glaciaire, qui constituent l'unité basale, forment un diamicton non stratifié et non trié, d'épaisseur et de relief variables, qui crée par endroits des formes de relief positives ou comble des dépressions du soubassement.

Les méthodes acoustiques de levés révèlent que les sédiments glaciomarins sont stratifiés et composés de boues laminées et de boues sableuses contenant des granules et galets.

Ces mêmes levés révèlent que les sédiments post-glaciaires sont acoustiquement transparents et se composent de boues non laminées qui présentent par endroits des marbrures. On n'y rencontre pas de « drop stones » (pierres libérées sur le fond par des icebergs); on les a toutefois rencontrées à certains endroits, par exemple dans les détroits de Wellington et de Byam Martin, où elles sont habituellement confinées aux 30 à 40 cm supérieurs de l'unité sédimentaire. On a calculé une data de 7970 ± 70 BP (TO-752) sur des valves de pélécypodes contenues dans les sédiments, à une profondeur d'environ quatre mètres à partir de la surface du fond marin, dans l'est du détroit de Barrow.

Un très mince placage de quelques centimètres d'épaisseur, composé de sédiments vaseux, limoneux, argileux, sableux et graveleux, recouvre les principales unités sédimentaires de la surface du fond marin dans de nombreux secteurs.

In Wellington Channel, the glacial drift commonly is in the order of 2-5 m thick, locally reaches 10 m, and attains 25 m in two accumulations that are interpreted to be moraines, midway along the southern part of the channel, and near its southern end adjacent to Barrow Strait. Postglacial sediments, and to a lesser extent glaciomarine sediments, occur in the northern and western parts of Wellington Channel where water depths exceed 200 m.

Surficial sediments in Byam Martin and Austin channels in general are thicker than in Wellington Channel. Glacial drift deposits commonly range from 5 to 30 m, but locally reach 50 m. The latter accumulations frequently form positive features that may represent moraines. Such deposits often contain multiple drift sequences. Acoustically stratified sediments interpreted to be glaciomarine deposits are thin, 1-3 m, and discontinuous though more widespread than in Wellington Channel. Deposits of acoustically transparent postglacial sediments occur as small isolated patches, commonly 1-2 m and locally reaching 4 m in thickness.

Unconsolidated sediments in eastern Barrow Strait-western Lancaster Sound are the thickest of those in the interisland channels of the study area. Glacial drift again is the most widely distributed and thickest unit, locally reaching 100 m. Multiple drift sequences are present locally. The drift is overlain in basinal areas by glaciomarine and postglacial sediments which attain thicknesses of up to 4 m and 7 m, respectively.

Analyses of core samples indicate good correlation of geotechnical properties, foraminiferal assemblages, and acoustic character of the three main surficial sediment units. The postglacial sediments are characterized by high water content, low bulk density, low shear strength, and a relatively diverse foraminiferal population. Glaciomarine sediments and glacial drift have significantly lower water content, and higher bulk density and shear strength. Foraminiferal populations are less diverse in the glaciomarine than in the postglacial sediments and the drift is barren.

The unstructured, faunally barren, and ice-loaded glacial drift with its wide range of unsorted textural sizes, high shear strength and bulk density, and low water content was deposited in a faunally inhospitable environment beneath a grounded ice sheet.

The laminated sandy and pebbly muds of the acoustically stratified unit with restricted faunal assemblages, moderate shear strength and bulk density, and low water content are consistent with deposition in glaciomarine environments, proximal or distal to a glacial ice front, or beneath an ice shelf.

Dans le détroit de Wellington, les matériaux de transport glaciaire ont généralement de 2 à 5 m d'épaisseur, parfois jusqu'à 10 m, et attaignent 25 m d'épaisseur à l'emplacement de deux monticules que l'on considère comme des moraines, à mi-chemin le long de la partie sud du détroit, et non loin de son extrémité sud à proximité du détroit de Barrow. On rencontre des sédiments postglaciaires et dans une mesure moindre des sédiments glaciomarins, dans les parties nord et ouest du détroit de Wellington où la profondeur d'eau dépasse 200 m.

En général, les sédiments superficiels sont plus épais dans les détroits de Byam Martin et d'Austin que dans le détroit de Wellington. Les matériaux de transport glaciaire ont souvent de 5 à 30 m d'épaisseur, mais atteignent par endroits 50 m. Leur accumulation forme souvent des reliefs positifs qui correspondent peut-être à des moraines. Ces dépôts contiennent souvent de multiples séquences de matériaux de transport glaciaire. On a interprété les sédiments qui salon les levés acoustiques sont stratifiés, comme de minces dépôts glaciomarins de 1 à 3 m d'épaisseur; ils sont discontinus, mais sont répandus sur une plus grande étendue que dans le détroit de Wellington. Les dépôts de sédiments post-glaciaires acoustiquement transparents se présentent sous forme de petites étendues sporadiques, qui généralement atteignent 1 à 2 m et jusqu'à 4 m d'épaisseur par endroits.

L'est du détroit de Barrow et l'ouest du détroit de Lancaster contiennent la plus épaisse accumulation de sédiments non consolidés parmi celles que l'on rencontre dans les chenaux qui séparent les îles dans la région à l'étude. À nouveau, les matériaux de transport glaciaire constituent l'unité la plus étendue et la plus épaisse, et atteignent par endroits 100 m d'épaisseur. Il existe à certains endroits des séquences multiples de tels matériaux. Dans les régions de bassins, ceux-ci sont recouverts par des sédiments glaciomarins et post-glaciaires qui peuvent atteindre respectivement 4 m et 7 m.

Les analyses des carottes d'échantillonnage indiquent un bon degré de corrélation entre les propriétés géotechniques, les types d'associations de foraminifères, et le caractère acoustique des trois principales unités sédimentaires de surface. Les sédiments post-glaciaires sont caractérisés par une teneur élevée en eau, une faible densité apparente, une faible résistance au cisaillement et une population relativement diversifiée de foraminifères. Les sédiments glaciomarins et les matériaux de transport glaciaire ont une teneur en eau nettement plus basse, mais une densité apparente et une résistance au cisaillement plus élevées. Les populations de foraminifères sont moins variées dans les sédiments glaciomarins que dans les sédiments post-glaciaires, et sont absentes des de matériaux de transport glaciaire.

Ces derniers, soit les matériaux de transport glaciaire non structurés, dépourvus d'éléments fauniques, caractérisés par des structures de surcharge imposée par la glace et une vaste gamme granulométrique d'éléments non triés, une résistance au cisaillement et une densité apparente élevées et une basse teneur en eau, ont été mis en place dans un milieu défavorable à l'établissement d'une fauna quelconque, au-dessous d'une nappe de glace ancrée au sol.

The faunally more diverse muds of the acoustically transparent postglacial sediments with their low shear strength and bulk density and high water content are consistent with deposition in a relatively quiescent Arctic marine environment. However, reduction in faunal populations in the upper part of this sequence suggests a change to more unfavourable ice and/or oceanographic conditions. A later change in conditions indicated by the wide range of textural sizes in the thin soupy sediment veneer encountered at the immediate seafloor in many areas appears to reflect the seasonally mobile ice pack/limited open water conditions that characterize the surveyed areas in the present day.

Magnetic susceptibility (MS) data suggest that most of the sediments were derived from rocks with low MS, such as the Paleozoic rocks that are widespread throughout the region. However, a higher MS signature of the glacial drift in northern Prince Regent Inlet and of glaciomarine sediments in eastern Barrow Strait-western Lancaster Sound indicate that at least some of these sediments were derived from areas with higher MS such as Archean rocks bordering the Gulf of Boothia.

All of the western and central islands of the Canadian Arctic Archipelago have been overridden by glacial ice, but when this occurred has not been established. Late Wisconsinan glacial ice is known to have been present on the islands south of Parry Channel and as local ice caps on Devon, Cornwallis, and Bathurst islands, and to have deposited tills on southern Melville and Byam Martin islands. The drift deposits in the interisland channels may represent deposition by regionally extensive ice sheets as well as by local ice caps. The ages of these deposits have not been determined, but the possibility that some of these are of Late Wisconsinan age is suggested by the proximity of some of the offshore/onshore deposits, e.g. moraine-like features in western Wellington Channel and Late Wisconsinan moraines nearby on eastern Cornwallis Island.

The mode of origin and evolution of the channels, like the chronology of the surficial sediments, requires further investigation. Preliminary data suggest a greater structural influence on the seabed morphology in the eastern part of the Arctic Islands region than farther west. However, differential erosion of the underlying bedrock appears to have exerted a large influence on the present day seabed morphology in most areas.

La formation des boues laminées, sableuses et caillouteuses qui constituent l'unité stratifiée selon les levés acoustiques et caractérisée par des associations fauniques appauvries, par une résistance au cisaillement et une densité apparente moyennes et par une basse teneur en eau, est conforme à une sédimentation en milieux glaciomarins, en position proximale ou distale par rapport au front glaciaire, ou au-dessous d'une plate-forme de glace.

La mise en place des boues des sédiments post-glaciaires, transparents aux signaux acoustiques, caractérisées par leur contenu faunique plus diversifié et leur résistance mécanique et densité apparente faibles et leur teneur en eau élevée, a dû se produire dans un milieu marin arctique relativement tranquille. Cependant, dans la partie supérieure de cette séquence, l'appauvrissement des populations fauniques semble indiquer un passage de l'état du milieu en question à des conditions glaciologiques ou océanographiques, ou les deux, défavorables. Une variation ultérieure des conditions du milieu, indiquée par la vaste gamme granulométrique caractérisant le mince sédiment vaseux que l'on rencontre sur le fond marin lui-même dans de nombreux secteurs, correspond sans doute à la présence d'une banquise mobile selon les saisons et de polynies, situation qui règne encore dans les régions faisant l'objet des levés.

Les données de susceptibilité magnétique (SM) semblent indiquer que la plupart des sédiments provenaient de roches de faible SM, comme les roches paléozoïques que l'on retrouve dans toute la région. Cependant, une signature SM plus prononcée, caractérisant les matériaux de transport glaciaire du nord de l'inlet de Prince-Regent et les sédiments glaciomarins de l'est du détroit de Barrow et de l'ouest du détroit de Lancaster, indique qu'au moins une partie de ces sédiments provenaient de régions de SM élevée comme les roches archéennes bordant le golfe de Boothia.

Toutes les îles occidentales et centrales de l'archipel Arctique canadien ont été recouvertes par des glaciers, mais on ne peut préciser à quelle époque. On sait que, durant le Wisconsinien supérieur, des glaciers ont existé dans les îles au sud du détroit de Parry et ont constitué des calottes glaciaires localisées dans les îles Devon, Cornwallis et Bathurst, et one déposé des tills dans le sud des îles Melville et Byam Martin. Il est possible que dans les chenaux séparant les îles, les matériaux de transport glaciaire aient été mis en place par des inlandsis de grande étendue régionale, ainsi que par des calottes glaciaires localisées. On ne connaît pas l'âge de ces dépôts, mais la proximité de certains des dépôt côtiers et extracôtiers, par exemple des structures de type morainique présentes dans l'ouest du détroit de Wellington et des moraines datant du Wisconsinien supérieur présentes mon loin dans l'est de l'île Cornwallis, semble indiquer qui il soit possible que certains de ces matériaux de transport glaciaire datent du Wisconsinien supérieur.

Pour connaître l'origine et l'évolution des détroits, par exemple la chronologie des sédiments superficiels, il est nécessaire de poursuivre ca type d'études. Les données préliminaires semblent indiquer que les éléments structuraux ont joué une plus grande influence sur la morphologie du fond marin dans la partie est de l'archipel Arctique que plus à l'ouest. Toutefois, il apparaît que l'érosion différentielle de la roche de fond sous-jacente a au une grande influence sur la morphologie actuelle du fond marin dans la plupart des régions.

INTRODUCTION

This report outlines results of shipborne geological, geophysical, and geotechnical investigations in the central part of the Canadian Arctic Archipelago carried out from CSS HUDSON in 1986 (Cruise 86-027). The work included extensive surveys in Wellington, Byam Martin, and Austin channels and part of eastern Barrow Strait-western Lancaster Sound (Fig. 1). In addition, reconnaissance surveys were carried out in parts of Queens Channel, northern Viscount Melville Sound, and western Barrow Strait.

Program objectives were: 1) to delineate and map the surficial seabed sediments including their areal distribution, composition, thickness, stratigraphic relationships, geotechnical properties, and postdepositional modification; and 2) to obtain reconnaissance information on the near surface bedrock.

Studies of the surficial sediments in the interisland channels also: a) contribute to a better understanding of the regional Quaternary history as they contain a more continuous record of glacial and postglacial events than the presently known onshore deposits; b) provide geological and geotechnical information necessary for informed planning and decision making by government and industry relating to the development and transportation of subsea resources in a prudent and environmentally safe manner; and c) provide information on paleoclimatic and oceanographic conditions, important not only in helping to understand the regional Quaternary history, but also to the broader understanding of global change.

Previous work

Recorded exploration of the central Arctic Islands region dates back to the search for a Northwest Passage in the early 1800s. The early geological work generally comprised studies of samples and information collected during those voyages. The advent of access by aircraft beginning in the late 1940s and early 1950s led to the extensive geological mapping of the Arctic Islands that subsequently has taken place. To date, however, the chronology of Quaternary events in many parts of the Arctic Archipelago is poorly known. This is mainly due to the ill-defined nature and scattered occurrence of Pleistocene sediments on the islands, and inaccessibility of many of the marine areas.

Little or no geological data previously existed for most of the offshore area included in this report, except for sediment sampling and seismic profiling in more accessible areas of Barrow Strait and Lancaster Sound. The scarcity of offshore data in this region is the result of its remoteness,

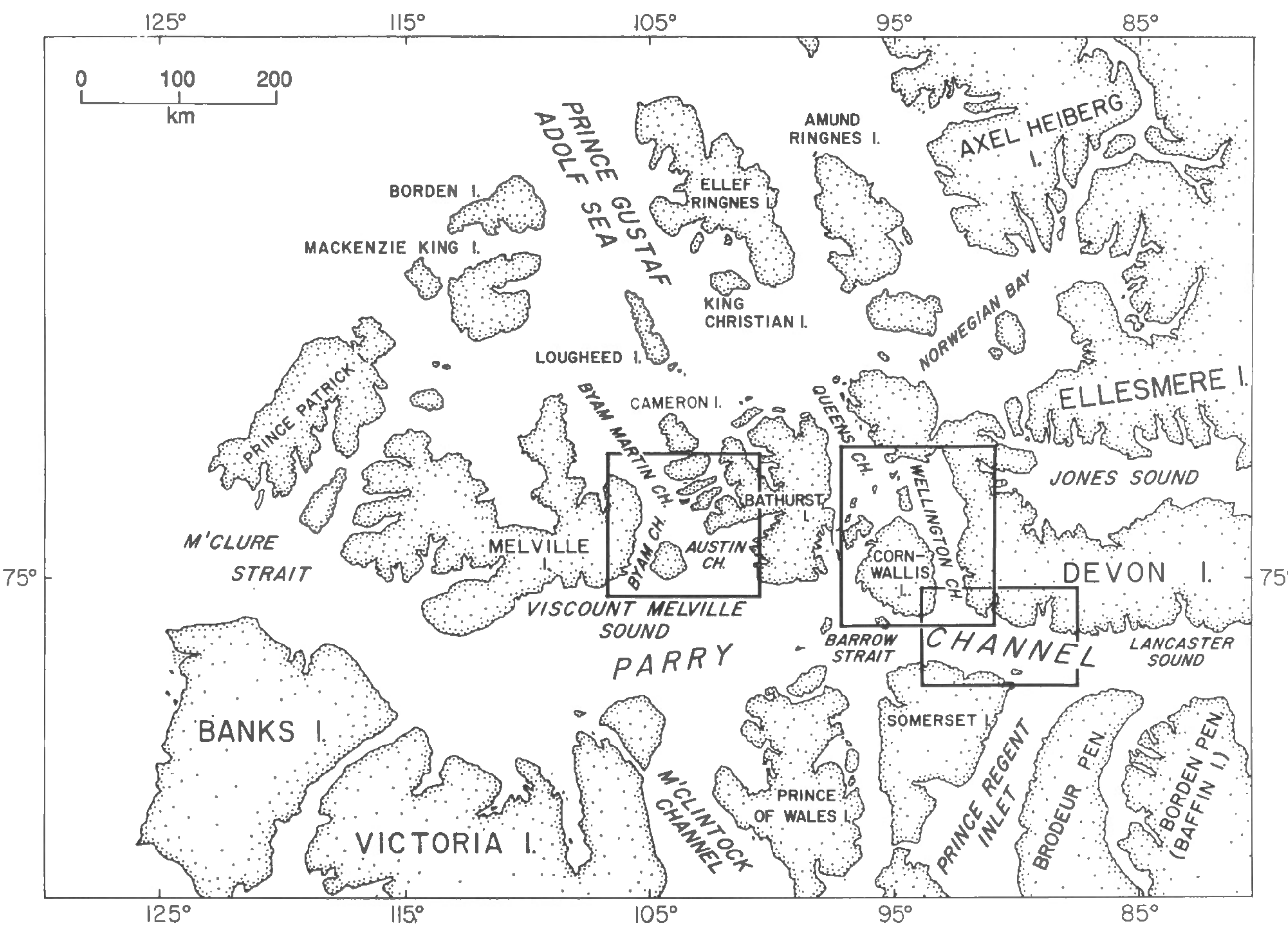

Figure 1. Index map of the study areas. The blocks outline the three main areas discussed in this report.

and more importantly, the presence of sea ice which renders marine areas of the archipelago inaccessible to conventional shipborne geological and geophysical surveys for most of the year.

Previous marine geological or geophysical investigations in the Wellington-Queens channel region were limited to a few samples and magnetometer profiles from the southern part of Wellington Channel obtained by J.R. Lazier and D.L. Barrett (Bedford Institute of Oceanography, Internal Report on Cruise 22-65, CCGS Labrador, 1965). Extensive sampling of sediments in Lancaster Sound and eastern Barrow Strait was carried out by Buckley (1971) and in western Barrow Strait by Henderson (1971) and Blake and Lewis (1975). Sediments were sampled by industry (Polar Gas Project) along a proposed pipeline route from Bathurst Island to Prince of Wales Island and across Peel Sound. Shallow seismic profile data also were collected in this region by Bornhold et al. (1976) and Lewis et al. (1977).

Previous offshore surficial geological investigations in the general region of Byam Martin Channel included petroleum industry surveys (Polar Gas Project) consisting principally of sediment sampling along proposed pipeline routes across Byam and Austin channels and Byam Martin Channel, and experimental surveys with acoustic profiling equipment across Austin Channel (M.J. O'Connor and Associates, unpublished report prepared for the Geological Survey of Canada,1984). Sediment samples were collected through the ice by Marlowe and Vilks (1963), Marlowe (1968), and MacLean and Vilks (1986) to provide regional information on the surficial geology and seabed conditions from Byam Martin Island northward to the MacKenzie King-Lougheed Island region. The geochemistry and mineralogy of the sediments were investigated by Macko et al. (1986). Acoustic profiles were obtained by G.V. Sonnichsen (Bedford Institute of Oceanography, Internal Report on Cruise 85-071, CCGS Des Groseilliers, 1985) south of Bathurst Island, east of Austin Channel, as well as some sediment samples in Byam Martin Channel. Shallow seismic reflection and 12 kHz acoustic profiles were obtained through leads in the sea ice in the Cameron-Lougheed-eastern Melville-King Christian islands region by Sonnichsen and Vilks (1987) and Sonnichsen and MacLean (1988). Studies of subseafloor thermal conditions were carried out in various areas by Judge and Taylor (1984) and A. Taylor (1987). Investigations of coastal and nearshore geology of eastern Melville and western Byam Martin islands were made by McLaren (1975, 1982) and McLaren and Barnett (1978), and in various other parts of the region by Forbes et al. (1986) and R.B. Taylor (1987). Extensive petroleum exploration carried out in the Arctic Islands by Panarctic Oils Ltd. has resulted in several onshore and offshore discovery wells. Tanker shipments of crude oil from the southernmost of these, the Bent Horn Field on Cameron Island, which began in 1985 via Byam Martin and Austin channels and eastward through the Northwest Passage, have led to increased bathymetric charting of the region by the Canadian Hydrographic Service using through ice techniques and shipborne surveys.

Onshore, a much larger body of information exists on the geology of the Arctic Islands region. Sedimentary rocks of Ordovician to Devonian age on eastern Cornwallis, western Devon, and northern Somerset islands, which border Wellington Channel and Barrow Strait, have been extensively studied by Thorsteinsson (1958, 1986), Blackadar and Christie (1963), Thorsteinsson and Uyeno (1981), Stewart (1987), and Thorsteinsson and Mayr (1987). Following earlier investigations of parts of the region during Operation Franklin (Fortier et al., 1963), the stratigraphy and structure of the predominantly Middle to Upper Devonian sedimentary rocks of western Bathurst and eastern Melville islands, which border Byam, Byam Martin, and Austin channels, have been extensively studied by Tozer and Thorsteinsson (1964) and Kerr (1974).

The Quaternary geology of the Arctic Islands has also been investigated by many workers. The history of this region from Sangamonian to Holocene has been reviewed and discussed recently by Dredge and Thorleifson (1987), Dyke and Prest (1987a,b,c), Hodgson (in press), St-Onge (1987), and Vincent and Prest (1987). Studies in the proximity of the present study area and therefore of particular relevence include the work of Fyles (1967), Dyke (1983, 1987), Hodgson and Vincent (1984), and Hodgson et al. (1984).

The following section outlines the regional geological setting as developed by the various studies.

Regional setting

The bedrock of the islands bordering the study area consists predominantly of carbonate and clastic sedimentary rocks ranging in age from Ordovician to Late Devonian, with outliers of Early Cretaceous strata present locally on eastern Melville Island , and Cretaceous and/or Tertiary strata on Cornwallis, Griffith, and Somerset islands (Thorsteinsson, 1958, 1986; Blackadar and Christie, 1963; Tozer and Thorsteinsson, 1964; Kerr, 1974; Thorsteinsson and Uyeno, 1981; Stewart, 1987; Thorsteinsson and Mayr, 1987). Strata in the eastern part of the study area lie partly within the north-trending Cornwallis Fold Belt (Early to Late Devonian) whereas those in the west are in the east-trending Parry Islands Fold Belt (Late Devonian to Early Permian). The region was also affected by a third later orogeny of Cretaceous and probable Tertiary ages (Kerr, 1974). Northward beyond the study area, the Paleozoic rocks are overlain by Mesozoic and Cenozoic strata of the Sverdrup Basin.

Various origins have been postulated for the interisland channels. They were interpreted by Fortier and Morley (1956) to represent a drowned Tertiary fluvial system which Pelletier (1966) suggested was subsequently modified by glacial erosion. A submerged drainage pattern in Barrow Strait was reported by Bornhold et al. (1976) from bathymetry and seismic data. England (1987) proposed that the Arctic Islands represent a Tertiary fluvial landscape that was developed on a contiguous landmass and that the channels subsequently formed as a result of block faulting. The major channels of Lancaster Sound and Prince Regent Inlet east of the Barrow Strait study area have been postulated to be a failed triple junction (Lancaster Aulacogen) formed during Late Cretaceous to early Tertiary time (Kerr, 1980). Sobczak (1982) postulated a fragmentation of the Canadian Arctic Archipelago which embodied northeast-trending fractures and northwest-trending arches and rifts during and after the mid-Tertiary Eurekan Orogeny.

The onshore Quaternary sediments include Late Wisconsinan tills and earlier tills of undetermined ages, as well as evidence of marine transgressions, and emergence of the islands. Laurentide ice is thought to have advanced in the western part of the Arctic Archipelago in the Early Wisconsinan (Vincent, 1984). Existence of high relative sealevels in Middle Wisconsinan time indicates isostatic depression of the coast due to a nearby ice mass or residual effect of ice loading during the Early Wisconsinan (Dredge and Thorleifson, 1987). Blake (1970) postulated that a major ice sheet, the Innuitian Ice Sheet, covered a considerable part of the islands and interisland channels in the eastern and central part of the Arctic Archipelago and connected with Laurentide and Greenland ice during the last glaciation. However, Vincent (1984) found no direct evidence for such a Late Wisconsinan ice cover in the western part of the Queen Elizabeth Islands. He concluded that if these islands were covered by continental ice it would have been prior to theWisconsinan. Further studies suggested that ice cover also was more limited in the eastern Arctic Islands during the Late Wisconsinan (Prest, 1984). Hodgson et al. (1984) indicated that Late Wisconsinan continental ice did not extend onshore farther north than southern Melville Island, but local ice caps existed on some of the islands, e.g. Bathurst and Cornwallis (Dyke and Prest, 1987a).

The following outlines the terrestrial Quaternary record in more detail as it relates to the study area. In the late Quaternary, Parry Channel and the southern shores of the Queen Elizabeth Islands appear to have been a major impediment to northward flowing continental ice (Fig. 2). However, much earlier in the Quaternary, all of the western and central islands were overrun by ice, though only scattered erratics derived from the Canadian Shield remain as evidence, at elevations in places far above any known limit of marine emergence (Fyles, 1965; Hodgson, in press). Vincent (1984) suggested that the only continental ice sheet thick enough to have covered much of this region would have been pre-Wisconsinan and that the ice flow probably was controlled by the interisland channels. England (1987), on the other hand, postulated that if the Arctic Islands were ever covered by a regional ice sheet it possibly was during the late Tertiary before formation of the interisland channels, which he argued were formed subsequently by block faulting.

In the western part of the survey region, limits of three continental glacier advances from the south and their associated tills are found on southern Melville Island. Of these, the Dundas Till, which is the most extensive, has been correlated by Vincent (1984) with an early Quaternary glaciation of Banks Island. The other two tills barely overlap the south coast, and both are likely of Late Wisconsinan age, though only the uppermost deposit, the Winter Harbour Till, has bracketing age determinations (10 340 ± 150 and 9670 ± 150 BP, Hodgson et al., 1984). The Winter Harbour Till was deposited on southern Melville and Byam Martin islands by a surge of glacial ice from the south that formed a floating ice shelf across Viscount Melville Sound (Hodgson and Vincent, 1984; Hodgson et al., 1984). On the basis of dates from northern Prince of Wales Island, Dyke (1987) subsequently suggested that this advance occurred between 11 300 and 11 000 BP. The slightly (?) older Bolduc Till (11-12 ka?) was of similar origin, but the ice shelf extended farther west, into M'Clure Strait. The grounding line moved southward between the two surges, permitting substantial isostatic rebound to occur and resultant shoreline regression to be recorded on southern Melville Island. The Winter Harbour Till and the Bolduc Till likely are correlative with thick stony streamlined till moulded by advances and readvances of ice flowing over northeast Victoria Island and in M'Clintock Channel as late as 9 ka (Hodgson, 1987).

Farther north in the western part of the region, fossiliferous glaciomarine sediments overlying tills have been reported from Lougheed Island which lies to the north of Byam Martin Channel (Hodgson, 1981). The minimum age of the glaciomarine deposits there is 10 500 ± 130 BP. The source and age of the underlying glacial drift have not been established. No evidence for the occurrence of the Winter Harbour Till on the north side of Parry Channel east of Byam Martin Island has been reported, though northward-trending striations occur on Lowther Island (Barnett et al., 1976). On the south shore of Parry Channel, Prince of Wales Island was inundated by Late Wisconsinan Laurentide Ice, which retreated from an unknown limit southward and eastward across the length of the island between 11 ka and 9 ka (Dyke and Prest, 1987b). On northern Prince of Wales Island, and on islands to the east and west, glaciomarine deposits are generally restricted to a narrow strip of emerged shore, and are especially concentrated on the distal side of ice contact deltas. But on most of Prince of Wales Island, which lay below sealevel during the Late Pleistocene to Early Holocene, numerous pockets of glaciomarine stony silt or clay fill or thinly mantle depressions in till, analagous to the offshore record (A. Dyke, pers. comm., 1987).

Late Wisconsinan Laurentide Ice flowed east from Prince of Wales Island onto southern and western Somerset Island. A contemporaneous independent ice cap occupying northern Somerset Island was frozen to its base and thus was nonerosive at its centre, but warmed to a radial pattern of temperate ice at the margin (Dyke, 1983). Dyke and Prest (1987b) speculated that at the same time an ice shelf originating to the south filled central and eastern Parry Channel, as well as the re-entrant down Prince Regent Inlet and the Gulf of Boothia between Keewatin and Foxe sectors of the Laurentide Ice Sheet. Ice retreated from these waterways between 10 ka and 9.5 ka. Scattered erratics of Canadian Shield origin indicate continental ice once overrode all of Somerset Island, as well as islands farther north. Otherwise, the only record of older till anywhere in the central Arctic is on Boothia Peninsula, south of Somerset Island, where exposures of likely Illinoian age till are covered by Sangamonian deposits and Wisconsinan marine and glacigenic assemblages (Dyke and Matthews, 1987).

In the Queen Elizabeth Islands north of Parry Channel, adjacent to channels under study, late Quaternary glacial events are poorly defined except where Laurentide Ice impinged on southern Melville Island. Local ice caps existed on Devon, Cornwallis, and Bathurst islands (Fig. 1 and 2), which border the study area, during at least part of the Late Wisconsinan (Dyke and Prest, 1987a,b). As on Somerset Island, it is likely that where ice caps existed they were cold based and relatively unerosive. Datable land forms are rare. On Bathurst Island, for example, information about the end of the Pleistocene is limited to the knowledge that the highest marine sediments were deposited at or shortly after 10 ka, possibly concurrently with deglaciation. Some till exists on the perimeter of the island, but extensive

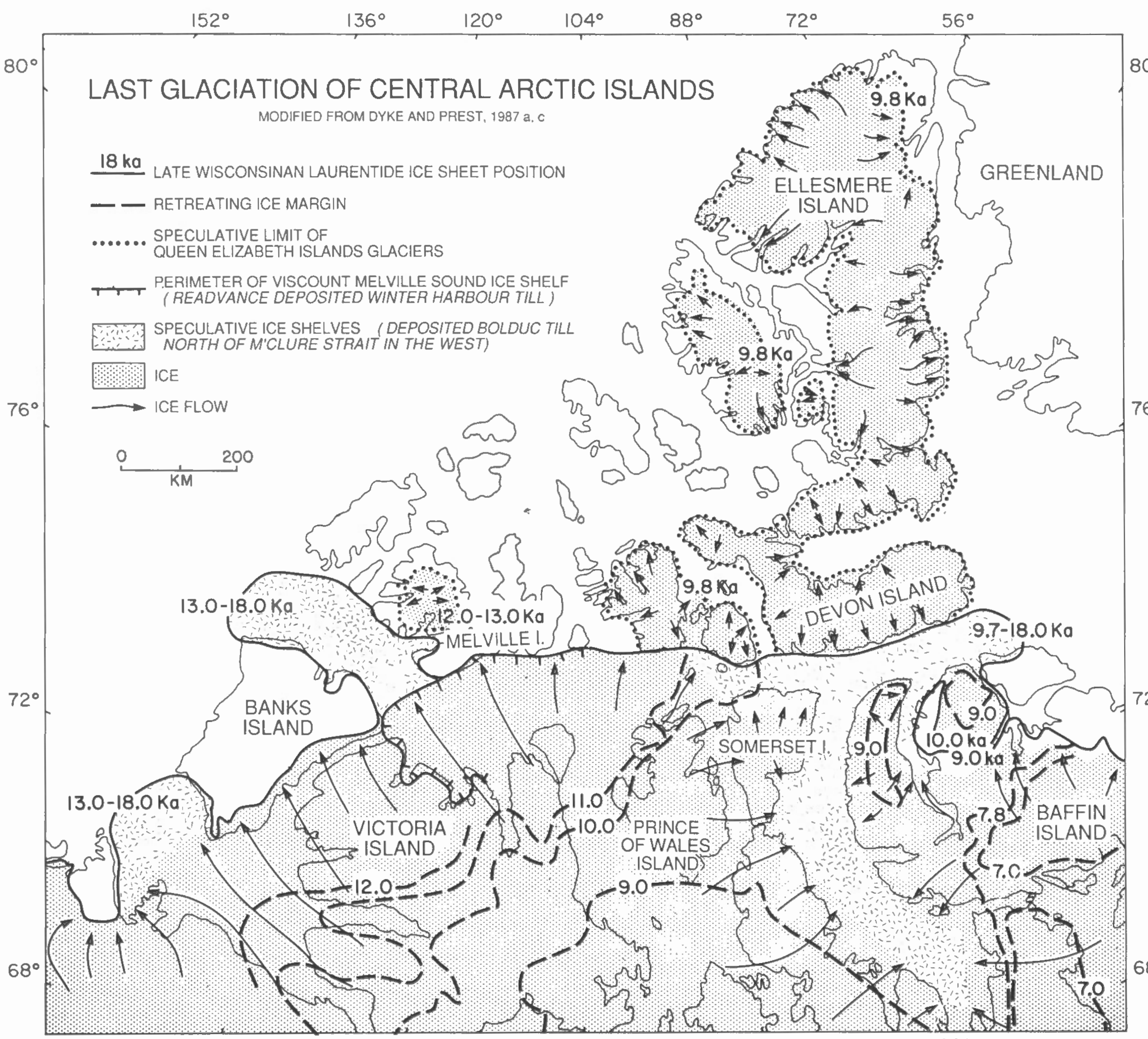

Figure 2. The last glaciation of the central Arctic Islands, showing postulated 18 ka and later ice margin positions (modified from Dyke and Prest, 1987a,c).

deposits like those in the channels are not present onshore. However, on Cornwallis Island, radial flow of ice is suggested by scattered overdeepened U-shaped valleys and cirques (especially on the east coast of Cornwallis Island) and by patches of locally derived till (Thorsteinsson, 1958; Barnett et al., 1976). Thorsteinsson (1958) also found evidence on eastern Cornwallis Island of locally thick till including moraines up to 75 m high near Read Bay and terminal moraines near Snowblind Bay.

The Arctic Islands have also been affected by substantial changes in relative sealevel. This apparently resulted from glacial isostatic depression, which exceeded any eustatic factor, and subsequent rebound. Coastal areas of Viscount Melville Sound were submerged due to ice loads to the south and southeast and in the Queen Elizabeth Islands to the northeast (Hodgson and Vincent, 1984). Submergence reached at least 90 m on southern Melville Island (Hodgson et al., 1984). Emergence of the south coast of Melville Island appears essentially complete while rebound of the northeast coast is continuing at a rate of approximately 0.35 m/century (McLaren and Barnett, 1978). The postglacial regressive shoreline deposits are commonly silt to boulder size and thus quite unlike postglacial sediments in deeper offshore areas.

In the eastern part of the survey area, Somerset Island experienced a high sealevel stand (76-160 m) at deglaciation (Dyke, 1983). Retreat of ice of the last advance from the northern part of the island which began about 9100-9200 BP was followed by rapid emergence, at a rate of 8-11 m/century. Rates at present and during the last 5000-6000 years are in the order of 0.46 m/century in the west and 0.28 m/century in the east (Dyke, 1983).

Acknowledgments

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Methods

Geophysical and other acoustical data were collected with a single-channel seismic-reflection system using a Bolt Associates 655 cm^3 compressed air energy source and a Nova Scotia Research Foundation hydrophone, a Huntec high resolution deep towed seismic system fitted with a towed streamer and 50 kHz sidescan sonar, Kelvin Hughes 26B echosounder, and Bedford Institute of Oceanography 75 kHz sidescan-sonar system. Samples of the unconsolidated seabed sediments were obtained mainly with piston and box corers and grab samplers. Photographs of the seabed were obtained at selected stations with UMEL underwater cameras.

Acoustic profiles, particularly high resolution seismic reflection profiles, supported by sample information, have been widely used as a marine mapping technique to distinguish and delineate sediment units and their regional distribution, thickness, and stratigraphic relations (e.g. King and Fader, 1986; Praeg et al., 1986; King et al., 1987). These techniques permit selective sampling of geological units and the regional correlation and extrapolation of the sample data along continuous profile sections. Where samples are not available, the profile data permit some inferences to be drawn based on knowledge of the acoustic character of sediment units in other areas for which an extensive data bank now exists.

The survey region is covered by sea ice throughout most of the year. This severely constrains conventional shipborne geological and geophysical surveys. The distribution of the ice during the operational season is unpredictable, and seldom is any one area completely ice free. The orientation and extent of survey tracks therefore, is frequently governed by ice conditions. Regional ice information was provided by a weather satellite imaging system loaned for use aboard CSS HUDSON by Polar Continental Shelf Project. A 206B helicopter was used for local, more detailed ice reconnaissance and for coastal and onshore geological investigations.

Navigational positioning was by BIONAV interfaced to Global Positioning System (GPS), Transit Satellite Navigation, log and gyro, and by radar range and bearing. The Navstar satellite availability permitted GPS positioning to 25 m accuracy for 12 hours per day. Positioning accuracy of the other systems used when GPS was unavailable was substantially less, commonly in the order of several hundred metres.

REGIONAL MARINE GEOLOGY

The following sections outline the results of the geological, geophysical, and geotechnical investigations in the main survey areas.

Wellington Channel

Wellington Channel is a 160 km long seaway between Cornwallis and Devon islands. It ranges in width from 27 to 35 km in the south and opens to 50 to 60 km in the north (Fig. 3). Water depths in the southern part of the channel are greatest along the western side, where they range between 200 and 250 m, and are 100 to 200 m elsewhere.

Depths in the northern wider part of Wellington Channel increase progressively from < 50 m in the east to nearly 400 m in the west. Depths in the eastern Queens Channel survey area ranged from < 50 m to nearly 300 m.

Tracks where acoustic profiles were obtained, and locations of sediment samples collected in Wellington Channel from CSS HUDSON in 1986 are indicated in Figure 4.

Surficial geology

Three main seabed surficial sediment units have been identified in Wellington Channel (Fig. 5). These main units are mantled by a fourth unit, too thin to be resolved acoustically, but recognized in samples as a thin veneer of sediment a few centimetres thick at the seabed. Total Quaternary sediment thickness is generally less than 5 m, but locally reaches 25 m (Fig. 6).

The lowermost surficial unit is a widespread acoustically unstratified unsorted sediment of diamictic texture, and variable thickness and relief. It lies unconformably on bedrock, and locally forms constructional features. It is barren of microfossils and generally has high shear strength and bulk density and low water content, as discussed later. The unit is interpreted to be glacial drift[1] on the basis of these various characteristics. It is similar to glacial drift deposits in other offshore areas of eastern Canada (e.g. Josenhans et al., 1986; King and Fader, 1986; Praeg et al.,1986) and

1 The term glacial drift is used in this paper to describe sediments that we consider to be primarily glacial till deposited beneath grounded glacial ice, but as the data do not permit discrimination of different till types or small local occurrences of other ice-contact deposits, the broader term glacial drift has been applied to these sediments.

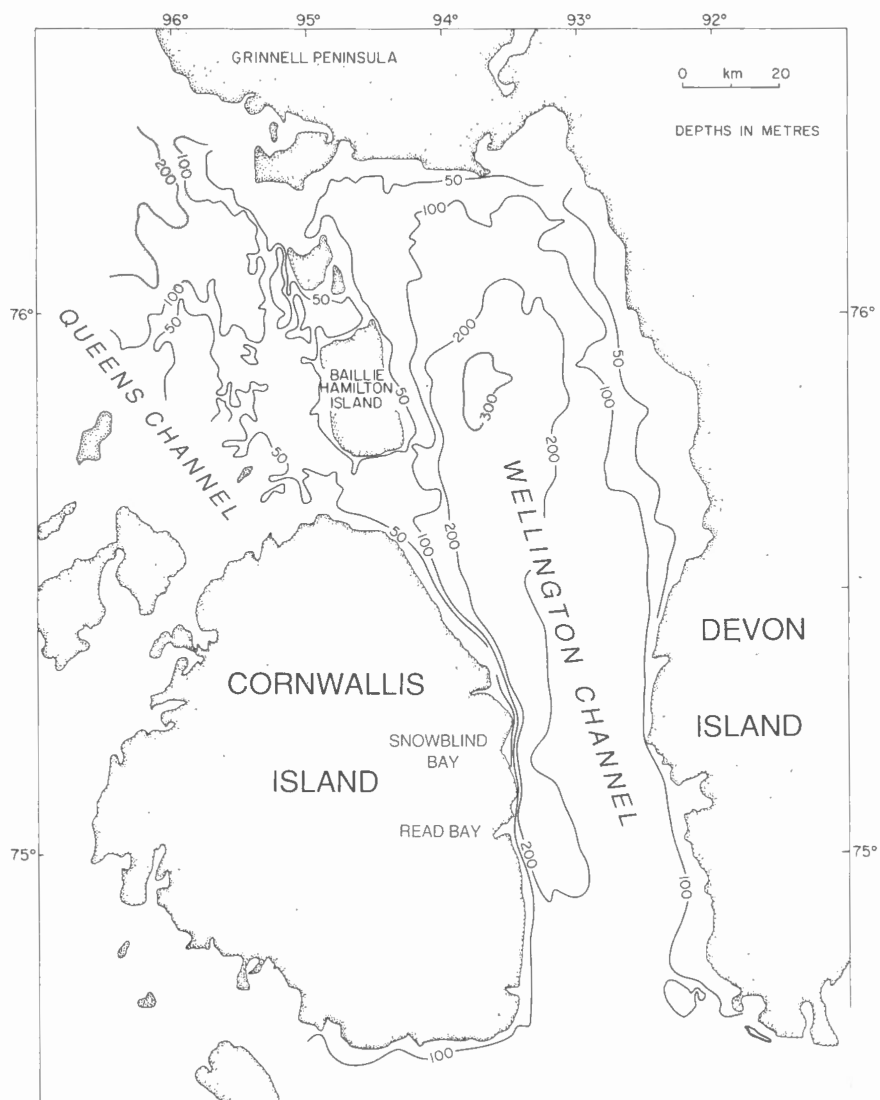


Figure 3. Generalized bathymetry of Wellington-eastern Queens channel region. Derived from published Canadian Hydrographic Service Charts (depths in metres).

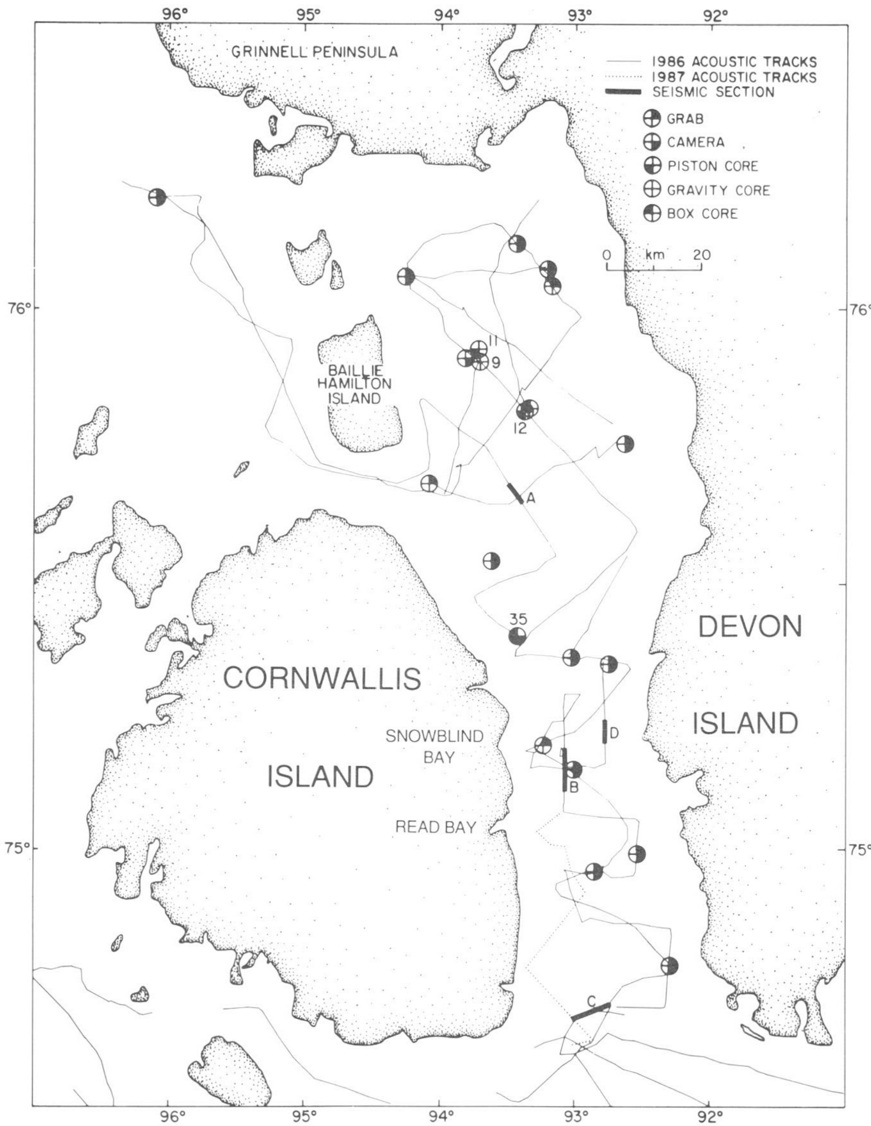


Figure 4. Acoustic track and sample station locations in Wellington-eastern Queens channel region.

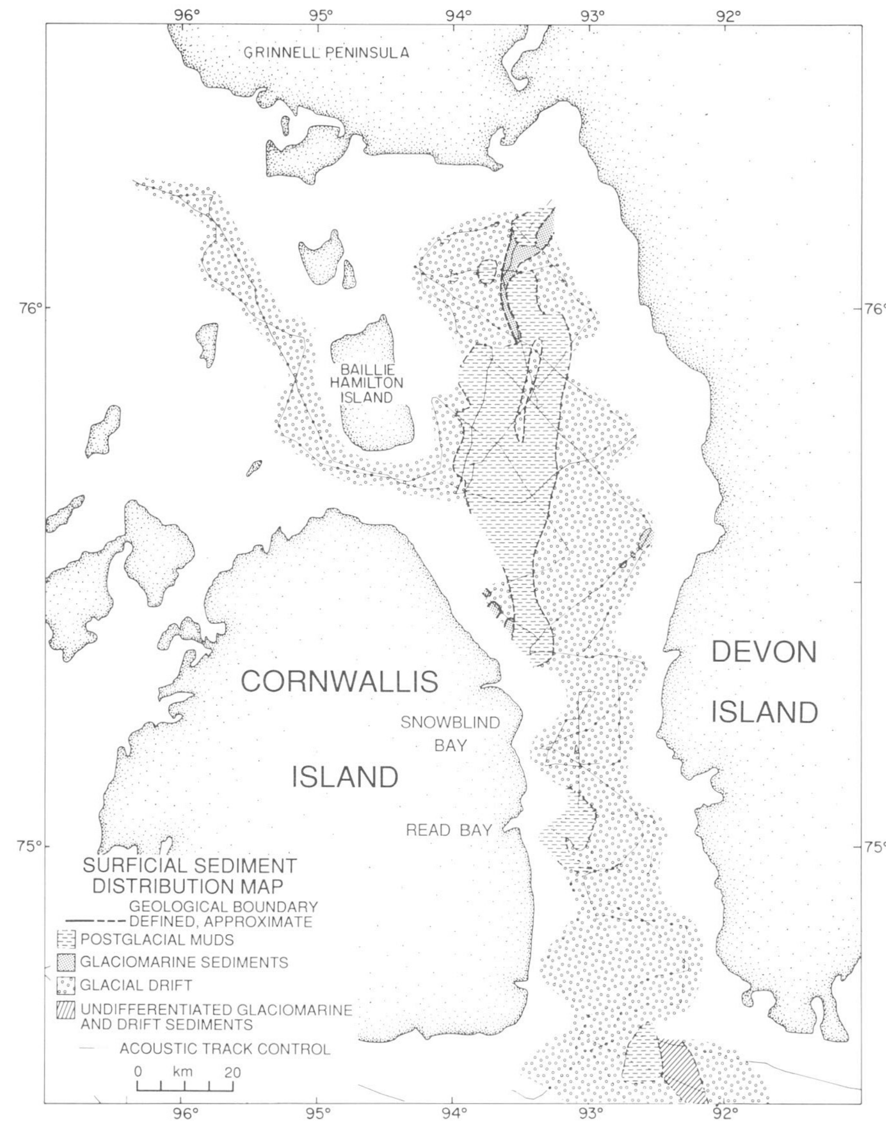


Figure 5. Distribution of surficial sediment units in Wellington and eastern Queens channels, based on acoustic profile and sample data.

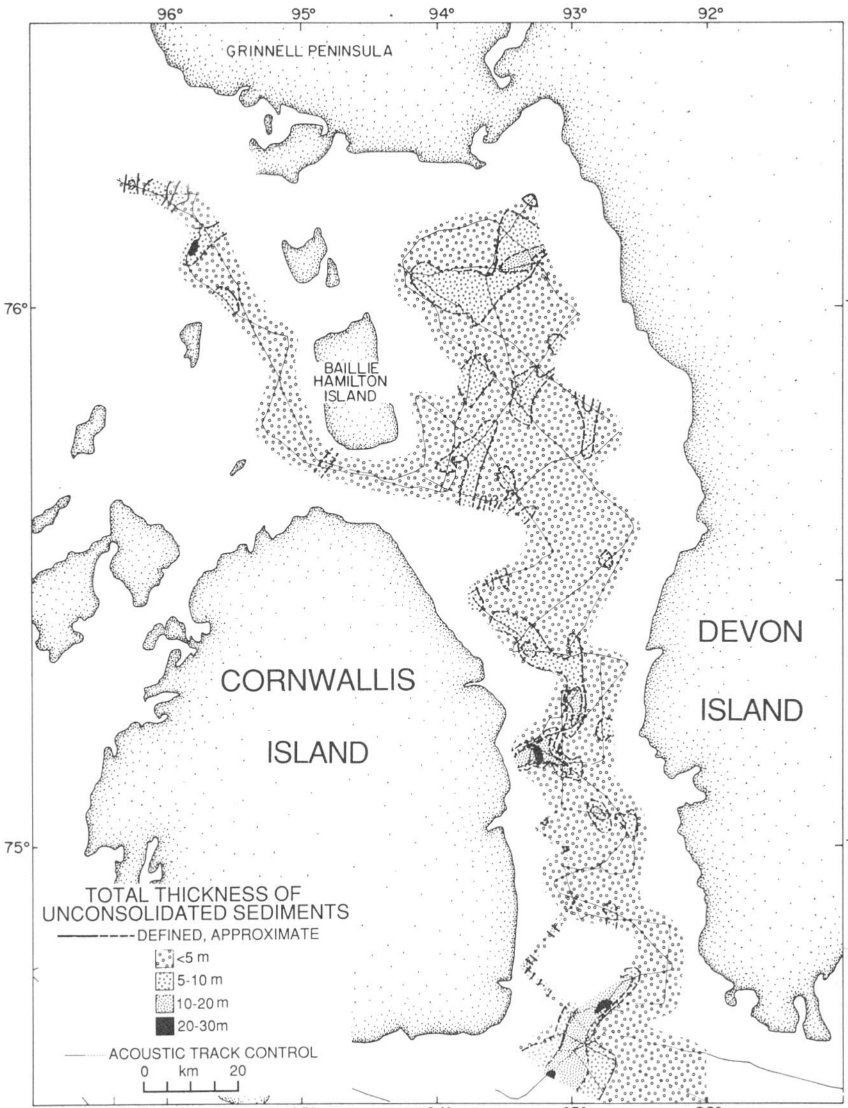


Figure 6. Isopach map of Quaternary sediments in Wellington and eastern Queens channels. Thicknesses in this and the subsequent isopach maps are based on the velocity of sound in water.

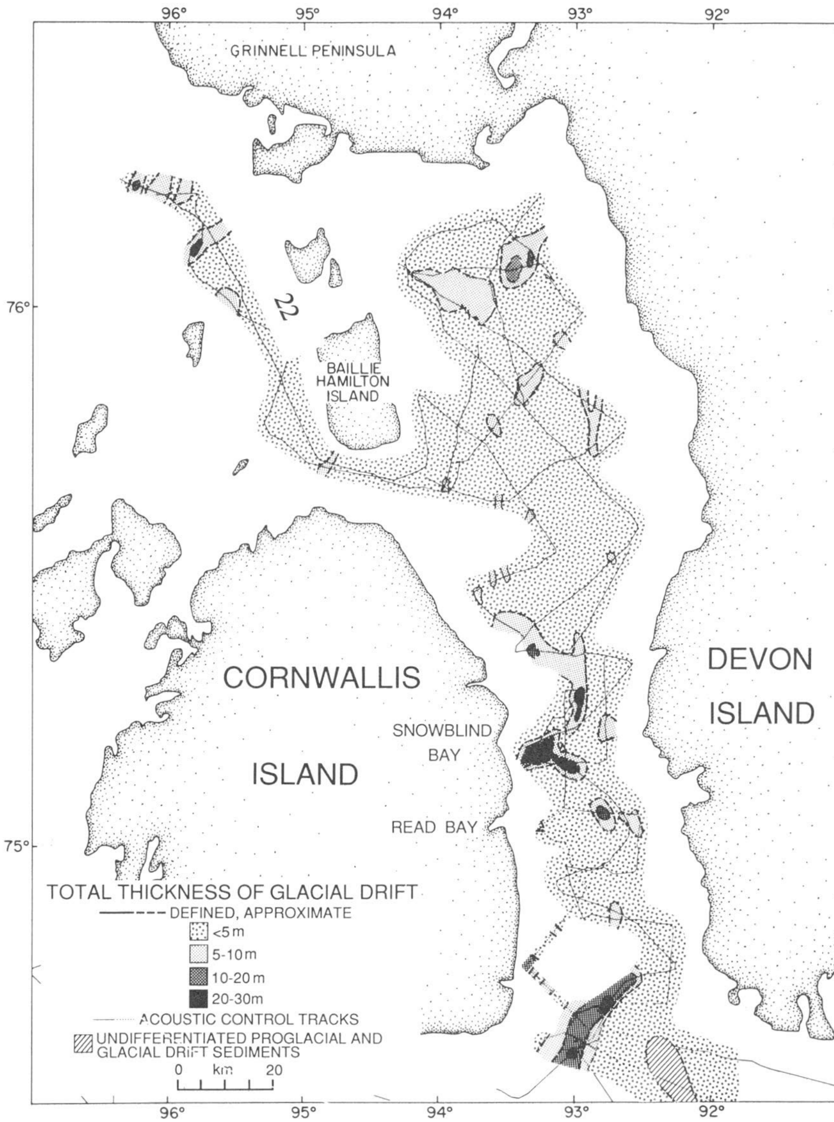


Figure 7. Isopach map of glacial drift sediments in Wellington and eastern Queens channels.

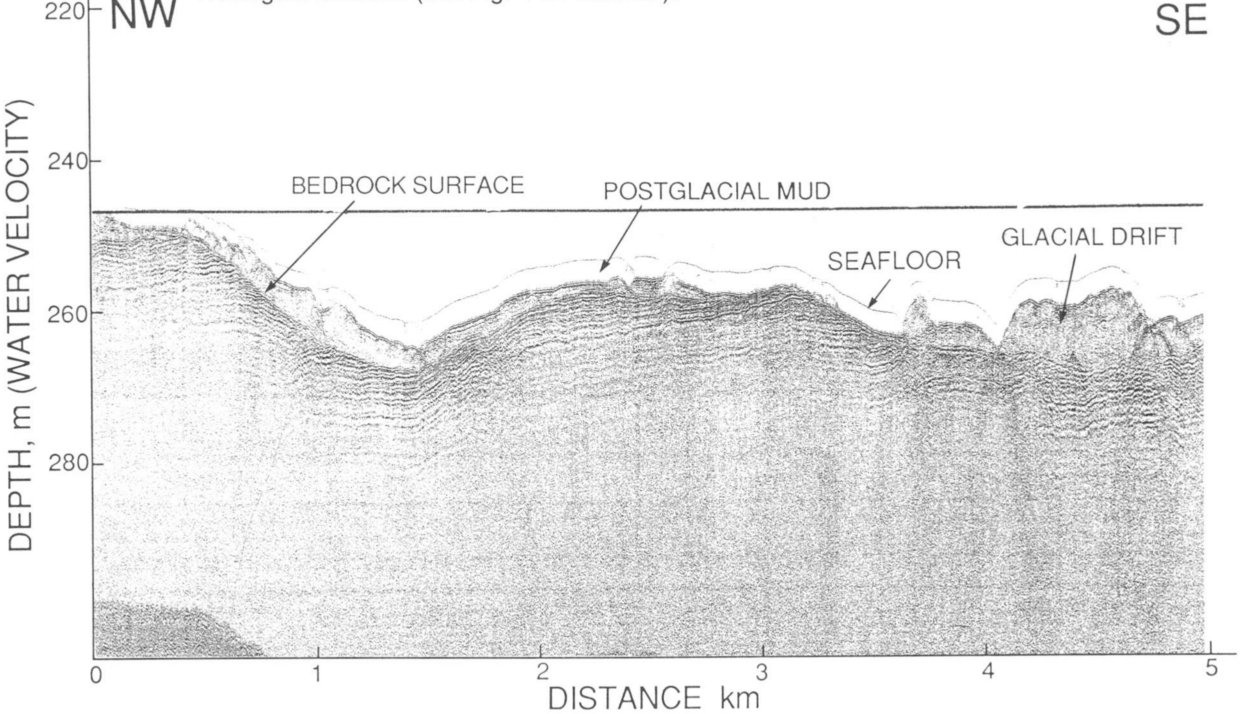


Figure 8. Section A: Huntec high resolution seismic reflection profile illustrating acoustically transparent postglacial mud mantling glacial drift and bedrock in northern Wellington Channel (see Fig. 4 for location).

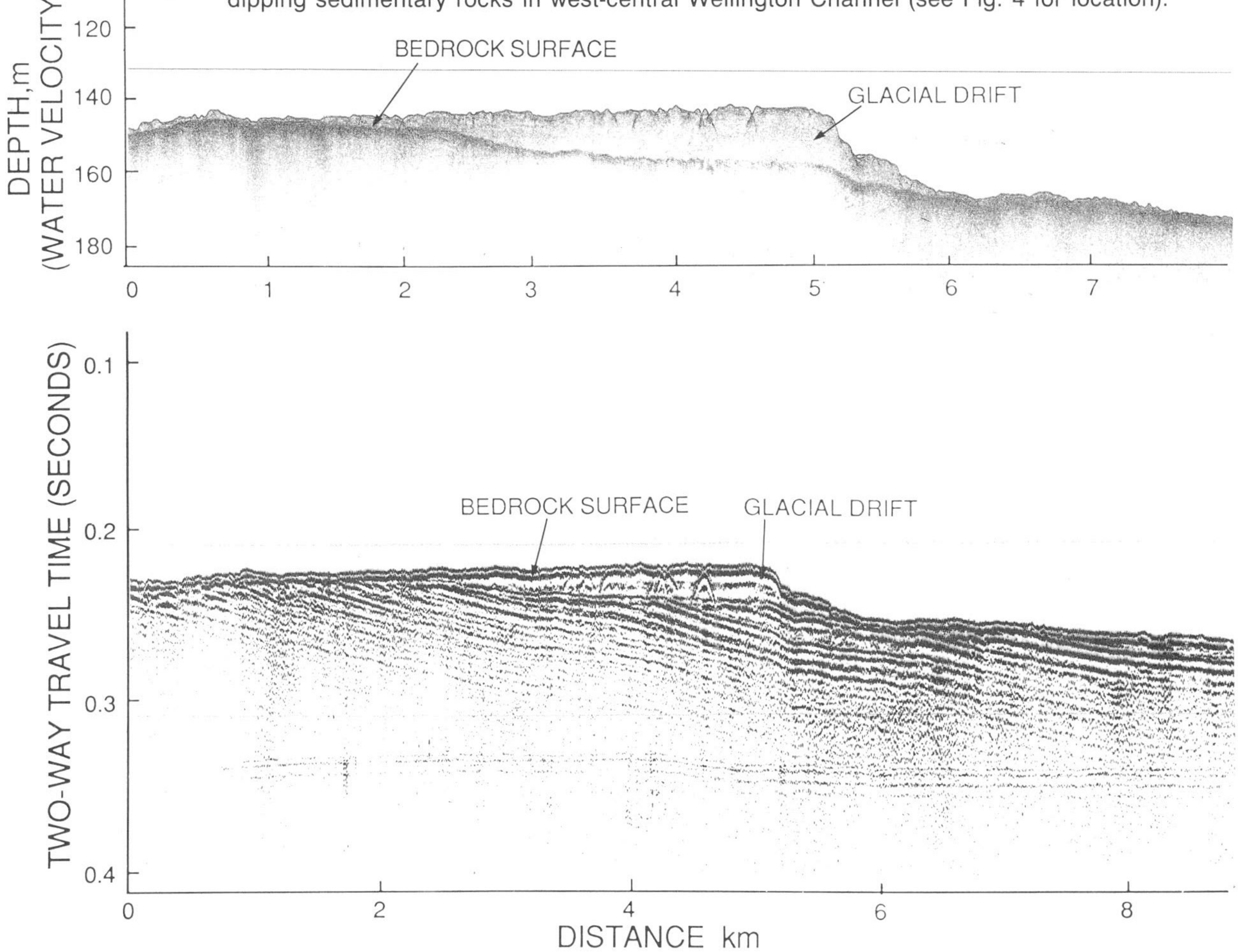


Figure 9. Section B: Huntec profile (upper) and single channel (airgun) seismic reflection profile (lower) illustrating a moraine-like accumulation of glacial drift lying on southwesterly dipping sedimentary rocks in west-central Wellington Channel (see Fig. 4 for location).

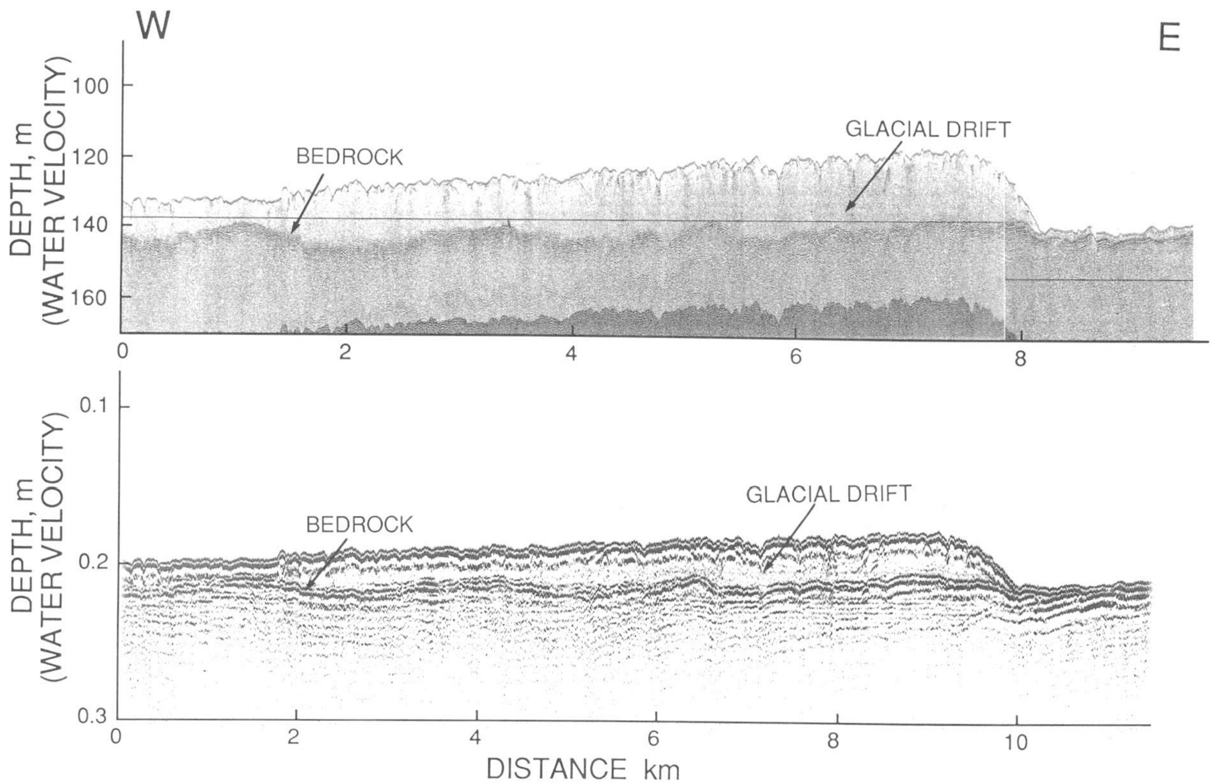


Figure 10. Section C: Huntec (upper) and single channel (airgun) seismic reflection (lower) profiles showing moraine-like accumulation of glacial drift on the western side of Wellington Channel near its southern end (see Fig. 4 for location).

Figure 11. Bottom photograph illustrating glacial drift at the seabed in northern Wellington Channel. For scale--outer diameter of compass housing = 11.4 cm.

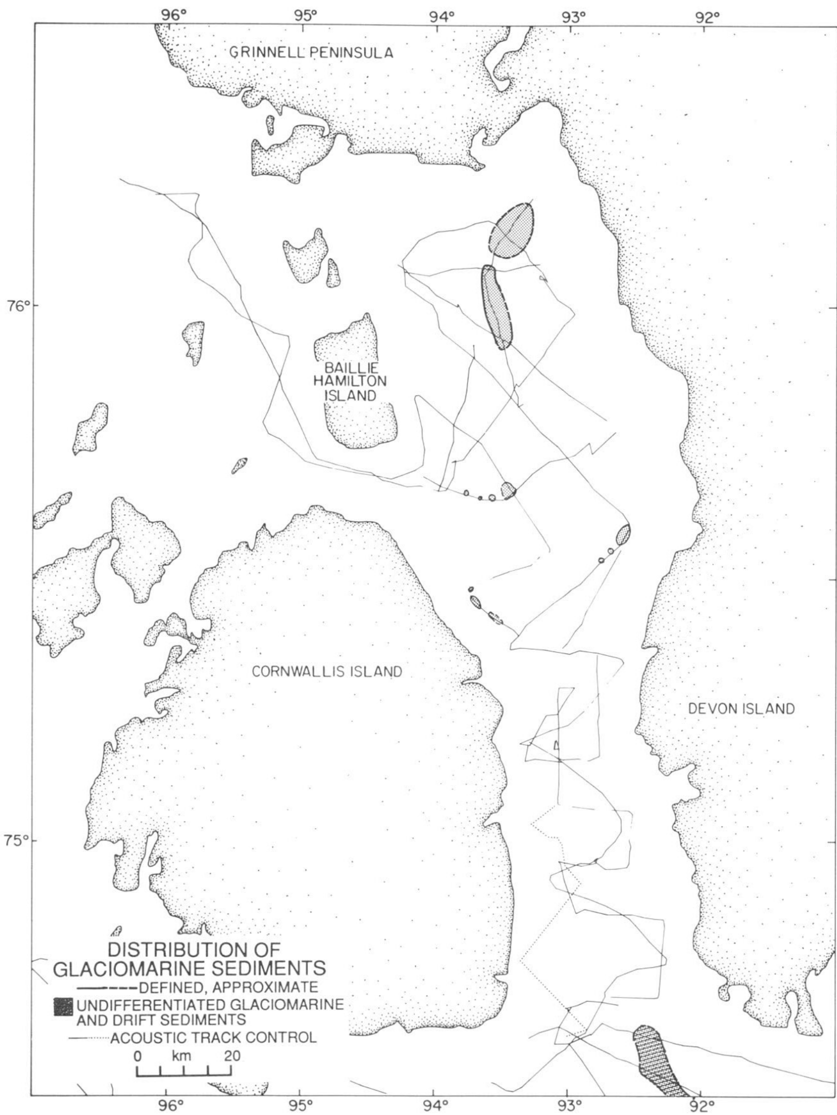


Figure 12. Distribution of acoustically stratified sediments interpreted to be of glaciomarine origin in Wellington Channel. These sediments commonly are in the order of 1-2 m in thickness. Glaciomarine and glacial drift sediments locally are undifferentiated in northern Barrow Strait.

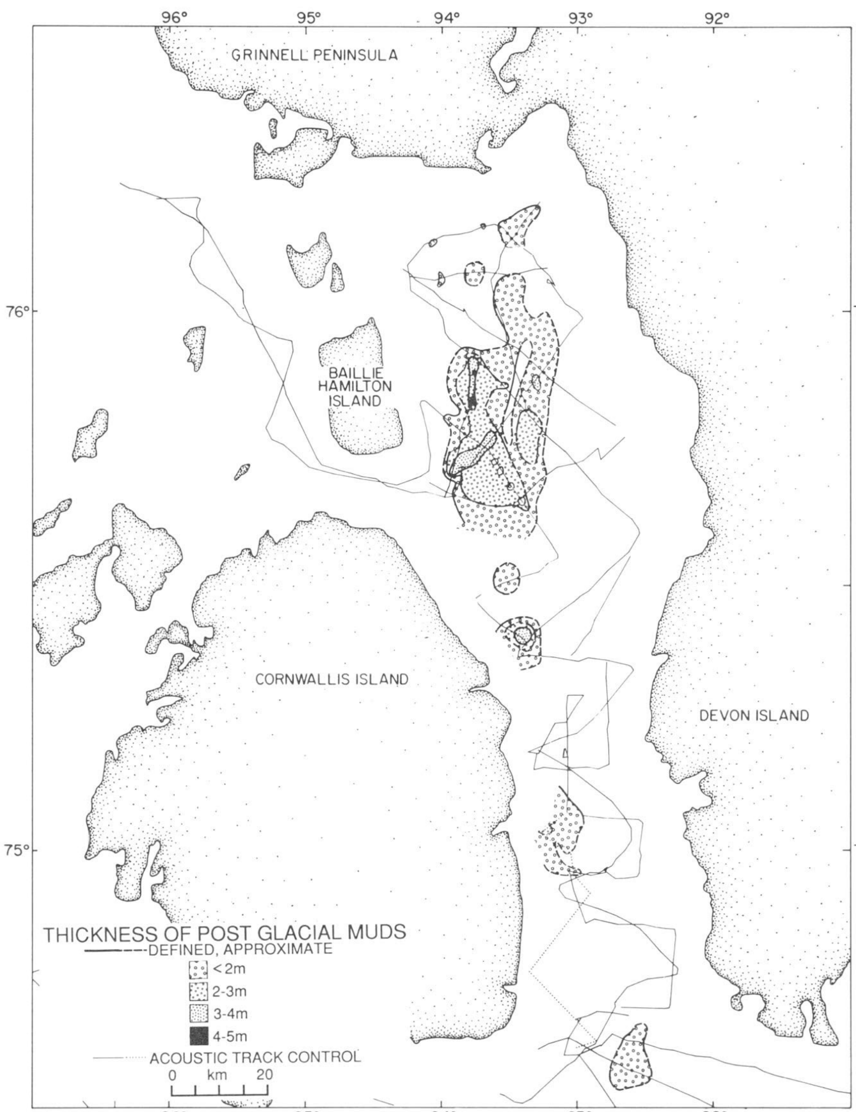


Figure 13. Isopach map of acoustically transparent postglacial sediments in Wellington Channel. These sediments consist mainly of silty clay with minor sand and pebble components locally.

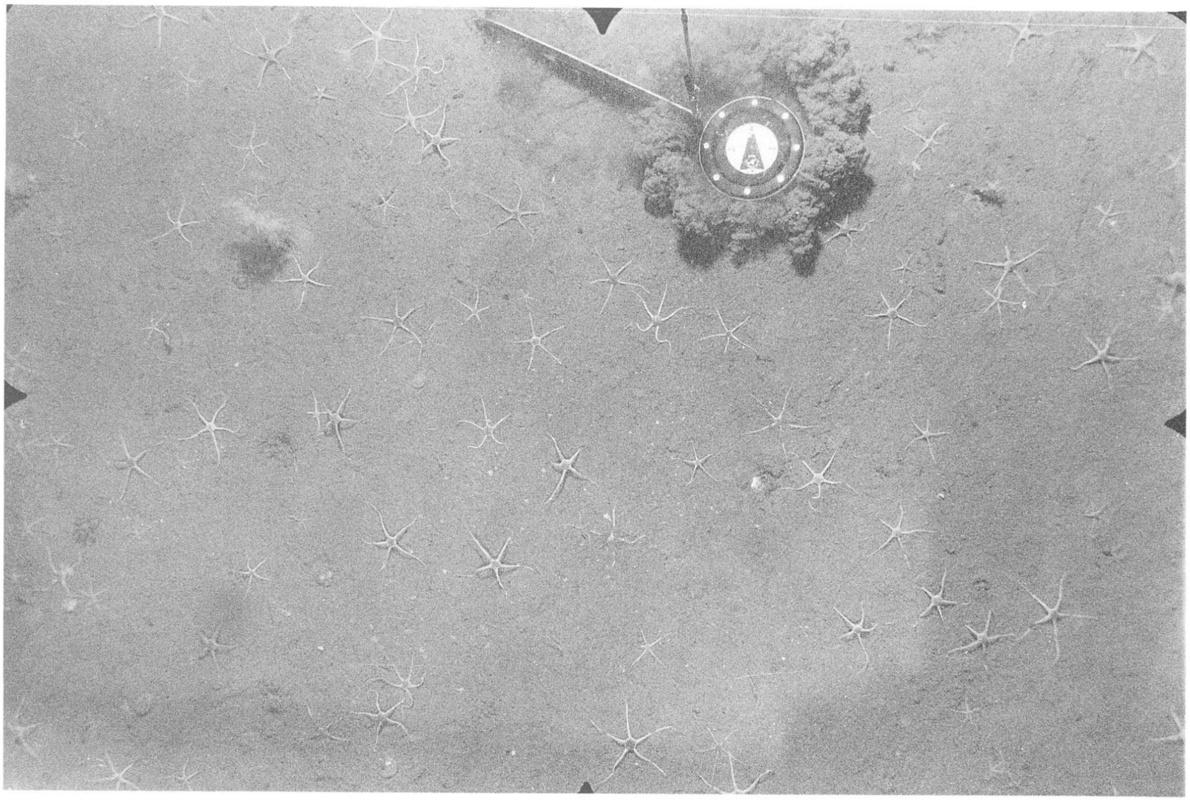


Figure 14. Bottom photograph illustrating fine grained clayey and silty postglacial sediments in northern Wellington Channel. Scale as in Figure 11.

Figure 15. Bottom photograph illustrating a gravel lag armoring the seabed in northeastern Wellington Channel. Scale as in Figure 11.

of the Norwegian Shelf (King et al., 1987). The drift is the most areally extensive of the three units (Fig. 5), and regionally, it is also the thickest (Fig. 7). The drift in Wellington Channel commonly is in the order of 2-5 m thick, but locally reaches 10 m or more (Fig. 7 and 8). It is locally discontinuous (Fig. 8). The thickest deposits are in the southern half of the channel where accumulations up to about 25 m thick occur midway along the western side (Fig. 7 and 9), and also at its southern end adjacent to Barrow Strait (Fig. 10). These deposits are interpreted to be moraines on the basis of their acoustic character and morphology. The constructional shape and location of these features on the western side of the channel suggest they may have been deposited by an advance of glacial ice centred on Cornwallis Island, or alternately, they may mark a still stand in the general retreat of a more regionally extensive ice sheet. At the site midway along the southern part of the channel (Fig. 9), the bedrock surface slopes away southward and the ice sheet that deposited the drift stood in progressively deeper water in that direction. The southern limit of this accumulation (5-6 km along section in Fig. 9) may indicate a lift-off point of the grounded ice sheet, possibly with a calving margin or an ice shelf beyond. No direct chronological data on the age of the drift are available. The drift in Wellington Channel consists of calcareous very sandy mud with abundant, randomly distributed angular pebbles (Fig. 11). These sediments range from dark grey (5 Y 4/1[1]) at Station 12 in northern Wellington Channel to pinkish grey (7.5 YR 6/2) farther south at Station 35 (Fig. 4).

The second of the surficial units consists of acoustically stratified sediments up to 2 m in thickness that mantle and locally interfinger with the glacial drift in a few areas in the northern part of Wellington Channel (Fig. 5 and 12). This unit was not encountered in cores obtained in Wellington Channel but was sampled in Barrow Strait and Byam Martin Channel. Sediments of similar acoustic character are present in other areas (e.g. the Baffin, Labrador, and Scotian shelves [Praeg et al., 1986; Josenhans et al., 1986; King and Fader, 1986; respectively]) with similar interfingering relationships, stratigraphic position, texture, and microfossil assemblages. We interpret these to represent glaciomarine sediments deposited in environments proximal to distal from a glacial ice margin and beneath ice shelves.

1 Colour designations refer to Munsell Soil Colour Charts (1975 edition) published by Kollmorgen Corporation, Baltimore, Maryland.

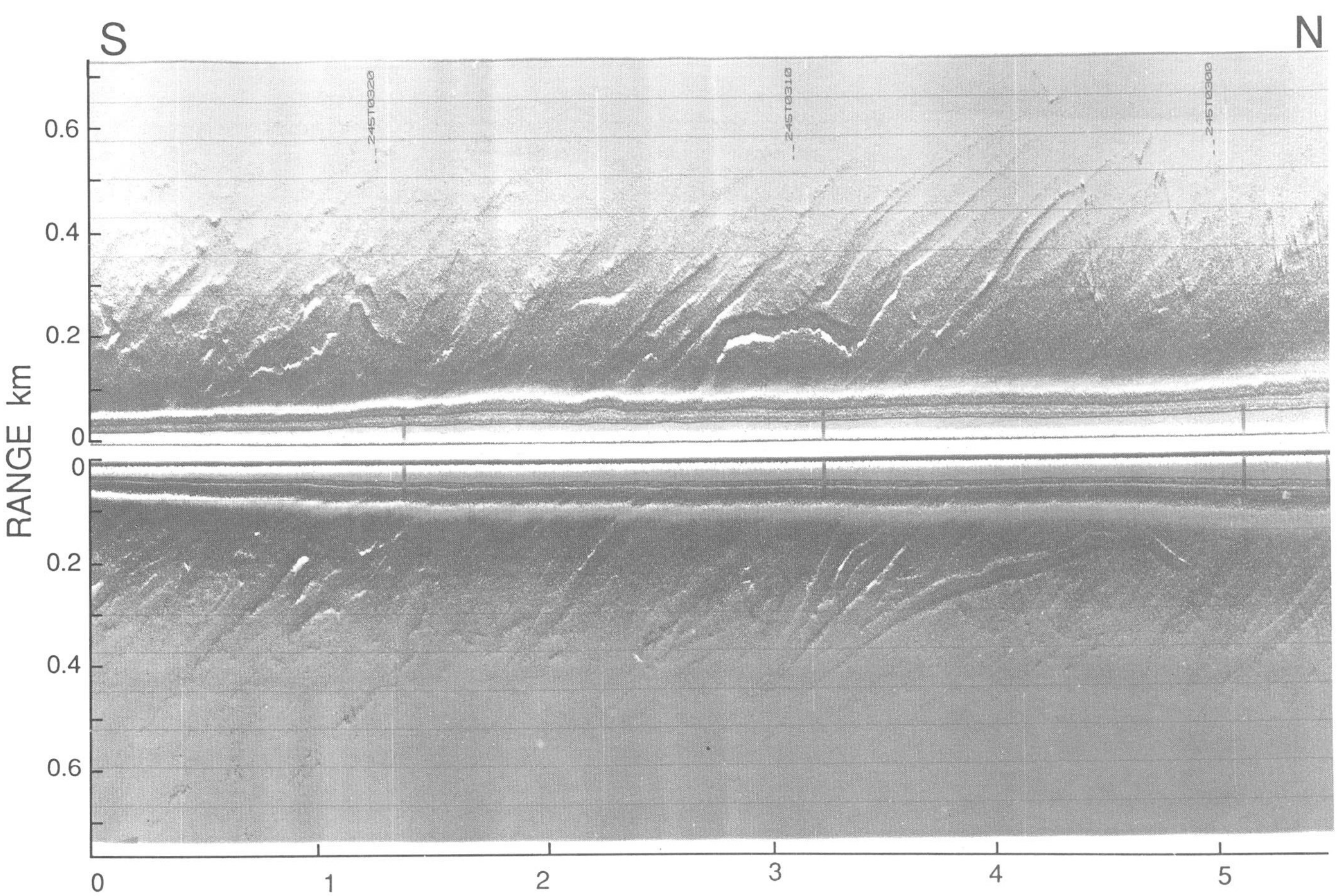


Figure 16. Section D: sidescan sonogram illustrating ice scouring of the seabed across probable morainal sediments in Wellington Channel. Many of the scours display a subparallel northwest-southeast orientation, crosscut in places by later scours. These are presumed to be relict features (see Fig. 4 for location).

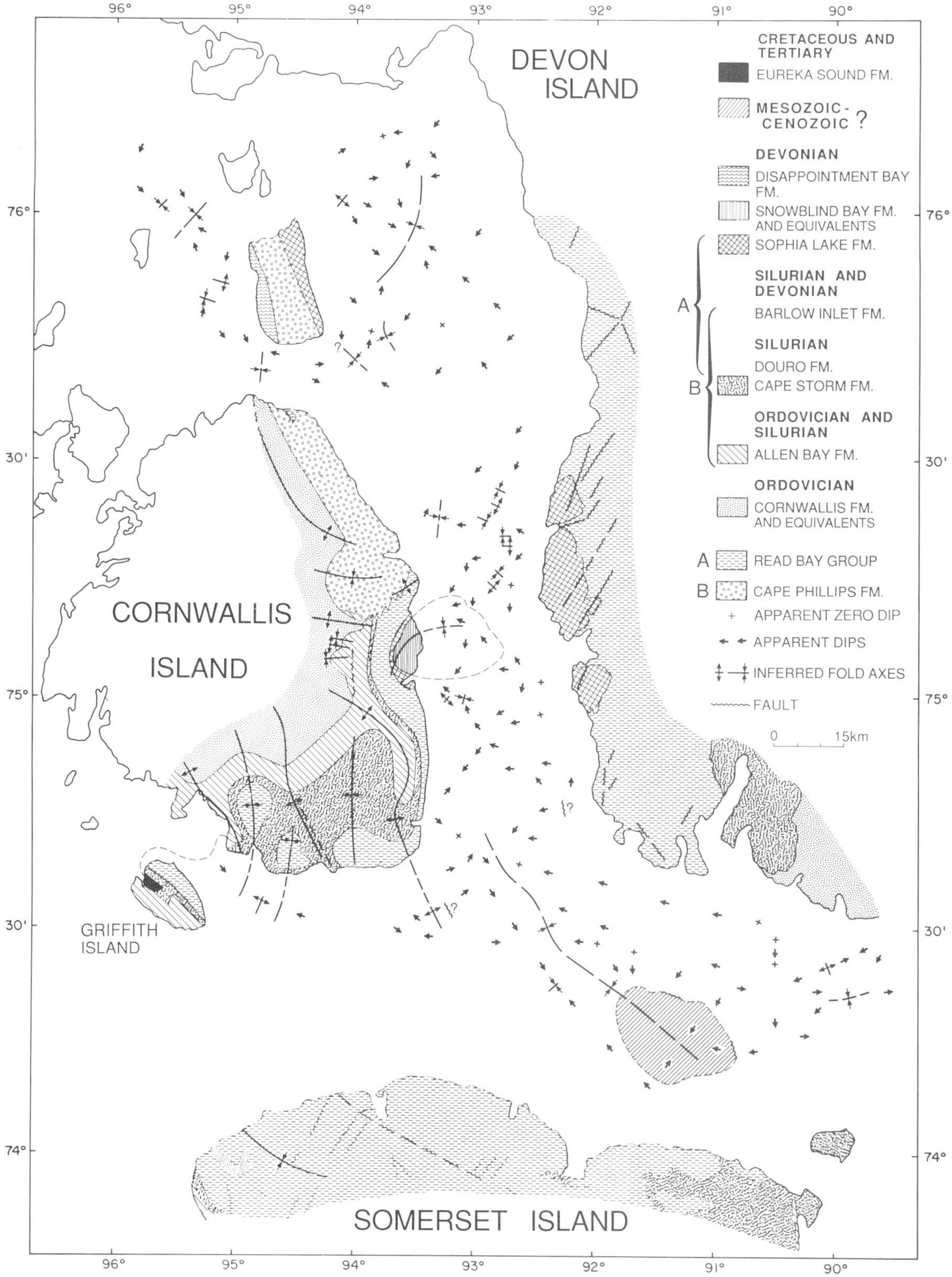


Figure 17. Diagram illustrating near surface structure of sedimentary bedrock strata underlying Wellington Channel and eastern Barrow Strait as revealed by apparent dips and fold axes from seismic reflection profiles. The predominant dip in Wellington Channel is westerly. These strata are inferred to primarily represent extensions of Ordovician to Lower Devonian sequences mapped onshore eastern Cornwallis, western Devon, and northern Somerset islands by Thorsteinsson (1958, 1986), Blackadar and Christie (1963), Thorsteinsson and Uyeno (1981), Stewart (1987), Thorsteinsson and Mayr (1987). Strata in the central basin in eastern Barrow Strait may include younger sequences, possibly of Mesozoic or Cenozoic age as previously postulated by Bornhold and Lewis (1976) and Lewis et al. (1977).

The third surficial unit consists of acoustically transparent sediments, ranging between 1 and 4 m in thickness, which are most widely distributed and continuous in areas of northern Wellington Channel, where water depths exceed 200 m (Fig. 5, 8, 13, and 14). This unit also occurs in a few other localities (Fig. 5 and 13). Samples of these sediments consist mainly of olive-grey (5 Y 4/2) silty clay, and, in places are slightly sandy, darkly mottled, or contain a few pebbles. The generally fine grained texture, high water content, and low bulk density and shear strength are reflected in the acoustically transparent character of these sediments (Fig. 8). These sediments variably overlie the glacial drift and acoustically stratified sediment units, and in a few places lie directly on the bedrock (Fig. 8 and 13). These are the youngest of the main sediment units in Wellington Channel and contain the most diverse microfossil assemblages. These sediments are interpreted to be postglacial.

Datable material is not available for the samples from Wellington Channel, but similar sediments in Barrow Strait yielded a date of 7970 ± 70 BP (TO-752), and unpublished shell dates from similar sediments in Jones Sound yielded ages ranging from 8410 ± 200 (Beta 9712) to 2610 ± 110 (Beta 9010). Accumulation of these sediments in bathymetric depressions suggests their distribution has been largely controlled by the action of water currents.

A thin layer of surface sediment, up to a few centimetres thick, unresolved by acoustic profiles, is present in many of the areas sampled. It consists of a very thin greenish, soupy, silty, clayey, sandy, and gravelly cover over the other units at the immediate seabed. The very wide mixture of textural sizes and the setting in which this sediment occurs suggest that part or most of this surface veneer is the product of ice rafting. Exposed gravel clasts that completely armor the seabed in a few areas (Fig. 15) suggest stronger bottom currents may in places substantially modify the sediments.

Sidescan sonograms (Fig. 16) and acoustic profiles (e.g. Fig. 9) indicate that the seabed of the southern half of Wellington Channel has been scoured by ice. Figure 16 illustrates ice scours along a north-south transect across a possible small morainal area in 165 m of water at approximately 75°13′ N latitude in the southern part of the channel. Many of the scours, including a subdued background pattern, display a parallel-subparallel northwest-southeast orientation. These possibly include sole marks of a glacial ice sheet analogous to fluted drift seen on land. Some crosscutting scours with different orientations result from later iceberg groundings. The ice scours in Wellington Channel appear to be mainly relict. This interpretation is based on the absence of large icebergs in the area in the present day and the fact that the ice scours appear to be confined to the glacial drift unit. In northern Wellington Channel, the soft acoustically transparent postglacial sediments that occur in depths greater than 200 m appear to be unscoured, but the surface of the underlying drift has been ice scoured (Fig. 8). Formation of the scours possibly was contemporaneous with the presence of glacial ice and the calving of large bergs at the ice sheet margin.

Bedrock geology

Interpretation of the seismic reflection data obtained during CSS HUDSON cruise 86-027 indicates that Wellington Channel is underlain by sedimentary rocks. Lower Paleozoic sedimentary rocks constitute the bedrock of Cornwallis and western Devon islands which border Wellington Channel (Thorsteinsson, 1958, 1986; Thorsteinsson and Kerr, 1967; Thorsteinsson and Uyeno, 1981; Thorsteinsson and Mayr, 1987) (Fig. 17). The depth of penetration of seismic energy in Wellington Channel is generally consistent with that obtained previously from similar seismic systems across lower Paleozoic sedimentary rocks in other localities (e.g. Baffin Island Shelf and Hudson Strait), as opposed to that normally achieved over softer younger sedimentary rocks (MacLean et al. 1977, 1981, 1986). The amount of penetration, however, is only an approximate guide as to bedrock type. Figures 8 to 10 illustrate the bedrock character as seen on the shallow seismic reflection profiles. Apparent dips of the beds along track are indicated in Figure 17. In the absence of samples and given the conformable relations of the formations, a tentative assessment of the rocks offshore depends on the extension and extrapolation of onshore boundaries, structural axes, and formation thicknesses where possible, together with any regionally discernible variations in the acoustic character that may be associated with particular rock units. Some possible correlations have been observed in places; for example, beds which may represent the seaward extension of Snowblind Bay Formation locally in the western part of Wellington Channel, and other beds which may represent Allen Bay Formation south of Cornwallis Island. In general, however, there is not sufficient acoustic contrast between the rock units offshore to distinguish individual formations mapped onshore.

Eastern Queens Channel

Interpretation of the acoustic data indicates that glacial drift is the only surficial unit present in the portions of eastern Queens Channel that were surveyed (Fig. 4 and 5). The drift commonly is less than 5 m thick, but locally increases to a little more than 10 m over short distances in northeastern Queens Channel (Fig. 6).

Eastern Barrow Strait-Western Lancaster Sound

Parts of the eastern Barrow Strait-western Lancaster Sound region were surveyed in 1986. The generalized bathymetry is indicated in Figure 18. The seabed slopes from a 150 m depth southeast of Cornwallis Island and at the entrance to Wellington Channel into a 300 m depression toward the south side of Barrow Strait. Water depths in the eastern part of the area increase progressively to >400 m. The bathymetry shallows rapidly near shore. The location of 1986 and earlier survey tracks are indicated in Figure 19.

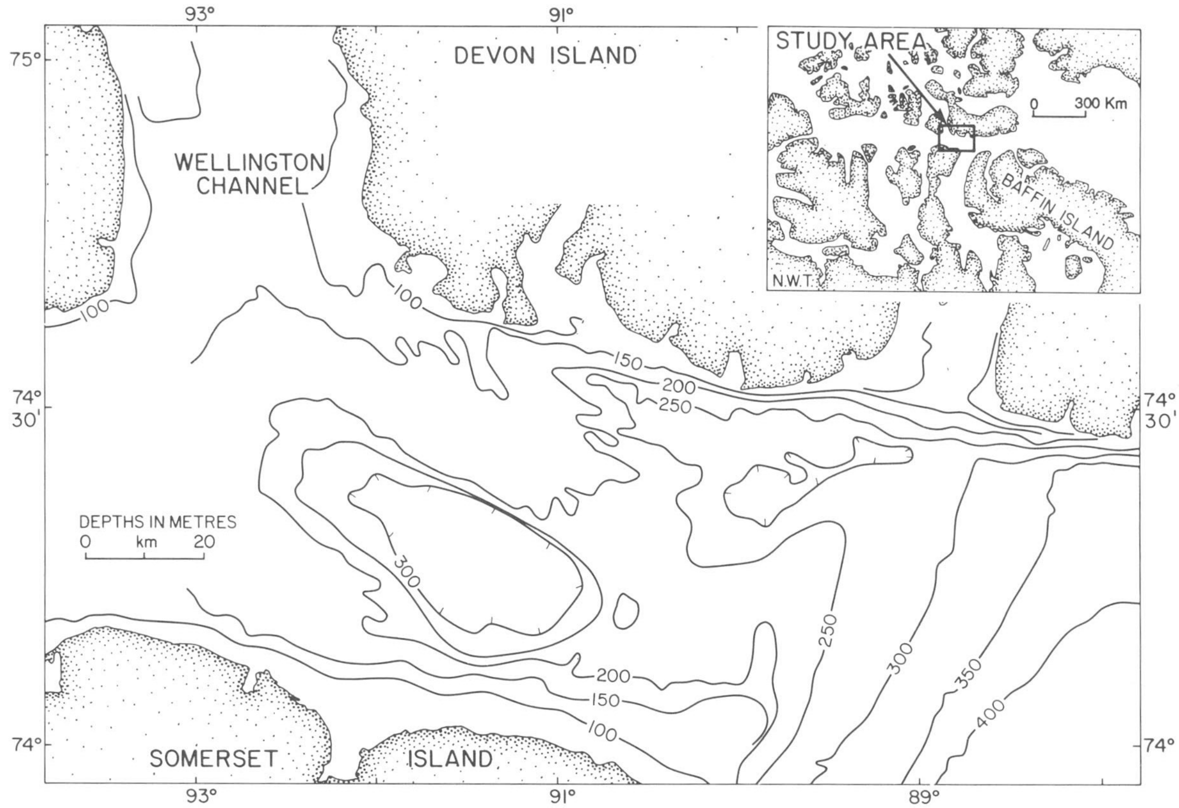


Figure 18. Generalized bathymetry in eastern Barrow Strait-western Lancaster Sound.

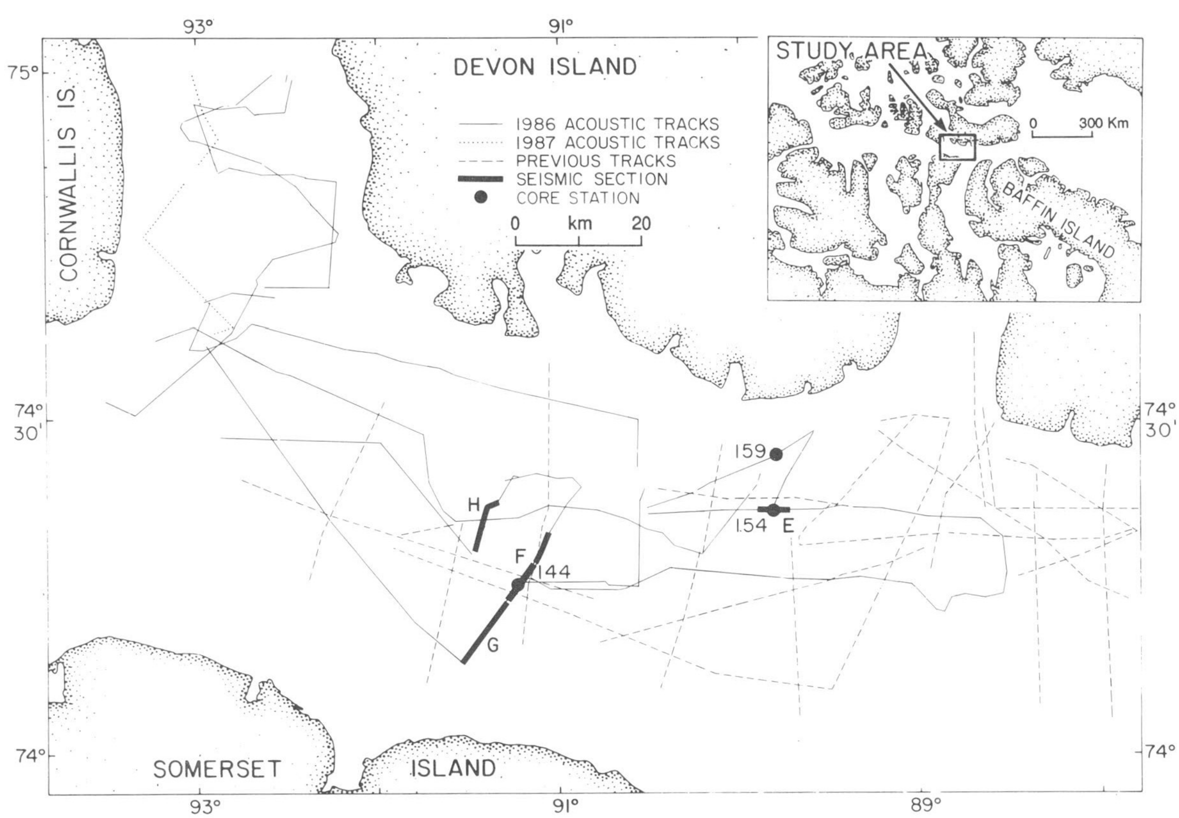


Figure 19. Acoustic track control and samples obtained in 1986 in eastern Barrow Strait and western Lancaster Sound.

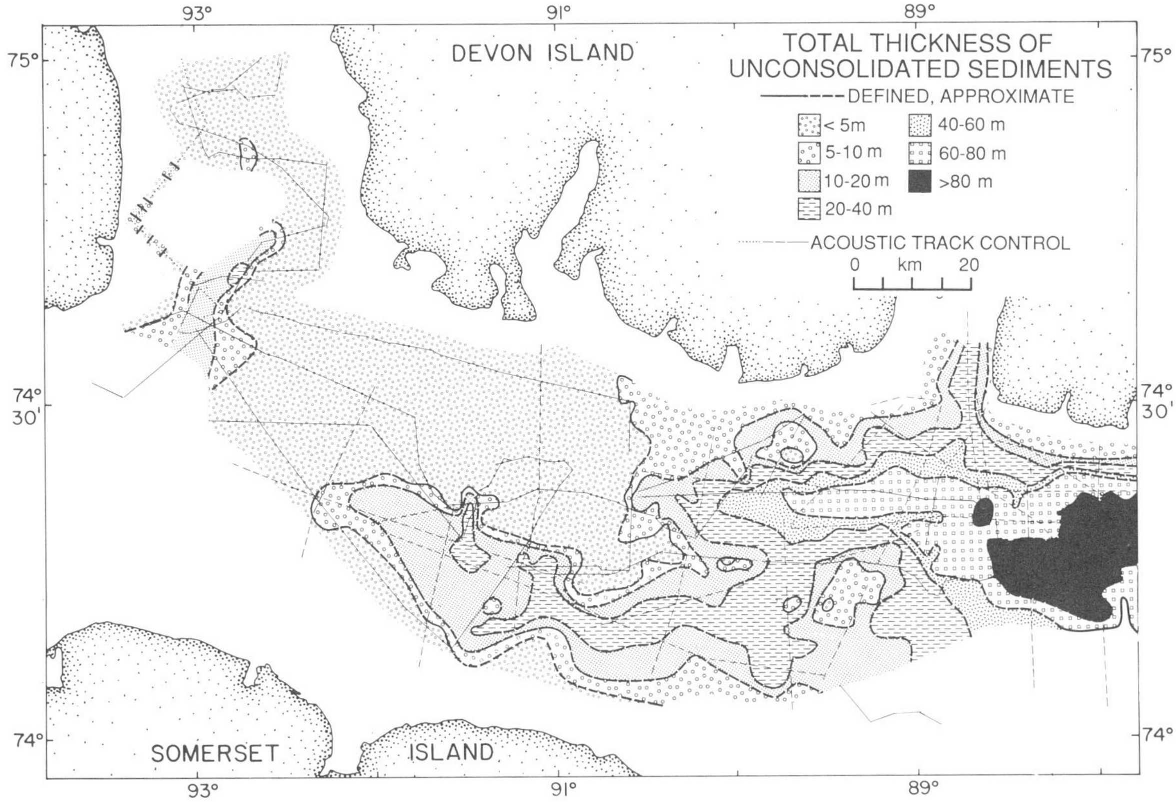


Figure 20. Isopach map of Quaternary sediments in eastern Barrow Strait-western Lancaster Sound.

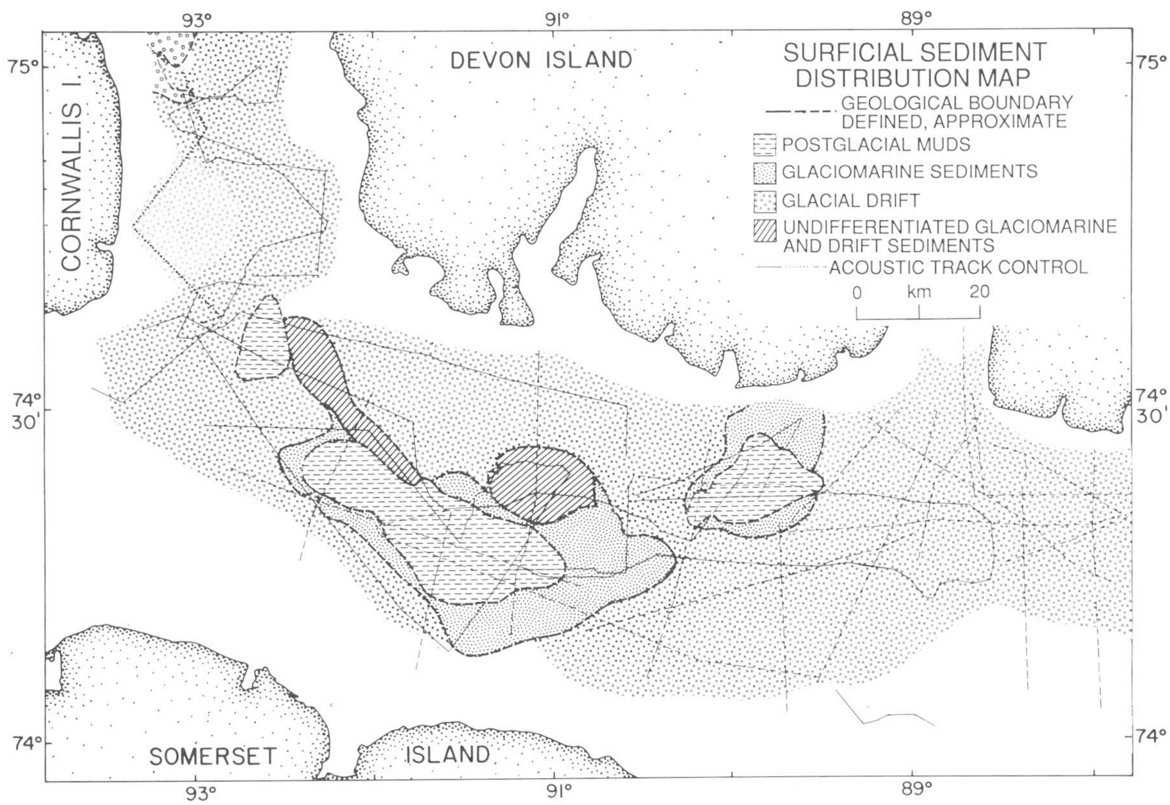


Figure 21. Distribution of surficial sediments in eastern Barrow Strait and western Lancaster Sound.

Surficial geology

The eastern Barrow Strait-western Lancaster Sound region contains the thickest unconsolidated sediments in the study area (Fig. 20). As in Wellington Channel, sediments interpreted to be glacial drift are the most areally extensive and thickest of the surficial units (Fig. 21 and 22). They consist of calcareous pebbly sandy mud (Fig. 23), and range in colour from very dark greyish brown (10 YR 3/2) at Station 144 in the west, to grey (10 YR 5/1, 6/1) at Stations 154 and 159, 44 km to the east (Fig. 19). Thickest accumulations, apart from the small area at the entrance to Wellington Channel, are in the southern and eastern parts of the area. Drift in the latter area locally reaches 100 m in thickness (Fig. 22). The glacial drift unit locally includes multiple sequences. These are separated in places by a thin deposit of acoustically stratified sediment (Fig. 19 and 24). The time span represented by these multiple sequences is not known. Such events may range from relatively brief pulses or oscillations of an ice margin to substantially longer term events involving more regionally extensive advances and retreats.

As in Wellington Channel, the overlying acoustically stratified and acoustically transparent sediments are interpreted to represent glaciomarine and postglacial sediments, respectively. Occurrences of these sediments in this region are the most extensive observed in any of the Arctic Island channel areas surveyed in 1986 (Fig. 21). Acoustically stratified sediments up to 4 m thick lie on the glacial drift in two main areas. The most extensive of these is in the basin in the southern part of the strait, and the second, in a smaller basin 5 km to the northeast (Fig. 18, 21 and 25). The acoustically stratified sediments in the latter area are thicker along the western part of the basin, and, as illustrated on Figure 24, the lower part of the sequence extends beneath a subsequent drift deposit in the east. The presence of acoustically stratified sediments in the area north and northwest of the main basin is uncertain, and they and the glacial drift are undifferentiated in those areas (Fig. 21 and 25). Core samples indicate that the acoustically stratified sediments consist of calcareous, laminated sandy and pebbly silt and clay with some coarse beds up to a few centimetres thick (Fig. 23). They range in colour from grey (5 Y 5/1) to dark greyish brown (10 YR 4/2). The distribution of the coarse fraction ranges from thin bands to dispersed. The sediments of this unit are inferred to be glaciomarine in origin.

Acoustically transparent sediments up to 7 m thick lie on the acoustically stratified sediments, but are not as extensive areally as the latter (Fig. 21 and 26), pinching out laterally over the underlying sediments (Fig. 27). Locally, these sediments lie on the drift in the northwestern part of the area (Fig. 21). Core samples indicate that the sediments of this unit consist of unstructured to weakly laminated olive-grey (5 Y 4/2) silty clay with some thin dark grey (5 Y 3/1)

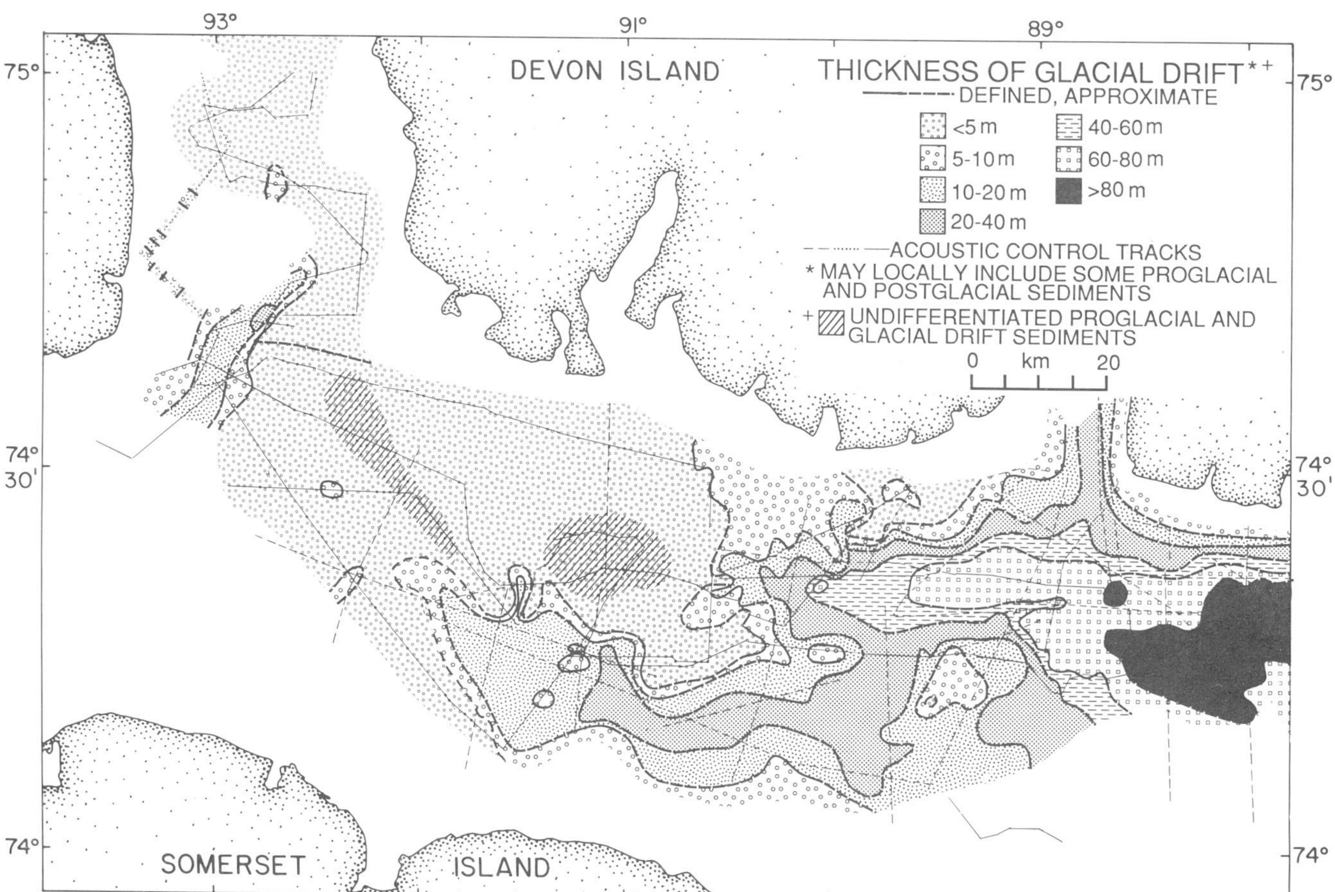


Figure 22. Isopach map of glacial drift sediments in eastern Barrow Strait-western Lancaster Sound region.

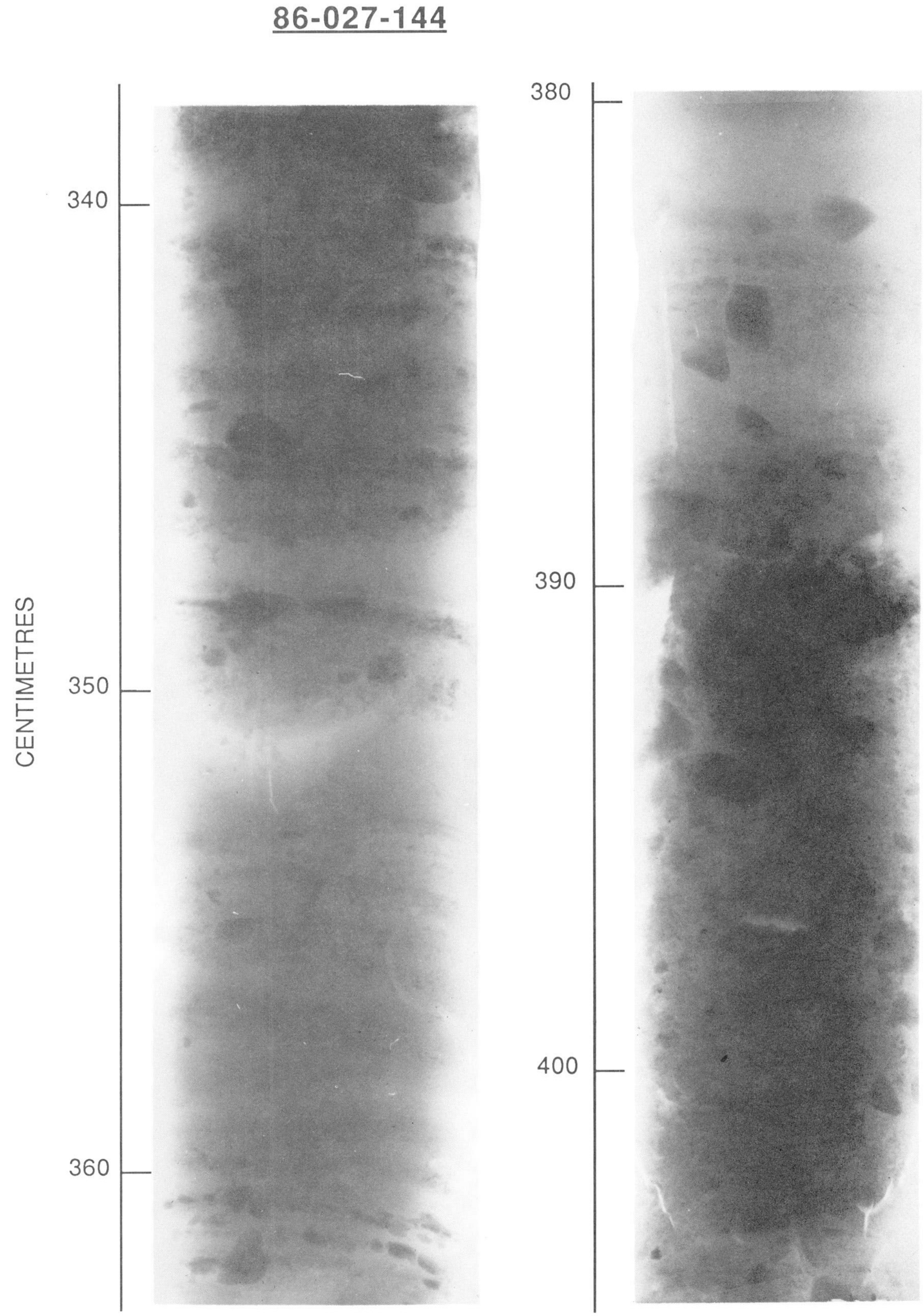


Figure 23. X-radiographs of Core 144 from eastern Barrow Strait, interval 3.4-3.6 m illustrating laminated sediments of the acoustically stratified glaciomarine unit and interval 3.8-4.05 m illustrating coarse textured diamict sediments of the glacial drift unit below 3.89 m.

horizons and burrows, with a few shells and rare gravel clasts. Small point source reflectors within this unit on the Huntec profile (Fig. 27) may indicate ice-rafted drop stones. This unit is 5 m thick at the core 144 locality. A pelecypod identified as *Bathyacra gracialis* (T. Cole, pers. comm., 1987) from a down-core depth of 1.72 m (reconstructed depth below seafloor, 4.1 m) in Core 144 yielded an AMS C-14 date of 7970 ± 70 BP (TO-752). This suggests a sedimentation rate of about 0.5 m/thousand years. If uniform, this would indicate an age of about 10 000 BP for the base of this unit in that area. The acoustically transparent sediments are interpreted to be the product of postglacial deposition by marine currents with some probable input from ice rafting.

Bedrock geology

Seismic reflection data indicate that eastern Barrow Strait-western Lancaster Sound is underlain by sedimentary rocks. The adjacent onshore areas include sedimentary rocks which range in age from Ordovician to Early Devonian (Blackadar and Christie, 1963; Stewart, 1987; Thorsteinsson and Mayr, 1987). Similar sequences are inferred to be present beneath eastern Barrow Strait. Strata in two areas (Fig. 17), however, permit greater penetration of seismic energy (Fig. 28) and these may represent Mesozoic or Cenozoic sequences, as previously suggested by Bornhold and Lewis (1976) and Lewis et al. (1977). Cretaceous and Tertiary strata are present locally in a few small fault controlled occurrences on Cornwallis and Griffith islands (Thorsteinsson, 1986) and lower Tertiary strata occur similarly on Somerset Island (Stewart, 1987). The strata in Barrow Strait and Lancaster Sound occur in bathymetric basins, which are in part structurally controlled. The western basin is a mainly synclinal feature (Fig. 28). The younger beds appear to be conformable with the underlying strata, but appear to be locally disturbed by faulting at and near the northern and eastern margins of the basin (Fig. 29). Relations appear conformable in the western part of the eastern basin. The beds throughout the region have been bevelled by erosion: presumably fluvial erosion followed later by glacial erosion, as proposed by Fortier and Morley (1956) and Pelletier (1966), respectively.

Byam Martin and Austin channels, and northern Viscount Melville Sound

Byam Martin Channel lies between Bathurst and Melville islands (Fig. 1). In the south it is divided by Byam Martin Island into Austin and Byam channels to the east and west, respectively (Fig. 30). Water depths commonly are less than 150 m in these areas, but elongate depressions with depths in excess of 200 m occur near the western side of Byam Martin Channel north of Byam Martin Island, northeast of Byam Martin Island, and along part of the eastern side of Byam Channel. Depths greater than 200 m also occur in a few small isolated depressions. Keene Bank is a shallow area with depths locally less than 4 m on the eastern side of the entrance to Austin Channel south of Bathurst Island. Maximum depths at the southern entrance to Austin Channel are in the order of 127 m. Northward beyond the map area depths increase to 300-400 m in the western part of Byam Martin Channel as it broadens to the west (Fig. 1). South of the map area depths increase gradually southwestward toward the central part of Viscount Melville Sound where they reach in excess of 500 m.

Surficial geology

Quaternary sediment units recognized on acoustic profiles (Fig. 31 and 32) in Byam Martin and Austin channels are similar to those recognized in Wellington Channel and eastern Barrow Strait. The Quaternary section in general is thicker than in Wellington Channel (Fig. 33), but thinner than in Barrow Strait and Lancaster Sound. The glacial drift unit is the most widely distributed and thickest of the surficial units (Fig. 32 and 34). The glacial drift sediments are dark grey (5 Y 4/1) to very dark grey (5 Y 3/1) calcareous pebbly and sandy mud (Fig. 35). The drift varies from <5 m to 50 m in thickness locally, but most commonly ranges between 5 and 30 m (Fig. 34). Drift thicknesses up to 53 m have been found farther north in this region between Cameron and Lougheed islands (Sonnichsen and Vilks, 1987). Multiple drift sequences are interpreted to be present in several of the localities surveyed. Figures 36, 37, 38, and 39 illustrate these deposits in Byam Martin Channel, and

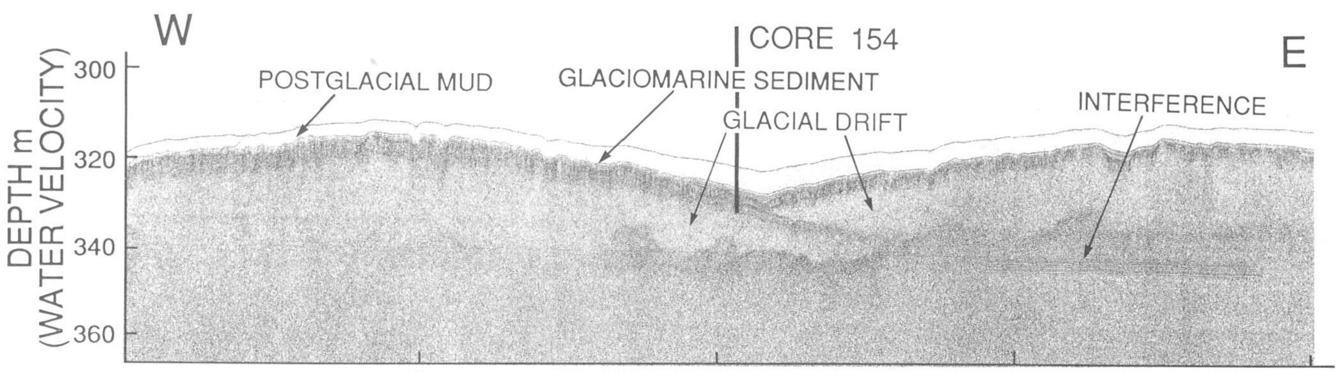


Figure 24. Section E: Huntec profile from eastern Barrow Strait illustrating glacial drift sequences overlain by up to 2-3 m of acoustically stratified glaciomarine sediment and up to 5 m of acoustically transparent postglacial mud. The lower part of the stratified sediment sequence underlies a later deposit of drift eastward from approximately 4 km along section (see Fig. 19 for location).

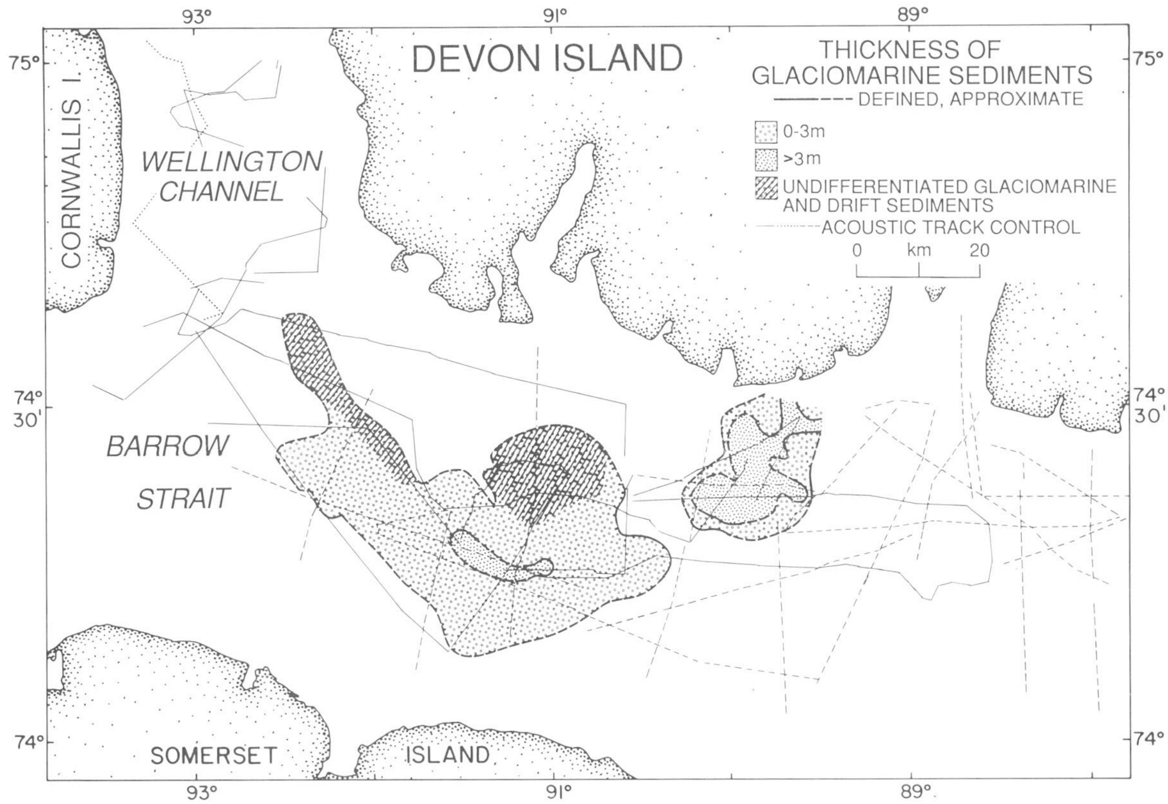


Figure 25. Distribution and thickness of acoustically stratified glaciomarine sediments in eastern Barrow Strait-western Lancaster Sound.

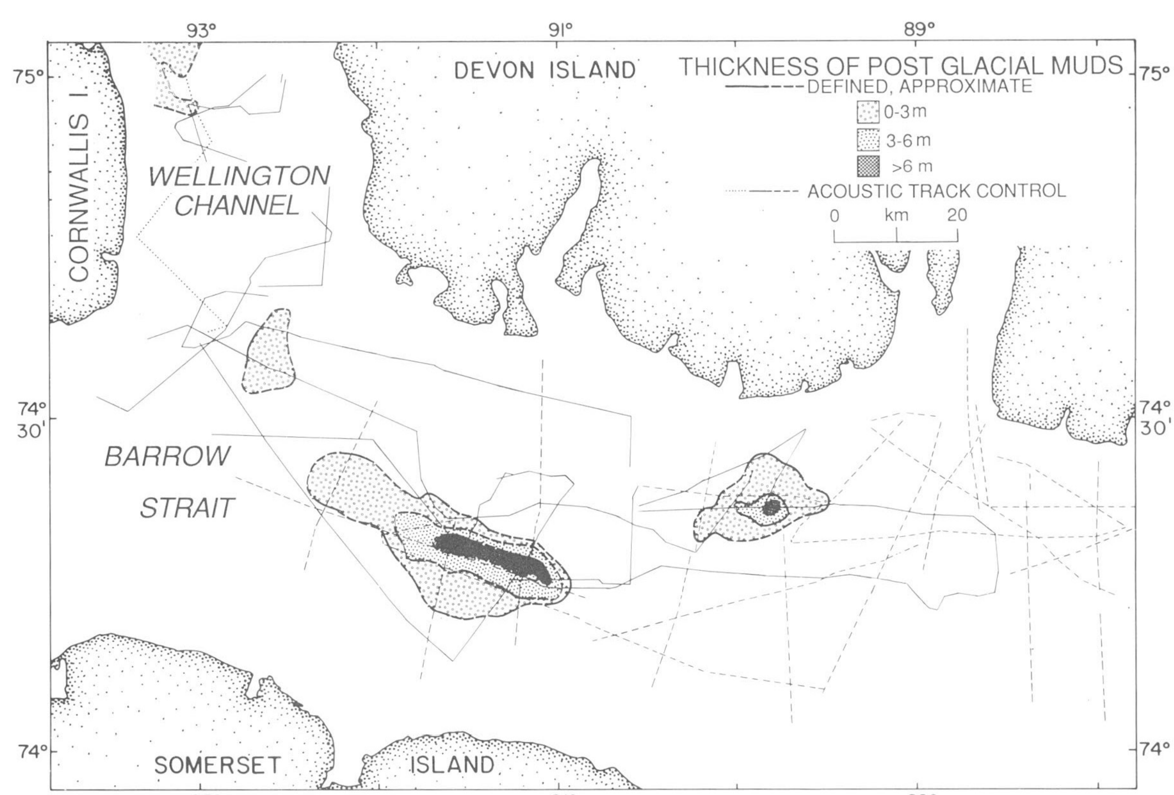


Figure 26. Isopach map of acoustically transparent postglacial sediments in eastern Barrow Strait-western Lancaster Sound.

Figure 27. Section F: Huntec profile illustrating acoustically transparent basin fill sediments (postglacial mud) pinching out over the underlying acoustically stratified glaciomarine and glacial drift sediment units. Ice-rafted dropstones cause small local point source reflections (see Fig. 19 for location).

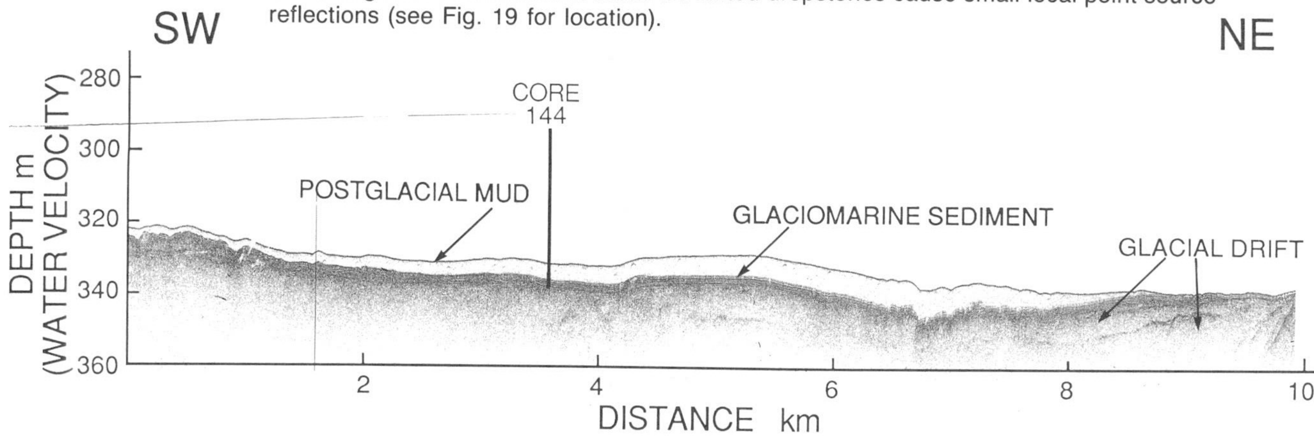


Figure 28. Section G: seismic reflection (airgun) profile illustrating bedrock strata and Quaternary sediments in the western basin of eastern Barrow Strait. The basin possibly includes sequences of Mesozoic or Cenozoic age (see Fig. 19 for location).

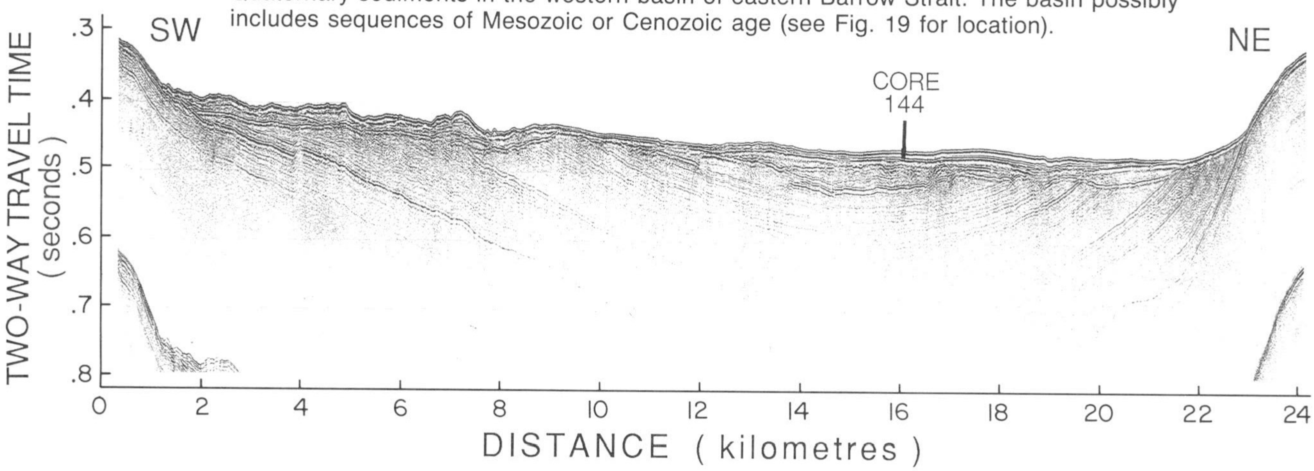
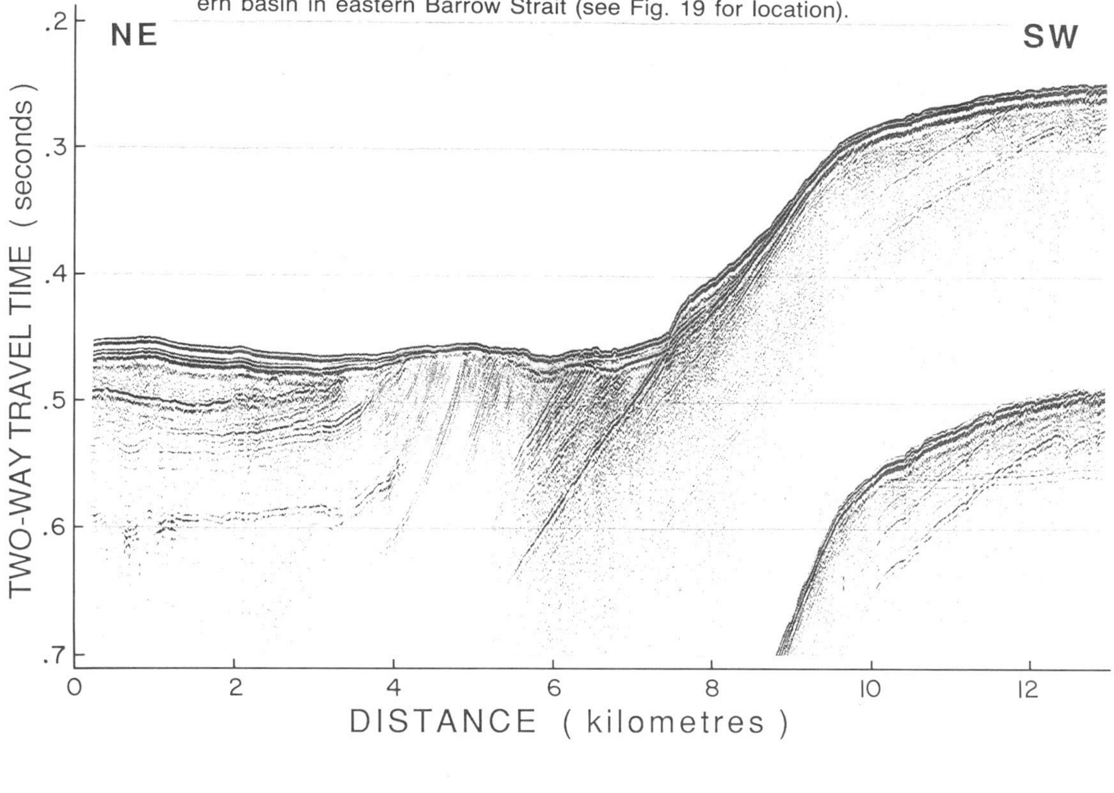


Figure 29. Section H: Seismic reflection profile showing apparent faulting (5-6 km along section) at the northern margin of the younger strata in the western basin in eastern Barrow Strait (see Fig. 19 for location).



Figures 40 and 41 those in Austin Channel and on Keene Bank, respectively. The amount of acoustic contrast between the different drift sequences is variable, but in places it is pronounced (Fig. 37 and 41). Similar contrasts are seen on parts of the southeastern Baffin Shelf (Praeg et al., 1986) and on the Labrador Shelf (Josenhans et al., 1986). The differences in contrast are thought to result from such factors as differences in loading applied by the depositing ice sheets, variations in textural and lithological composition, and geotechnical properties of the material. The multiple sequences in the Byam Martin-Austin channel region frequently are associated with local accumulations of sediment that form positive features or infill bedrock depressions. Drift thicknesses locally reach 30 to 50 m in such features.

Acoustically stratified sediments in Byam Martin and Austin channels are thin, 1-3 m, and discontinuous, though more widespread than in Wellington Channel (Fig. 32 and 42). They occur mainly in areas where water depths exceed 150 m. These sediments generally overlie the drift, but the two units may locally interfinger. Where sampled, sediments ascribed to this unit consist of olive to dark grey (5 Y 4/2 - 5 Y 5/1) and brown (10YR 4/3) laminated mud and sandy mud with gravel, except at Station 86 in eastern Byam Martin Channel (Fig. 31) where gravel and sand sized clasts were notably absent (Fig. 35). These sediments are interpreted to be primarily glaciomarine in origin.

Acoustically transparent muddy sediments, which form the third surficial sediment unit, locally overlie the acoustically stratified sediments or lie directly on the drift in Byam Martin and northeastern Austin channels and in parts of northern Viscount Melville Sound (Fig. 32). The sediments occur mainly as small isolated patches, commonly 1-2 m thick and locally reaching 4 m (Fig. 43 and 44). The largest of these are in areas more than 200 m deep northeast of Byam Martin Island. Nowhere in the Byam Martin-Austin channel region is the distribution of these sediments as extensive as that in northern Wellington Channel or eastern

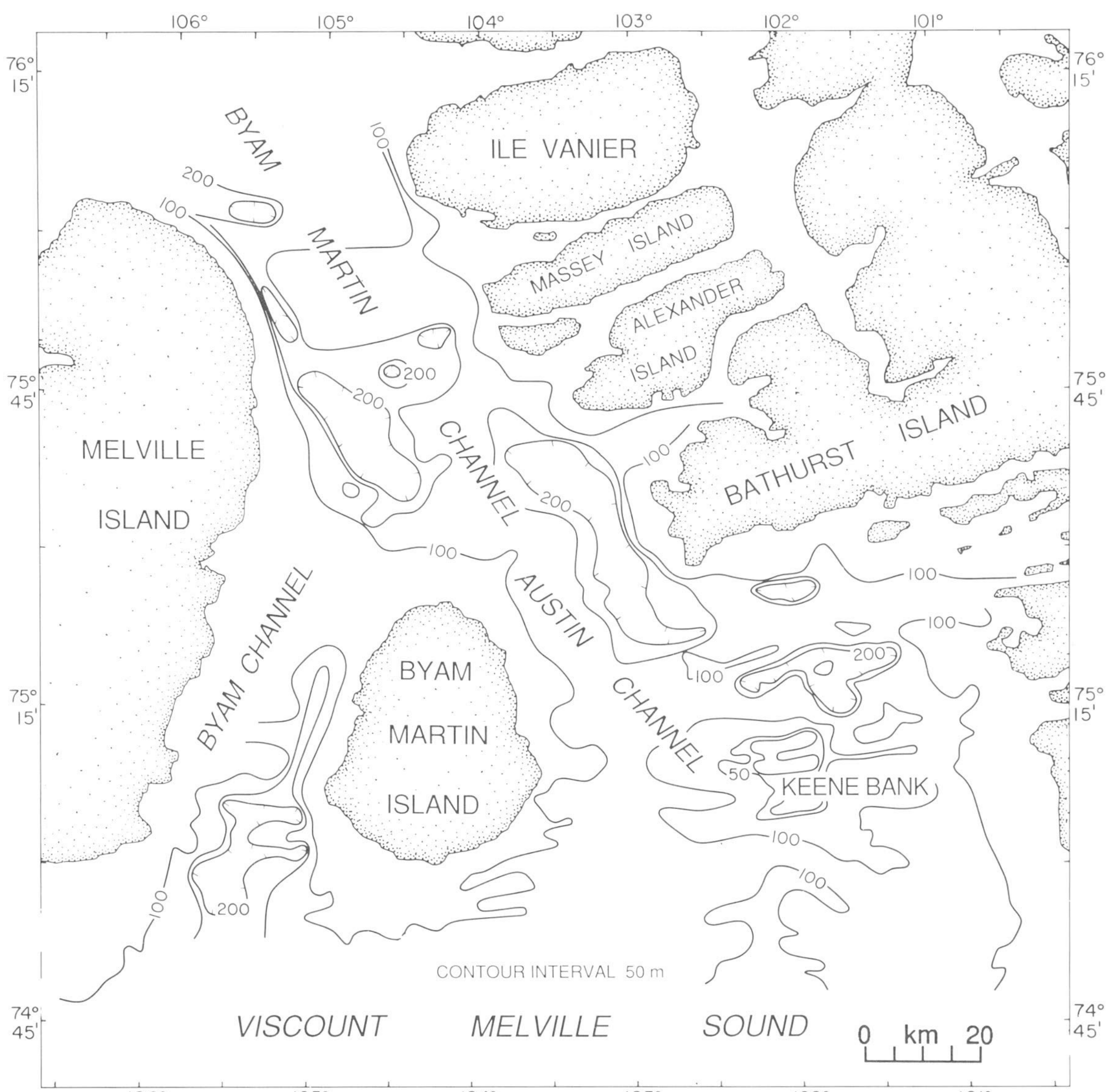


Figure 30. Generalized bathymetry of the Byam Martin — Austin channel region.

Barrow Strait. Sediment samples from this unit consist of structureless olive-grey (5 Y 4/2) silty mud and sandy mud with some dark to very dark grey (5 Y 4/1, 3/1) mottling and banding. Sediments of this unit are interpreted to be of postglacial origin.

The sediment units described are mantled in many localities by a thin brown soupy sediment consisting mainly of silt and clay with variable amounts of sand and gravel sized material. The coarse particles occur as scattered clasts or in crude layers; the sediment is otherwise unstructured (MacLean and Vilks, 1986). Where sampled, these sediments are 30 cm or less in thickness: too thin to be resolved by the acoustic systems used in this study. They are greenish brown in northern Viscount Melville Sound. These sediments appear to be similar to those at the immediate seafloor in parts of Wellington Channel.

Sidescan sonograms (e.g. Fig. 45 and 46) and acoustic profiles (e.g. Fig. 36 and 41) indicate that the seabed in many parts of Byam Martin and Austin channels and northern Viscount Melville Sound has been scoured by grounded ice. Observed ice scouring of the seabed coincides principally with areas of glacial drift outcrop (e.g. Fig. 32 and 41). Seabottom composed of glaciomarine and postglacial sediments appears to be mainly unscoured (e.g. Fig. 43). Scours on sidescan sonograms southwest of Byam Martin Island (Fig. 45) display a pronounced parallel orientation extending across an observed distance of 7.5 km. This suggests that they were formed by a laterally extensive mass of ice. More randomly oriented scours with numerous crossovers in some other shallower areas (e.g. Fig. 46) presumably reflect smaller (and possibly more recent) iceberg groundings.

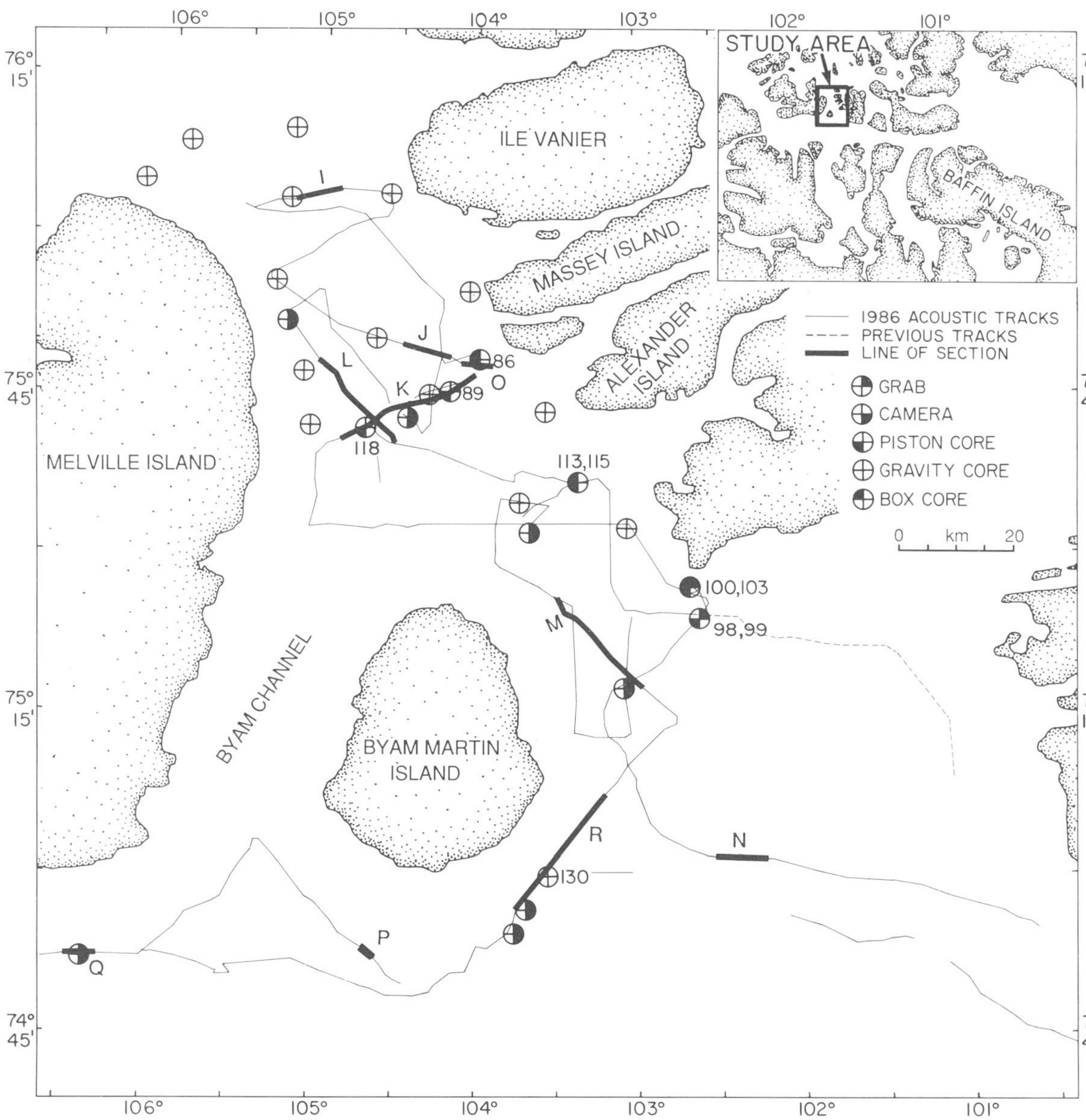


Figure 31. Acoustic tracks and sample stations in the Byam Martin-Austin channel region.

Bedrock geology

Figure 47 shows the bedrock geology underlying Byam Martin and Austin channels based on the interpretation of seismic reflection profiles and information from the adjacent onshore geology. Eastern Melville, Byam Martin, and western Bathurst islands are composed primarily of Middle to Upper Devonian clastic sedimentary rocks which lie in the Parry Islands Fold Belt (Tozer and Thorsteinsson, 1964; Kerr, 1974; A. Okulitch, pers. comm., 1987). Extensive folding of these rocks and subsequent erosional bevelling have produced a pronounced east-west grain to the geology in this region. Outliers of Lower Cretaceous clastic rocks (Isachsen Formation) are present on southeastern Melville Island (Tozer and Thorsteinsson, 1964). Fold axes intersected by the seismic reflection profiles obtained from CSS HUDSON (see for example in Fig. 48) have been used to extend and extrapolate the structural axes mapped onshore. The acoustic characteristics of the rock units on the seismic profiles in general are too uniform to allow distinction of the different units on that basis. Placement of formation boundaries on Figure 47 is based on the extension of unit boundaries from land using the fold axes, apparent bed attitudes, and stratigraphic relations as a guide. The formation boundaries offshore thus are approximate. Relationships observed on the seismic profiles suggest the possibility of minor faulting in a few areas.

Western Barrow Strait

Ice conditions in western Barrow Strait in 1986 prevented collection of sufficient regional profiles in that area to delineate the boundaries of the surficial sediment units. Acoustic profiles and sample data from Cores 72 and 77 (Fig. 49), however, do indicate the occurrence of the same

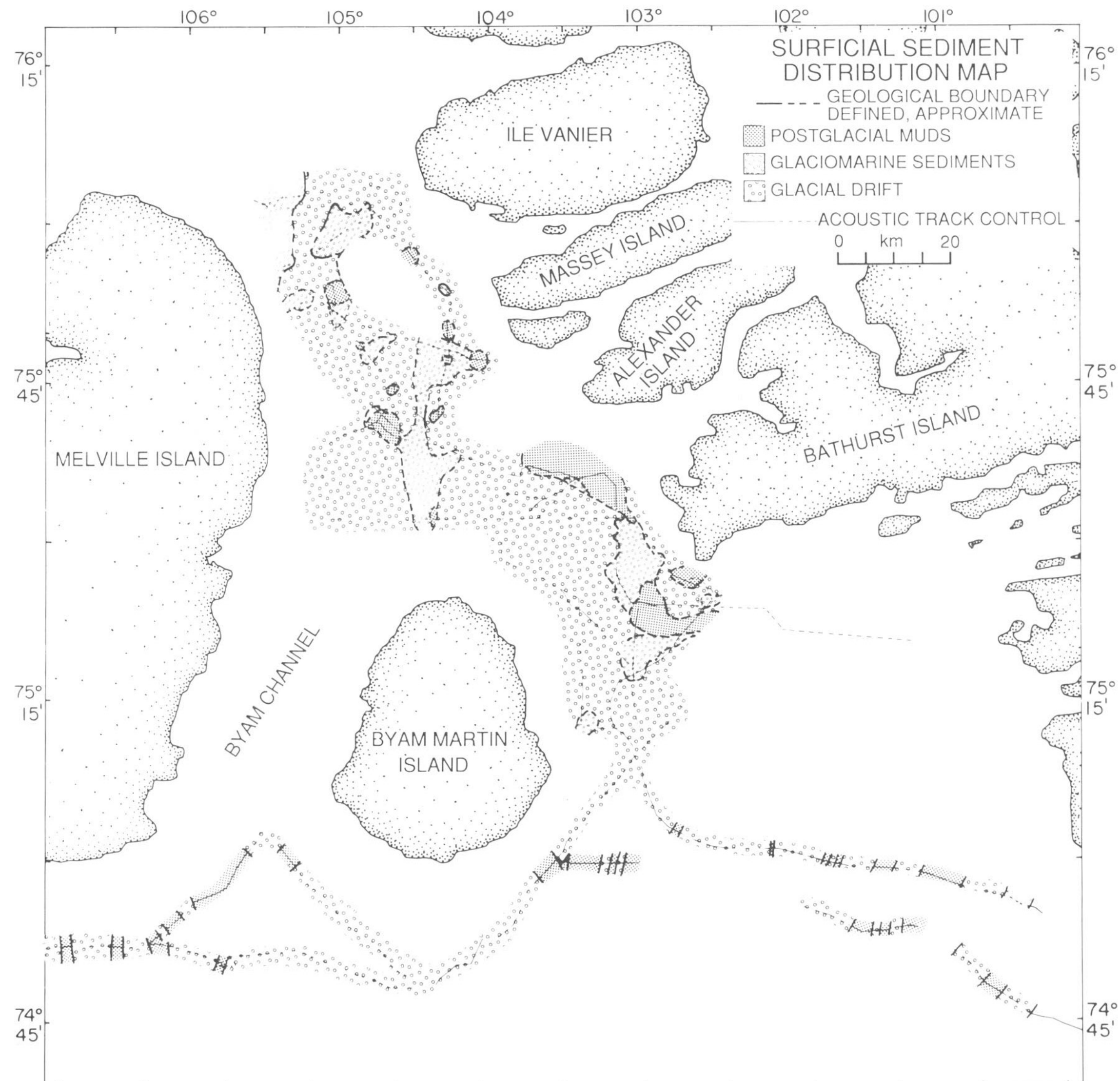


Figure 32. Distribution of surficial sediments in Byam Martin and Austin channels as interpreted from acoustic profiles and preliminary sample data.

three main sediment units recognized in the other Arctic island channel areas. Glacial drift is widespread and where sampled comprises a dark to very dark grey (10 YR 3/1 - 10 YR 4/1) calcareous, pebbly, and sandy mud. It commonly is <5 m thick but locally reaches 25 m in thickness. Acoustically stratified glaciomarine sediments composed of calcareous laminated mud, which is in part sandy and pebbly, locally form deposits up to 3 m in thickness overlying the drift. The sediments range in colour from grey (10 YR 5/1) to dark brownish grey (10 YR 4/2) at Station 72 and grey, olive-grey and very dark grey (5 Y 5/1, 5 Y 4/2 and 5 Y 3/1) at Station 77. The glaciomarine unit in Cores 72 and 77 contains diamict layers which are indicative of very ice-proximal conditions. Acoustically transparent postglacial sediments up to at least 5 m thick variably overlie glacial drift and glacial marine sediments. Samples of these sediments from western Barrow Strait consist of olive-grey (5 Y 4/2) and very dark grey (10 YR 3/1) mud and sandy mud.

SURFICIAL SEDIMENT GEOTECHNICAL PROPERTIES

Geotechnical methods

Analyses of the physical properties of the surficial sediments were carried out on selected core samples from Wellington Channel, eastern and western Barrow Strait, and Byam Martin and Austin channels. Analytical methods and results are outlined in the following sections. The physical properties reported here include undrained shear strength, water content, and bulk density. The undrained shear strength was measured using a modified Wykham-Farrance miniature vane shear apparatus. The modifications included an increased strain rate of 50°/minute and digital recording of torque and strain. Test methods are described by Lee (1985) and are reported here in units of kPa. The water content is defined here as a nondimensional ratio of the weight of pore water to the dried sample weight and is

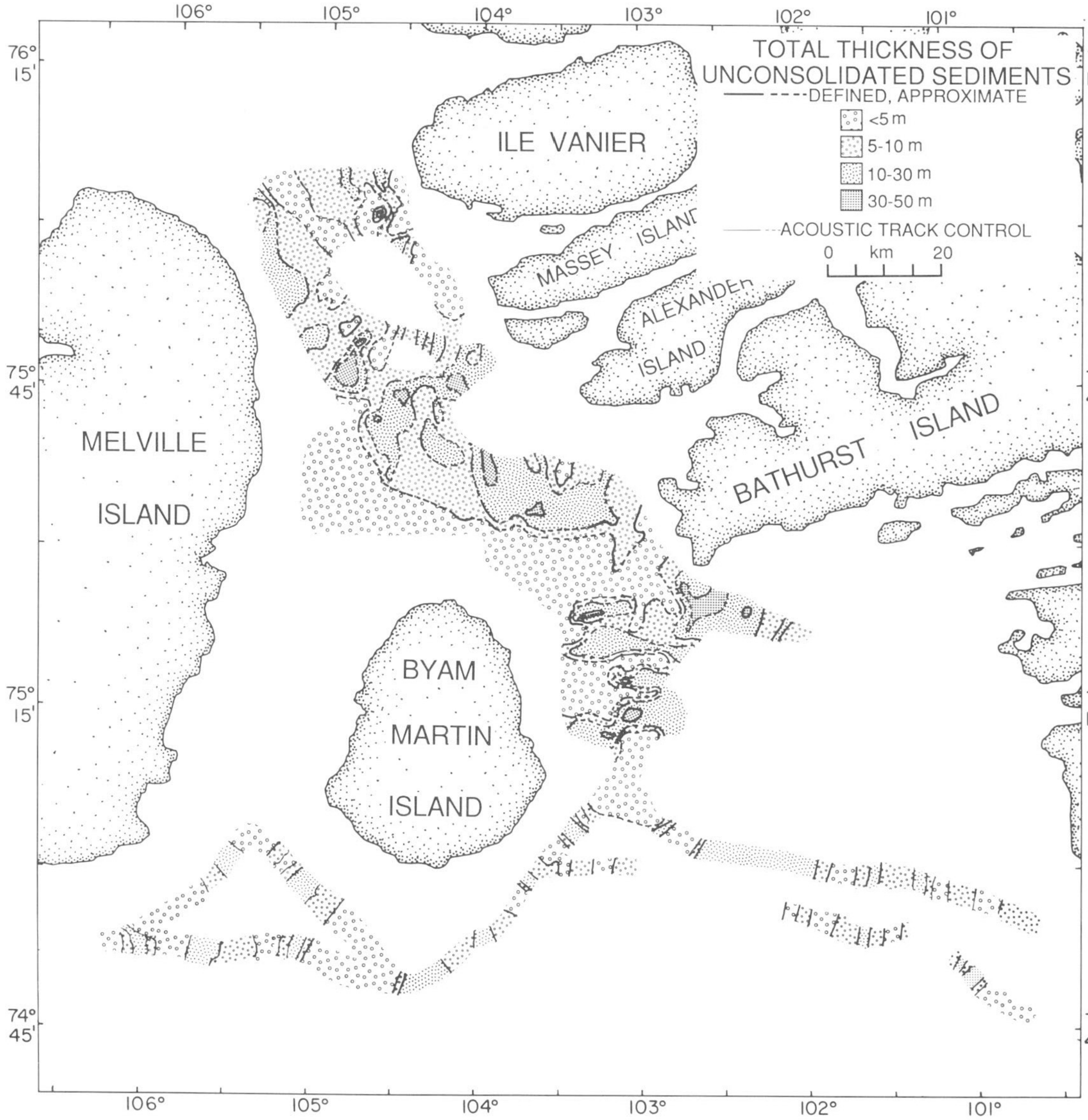


Figure 33. Isopach map of Quaternary sediments in Byam Martin and Austin channels.

reported as a percentage. The water content calculation has been corrected for salt assuming a salt content of 35 ppt as described by Noorany (1984). The bulk density measurement was made using a calibrated volumetric subsampler and direct measurement of the total sample mass. The bulk density is reported here in g/cm^3. All measurements were conducted on board ship on longitudinally split standard Benthos piston cores (inner diameter 7.26 cm) except in one instance (Station 11 in Wellington Channel), where the trigger-weight core was used.

Wellington Channel

In Wellington Channel, three cores were collected, subsampled, and tested for physical properties. Two of these, 86027-11 and 86027-12 were in the northern part of Wellington Channel between Baillie-Hamilton Island and Devon Island (Fig. 49). Core 86027-35 was collected farther south, between Cornwallis and Devon islands. All cores had recovery of less than 2 m of sediment. Correlation of piston cores with trigger-weight gravity cores and with unit thicknesses on acoustic profiles indicates that samples of the uppermost part of the sediment sequence generally were not recovered in the piston cores, due apparently to the very soft fluid nature of this sediment (acoustically transparent postglacial unit) which caused late triggering of the piston corer and allowed this material to be pushed aside by the corer.

Results of geotechnical studies of the sediments in the cores from Wellington Channel (Fig. 50) show the acoustically transparent postglacial unit to be a very soft sediment. It has low shear strength, with values ranging from 2.0 kPa in Core 12 to 3.9 kPa in Core 35, and low bulk densities, ranging from 1.1 g/cm^3 to 1.3 g/cm^3 in Core 11. These sediments have very high water contents, up to 180% in Core 11. Below this very soft unit, the glacial drift shows

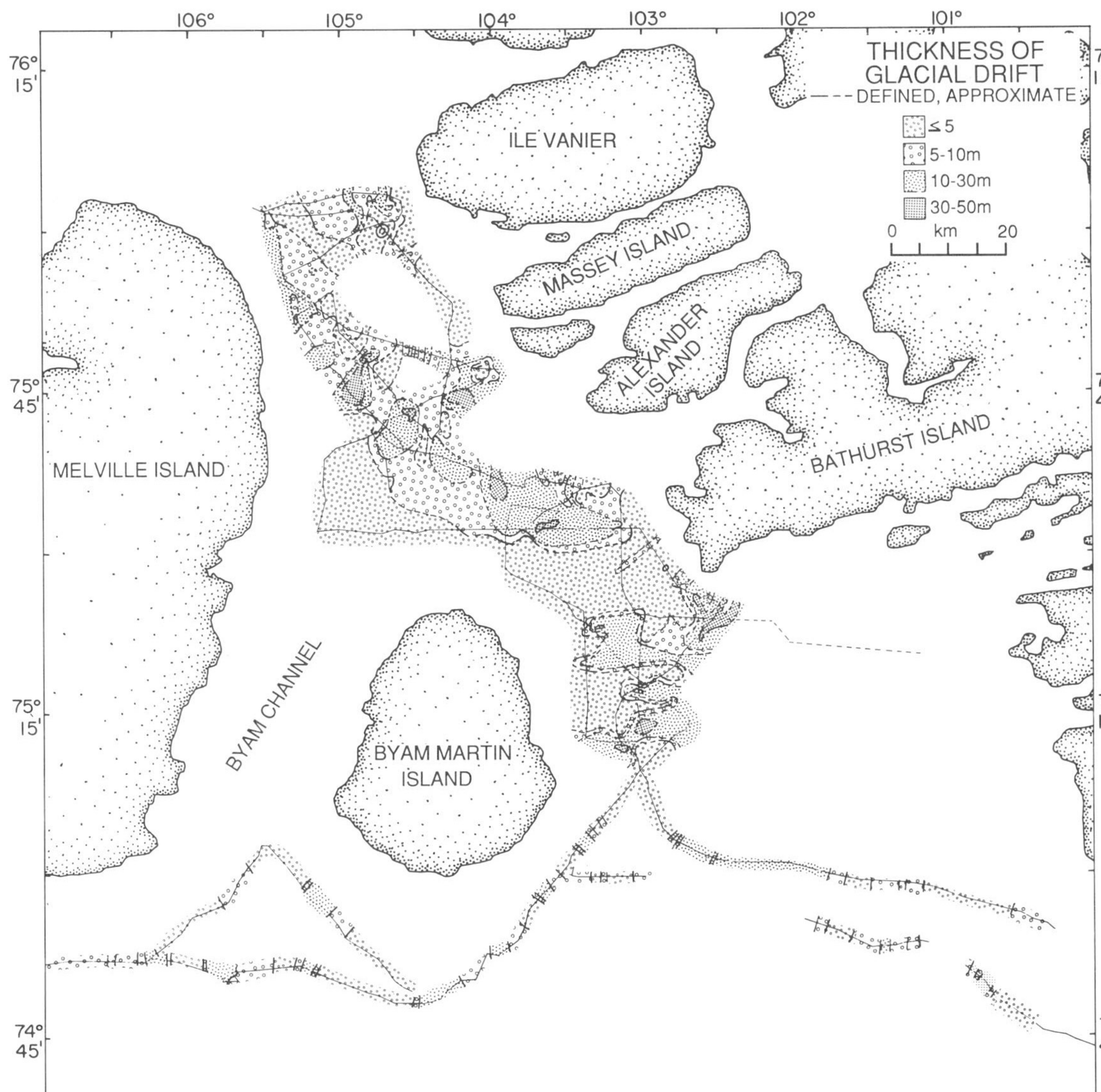


Figure 34. Isopach map of glacial drift in Byam Martin and Austin channels.

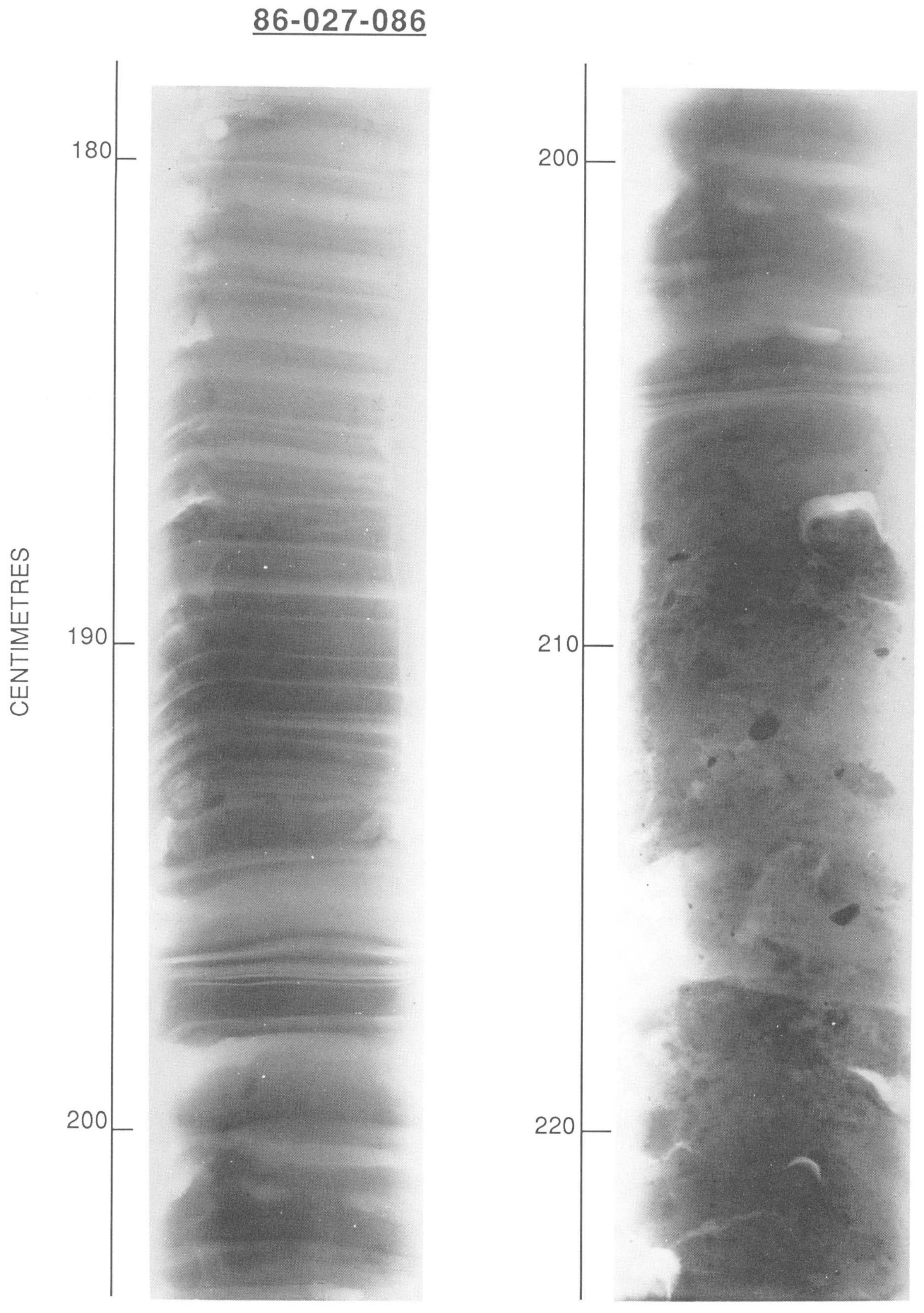


Figure 35. X-radiographs of Core 86, northeastern Byam Martin Channel, interval 180 to 220 cm illustrating laminated silty and clayey glaciomarine sediments above 208 cm, and coarser unstructured diamict glacial drift sediments below.

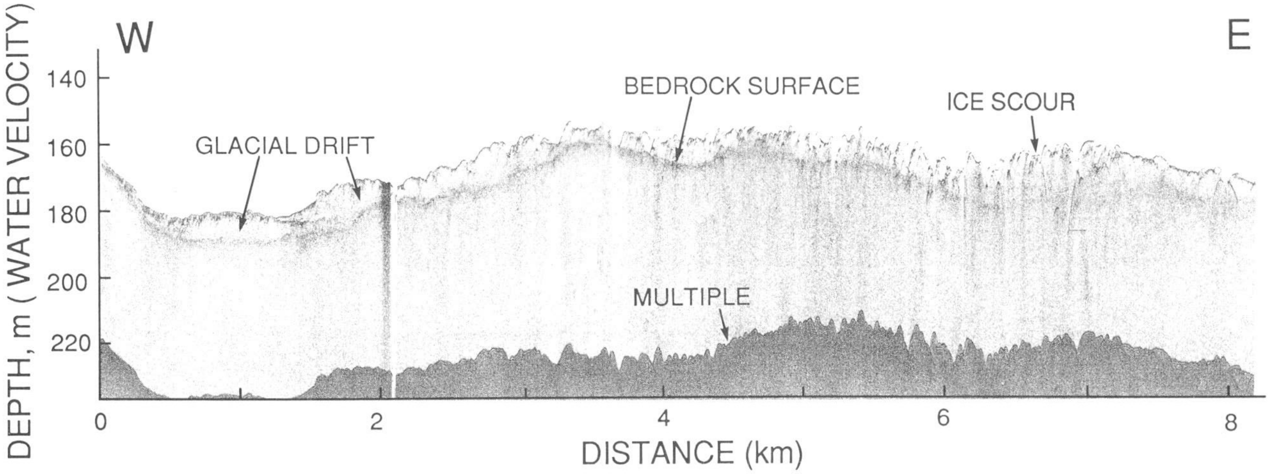


Figure 36. Section I: Huntec profile illustrating intensely ice-scoured seabed composed of glacial drift in northern Byam Martin Channel. Two drift sequences occur in the areas 1-2 km and 6-8 km along section (see Fig. 31 for location).

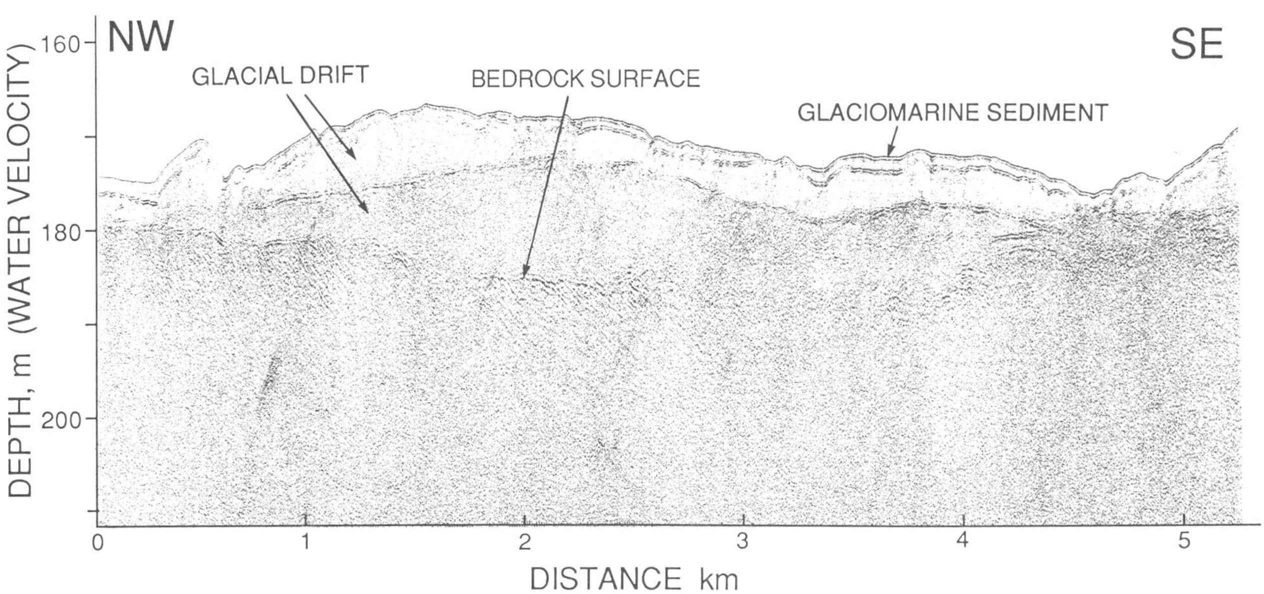


Figure 37. Section J: Huntec profile showing multiple drift sequences overlain by glaciomarine sediments in eastern Byam Martin Channel (see Fig. 31 for location).

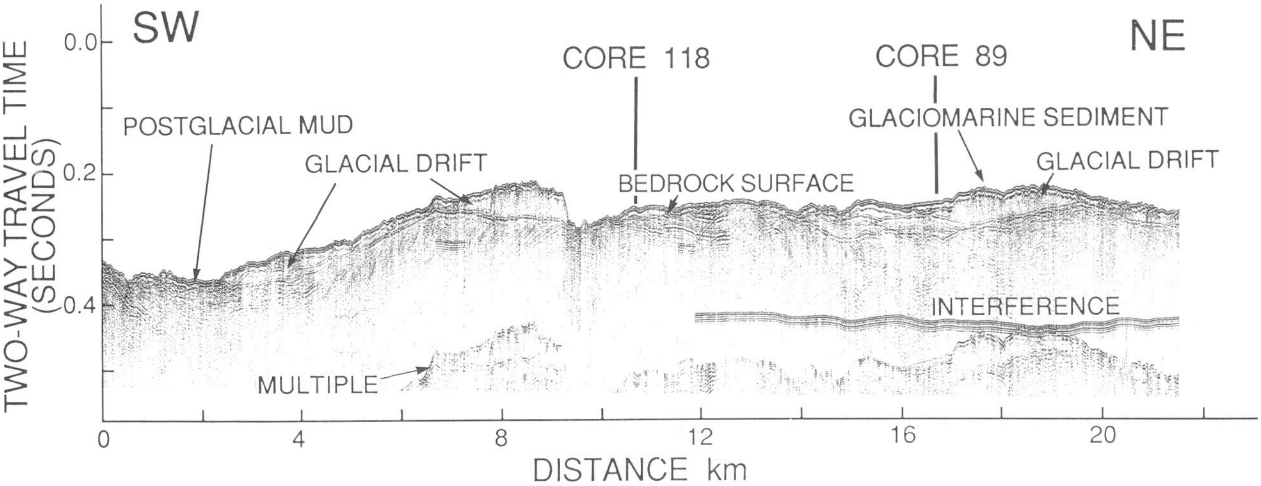


Figure 38. Section K: seismic reflection (airgun) profile illustrating positive glacial drift features in central Byam Martin Channel (see Fig. 31 for location).

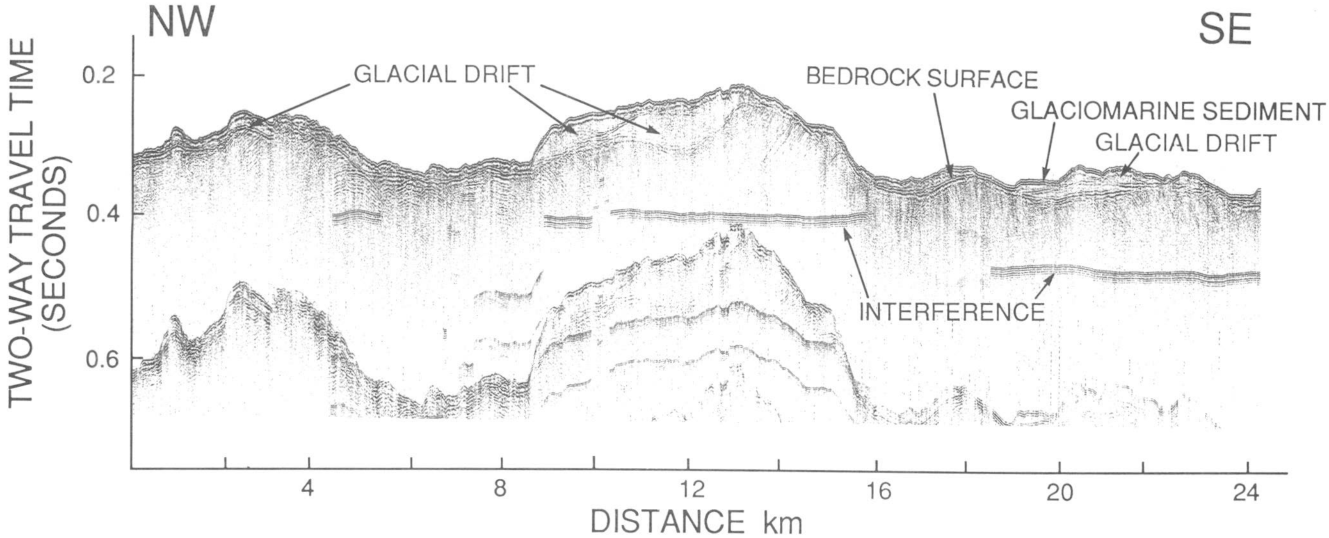


Figure 39. Section L: seismic reflection (airgun) profile illustrating bedrock structures and multiple drift occurrences in western Byam Martin Channel (see Fig. 31 for location).

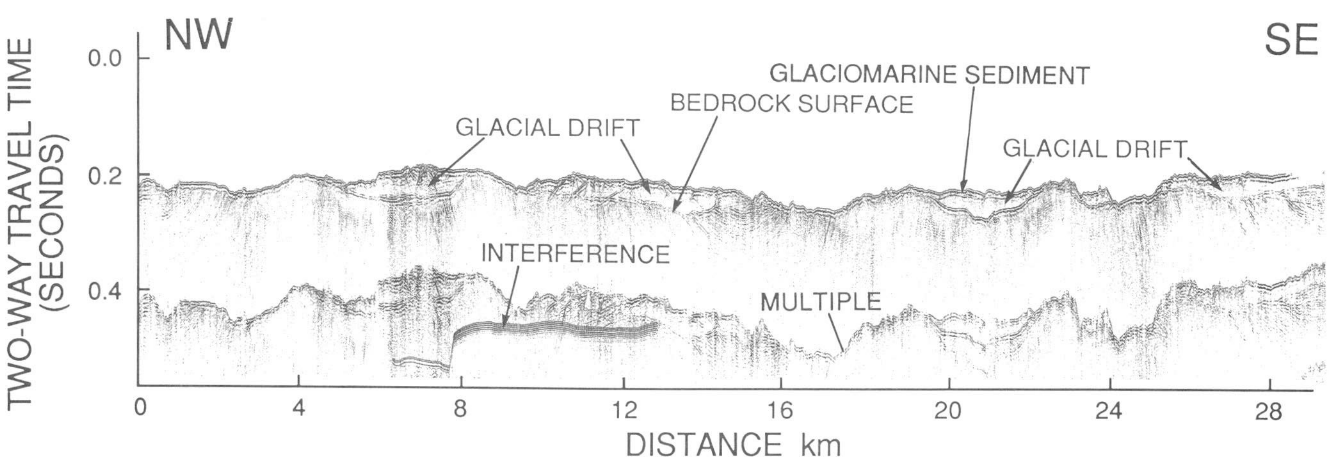


Figure 40. Section M: seismic reflection profile northwest-southeast along Austin Channel showing glacial drift forming positive features and infilling depressions. Note bedrock fold structures (see Fig. 31 for location).

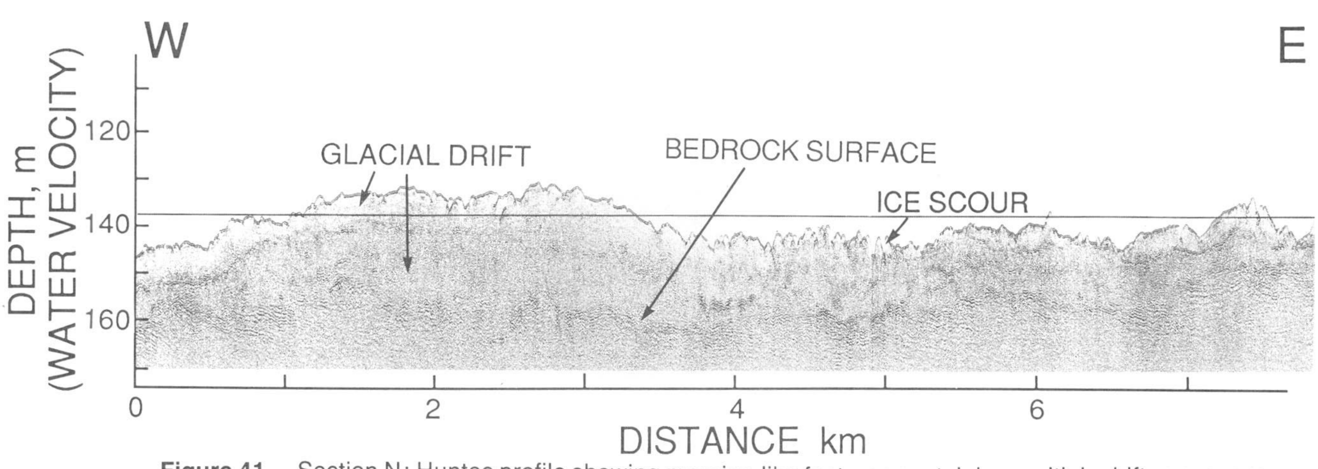


Figure 41. Section N: Huntec profile showing moraine-like features containing multiple drift sequences near Keene Bank in northern Viscount Melville Sound, east of the entrance to Austin Channel. The sediments have been extensively ice scoured (see Fig. 31 for location).

a dramatic change in values. Water content decreased to 15% in Core 12 and to 20% in Core 35. Bulk density and shear strength values were significantly higher than in the overlying sediments, up to 2.1 g/cm^3 and 9.5 kPa, respectively. The marked change in values apparently reflects either or both the textural change or a change in stress history between these sediment units.

Eastern Barrow Strait-western Lancaster Sound

Three piston cores in eastern Barrow Strait-western Lancaster Sound were subsampled and tested for physical properties. The cores are 86027-144, which was obtained in the western basin, and 86027-154 and 86027-159, which were collected in the eastern basin (Fig. 19 and 49). Cores 144 and 154 provide information on sediments of the glacial drift, acoustically stratified glaciomarine, and acoustically transparent postglacial units, while Core 159 penetrated only the lower two units (Fig. 51 and 52). Figure 24 illustrates these units at the Core 154 locality. A fourth core, 86027-162, collected in northern Prince Regent Inlet between Somerset Island and Brodeur Peninsula of Baffin Island (Fig. 49) mainly sampled glacial drift (Fig. 51).

The glacial drift in cores 144, 154, and 159 in eastern Barrow Strait-western Lancaster Sound characteristically had high bulk densities and low water contents. Densities ranged from 2.0 to 2.24 g/cm^3 while water content was in the order of 20%. Shear strength values were variable, ranging from 7.2kPa in Core 154 to 25 kPa in Core 144.

The acoustically stratified glaciomarine sediments were characterized by lower bulk densities, 1.8-1.9 g/cm^3, and somewhat higher water contents, ranging from 20-40%. Shear strengths ranged from 2.5 to 9 kPa.

Figure 42. Distribution of acoustically stratified sediments interpreted to be of glaciomarine origin in the Byam Martin-Austin channel region. Numbers indicate thickness in metres.

Bulk densities of the acoustically transparent postglacial unit sampled in cores 144 and 154 ranged from 1.4-1.6 g/cm^3, significantly lower than those of the acoustically stratified sediments. Water content was substantially higher, ranging from 96-112 % near the top of cores 144 and 154. These values decreased downcore to 40-50 % near the base of the unit (Fig. 51 and 52). Shear strength values which were characteristically low (3-4 kPa) near surface increased gradually downcore to a maximum of 8 kPa near the base of the unit in Core 144 (Fig. 51).

The physical property differences between the acoustically stratified glaciomarine and acoustically transparent postglacial sequences in these cores may relate either to differences in stress history or textural differences arising from different depositional environments, or both.

Core 162 was collected in northern Prince Regent Inlet (Fig. 49). The corer penetrated only 1.38 m of sediment of which the upper 0.20 m consisted of gravel; the lower part was interpreted to be glacial drift. Measurements of the drift unit show high bulk densities, ranging from 1.82-2.05 g/cm^3, and very low water contents in the order of 20 % (Fig. 51). These values resemble those from the glacial drift at cores 144, 154, and 159.

Byam Martin Channel

Physical property testing was carried out on four piston cores collected in Byam Martin Channel (Fig. 31 and 49). Cores 86027-86, 86027-89, and 86027-113 were collected in the eastern part of the channel near Bathurst Island, and Core 86027-118 on the western side.

These cores sampled acoustically stratified glaciomarine sediments and glacial drift (Fig. 53 and 54). Figure 43 illustrates the relationships of the sediment units. A thin 36 cm interval of the acoustically transparent postglacial unit present in the trigger-weight core from Station 86 was not recovered by the piston core. Physical property measurements show values for these sediment units in Byam Martin Channel generally similar to those in Wellington Channel and in eastern Barrow Strait-western Lancaster Sound.

Bulk density values in the glacial drift were in the range of 1.9-2.0 g/cm^3, while water content was mainly 15-20 %, and shear strength increased downcore from less than 5 to nearly 20 kPa. The acoustically stratified glaciomarine sediments yielded bulk density values in the order of 1.4-1.7 g/cm^3, water content values of 55-90 %, and shear strength values of 1.4 to 4.8 kPa (Fig. 53 and 54). Bulk density and shear strength typically showed a gradual

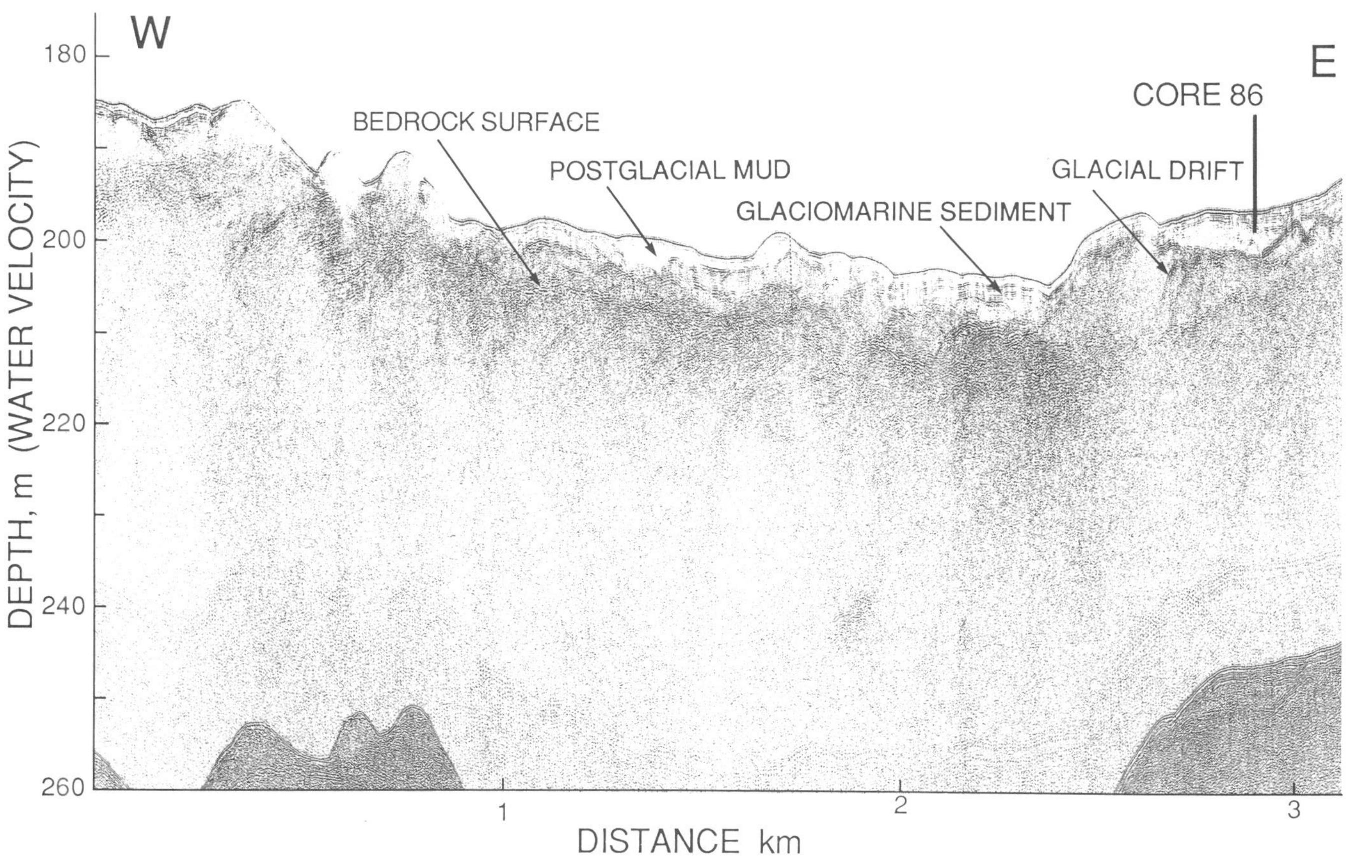


Figure 43. Section O: Huntec profile illustrating glacial drift sediments overlain by acoustically stratified and acoustically transparent sediments in eastern Byam Martin Channel (see Fig. 31 for location).

increase downcore in this unit while water content showed a gradual decrease. Core 86, the northernmost in Byam Martin Channel, texturally is atypical of the acoustically stratified glaciomarine sediments in that it is a distinctively banded silty clay devoid of granule and pebble sized clasts (Fig. 35) except in the uppermost 30 cm. The core yielded relatively constant values throughout the glaciomarine unit except for slight increases in water content near 1.1-1.4 m and 1.8 m (Fig. 53) which apparently relate to intervals containing some fine sand laminae.

The results of the physical property measurements on the core samples from Byam Martin Channel reflect distinct changes in both depositional environments and stress history of the glacial drift and glaciomarine sediment units.

Austin Channel

Three piston cores were collected in northeastern Austin Channel, 86027-100, 86027-99, and 86027-98 (Fig. 31 and 49). Water content and bulk density measurements were made on all three cores (Fig. 55). A thin sequence of acoustically transparent postglacial sediments lies on acoustically stratified glaciomarine sediments in Core 98, and on glacial drift in Core 99. Core 100 sampled only glacial drift. Bulk density values from the glacial drift were consistently high, ranging from 1.9 to slightly more than 2.0 g/cm^3, and water content was low, ranging from 18-24%. Measurements of the shear strength of the drift yielded values up to 14 kPa. Physical property measurements on the overlying postglacial sediments in Core 98 indicated a high water content, 75%, and low density, 1.5 g/cm^3, near surface.

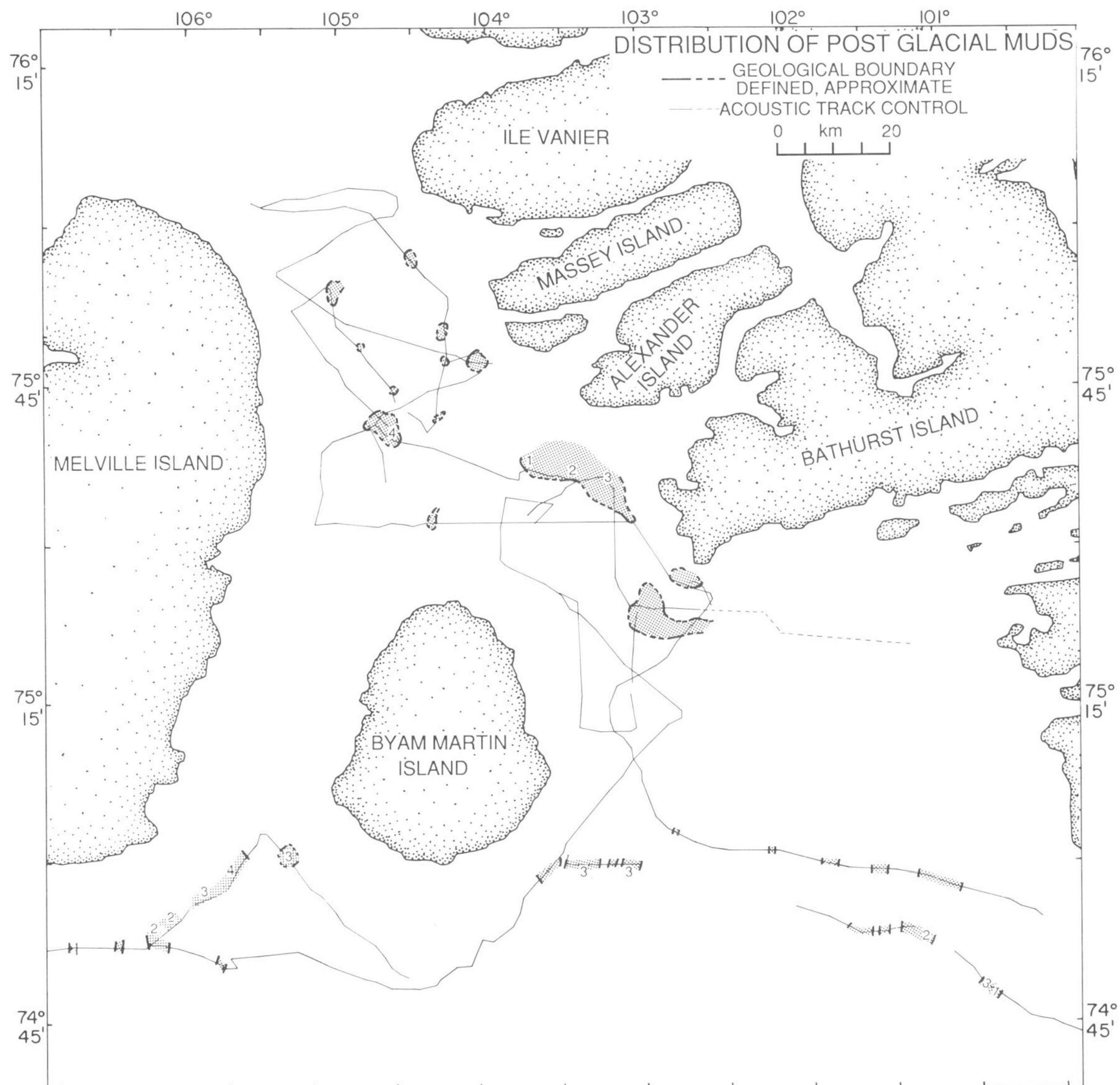


Figure 44. Distribution of acoustically transparent mud interpreted to represent postglacial sediments in the Byam Martin-Austin channel region. Occurrences of these sediments here are confined to localized depressions. Numbers indicate thickness in metres.

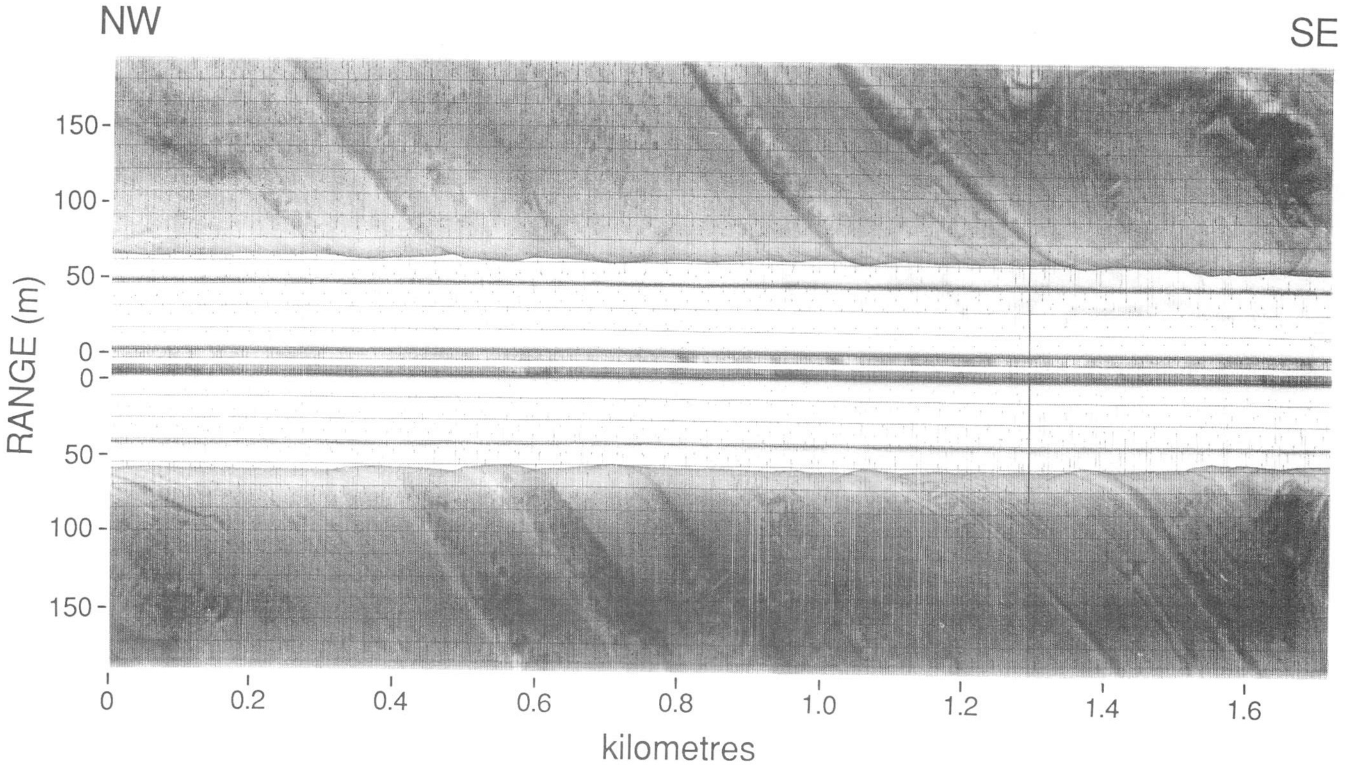


Figure 45. Section P: Sidescan sonogram illustrating parallel scours south of Byam Martin Island formed by the multiple keels of an extensive mass of ice; either a grounded glacial ice sheet or large iceberg (see Fig. 31 for location).

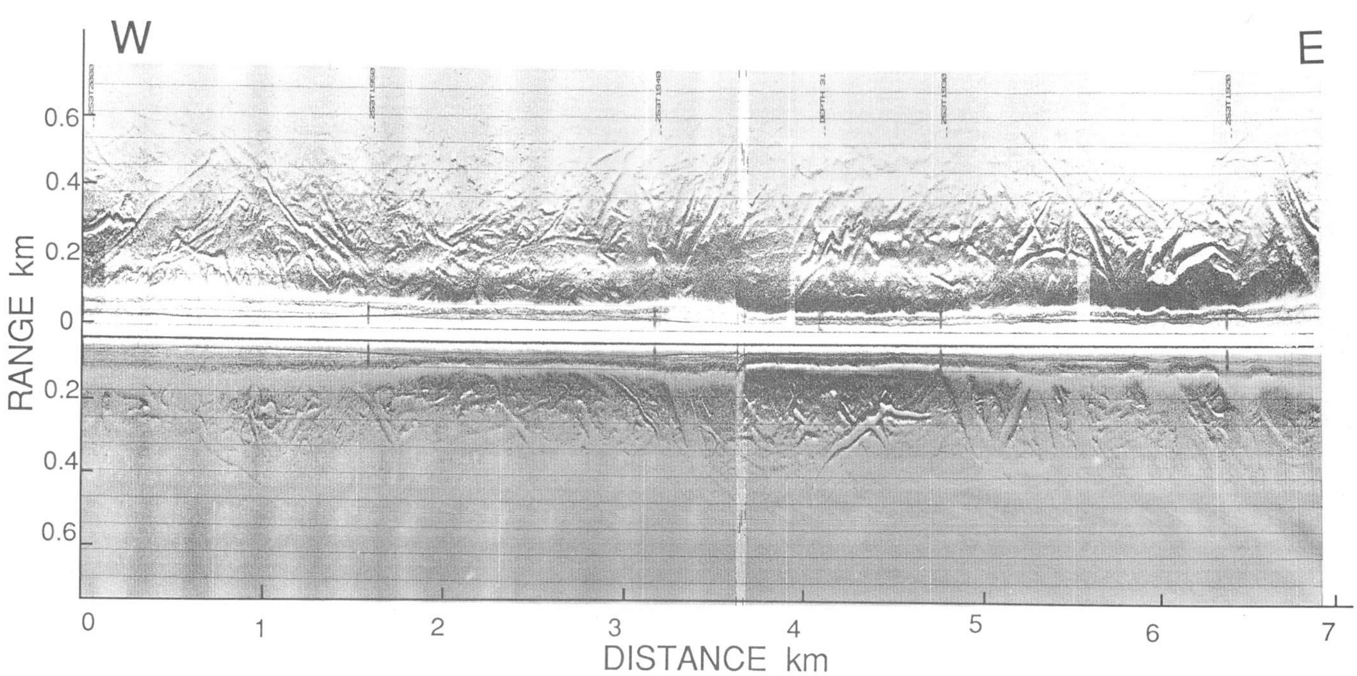


Figure 46. Section Q: Sidescan sonogram showing intense scouring of seabed sediments by grounded ice southeast of Melville Island in northern Viscount Melville Sound (see Fig.31 for location). The scours here display numerous crossover relationships and more random orientations than were observed farther north in Byam Martin Channel and in Wellington Channel (see Fig. 31 for location).

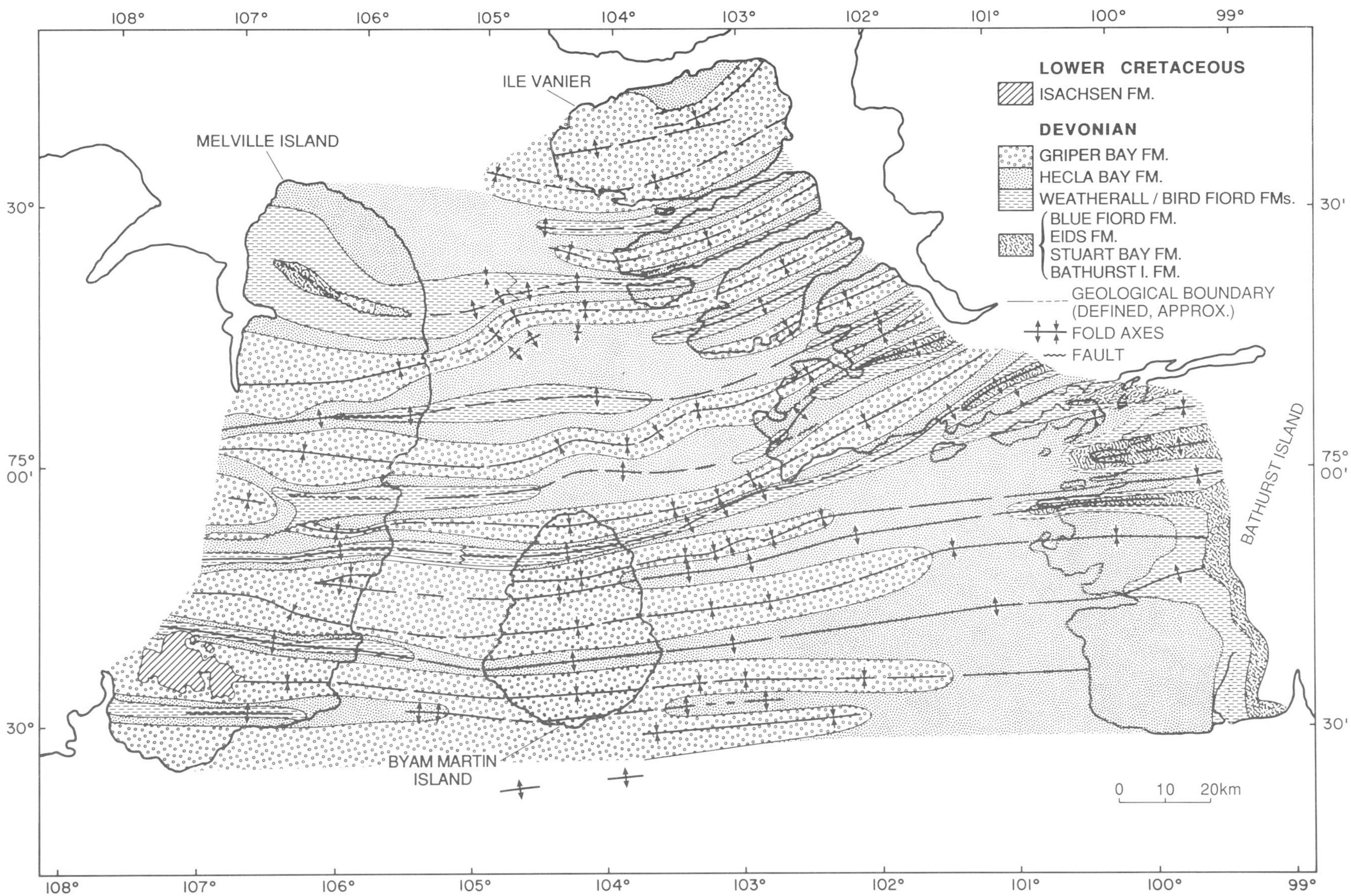


Figure 47. Map showing an interpretation of bedrock geology in the Byam Martin-Austin channel region derived by correlation of the fold structures intersected on the seismic profiles with those of the pronounced structural pattern of the adjacent Melville, Byam Martin, and Bathurst islands (Tozer and Thorsteinsson, 1964; Kerr, 1974; A. Okulitch, pers. comm., 1987). Formation boundaries offshore are approximate.

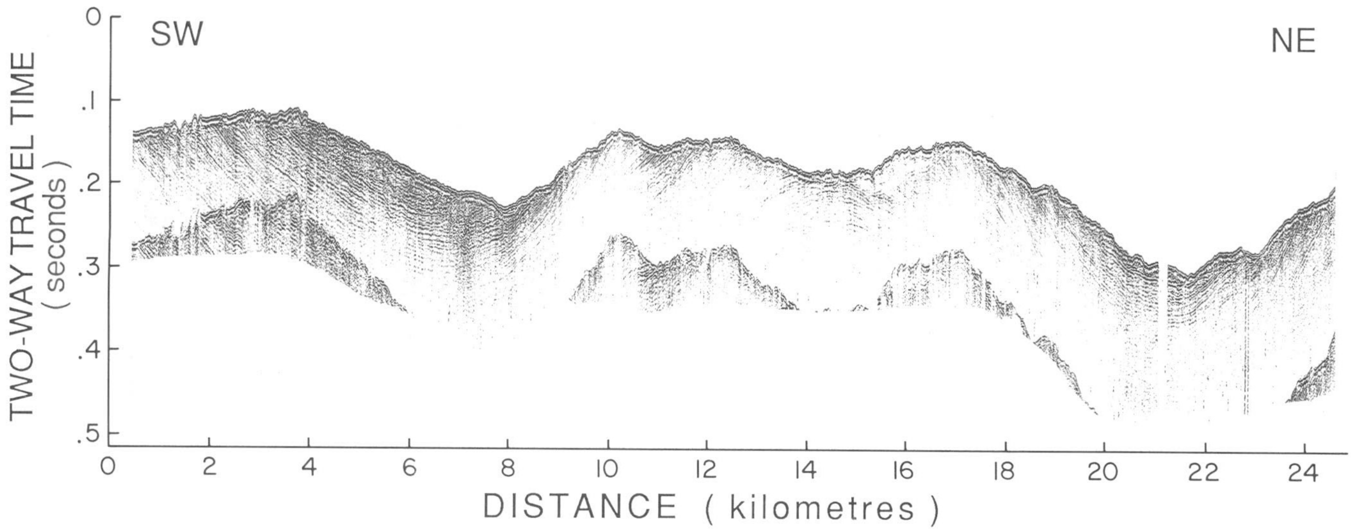


Figure 48. Section R: Seismic reflection profile showing folds in bedrock strata in Austin Channel. Glacial drift and other Quaternary sediments are very thin (see Fig. 31 for location).

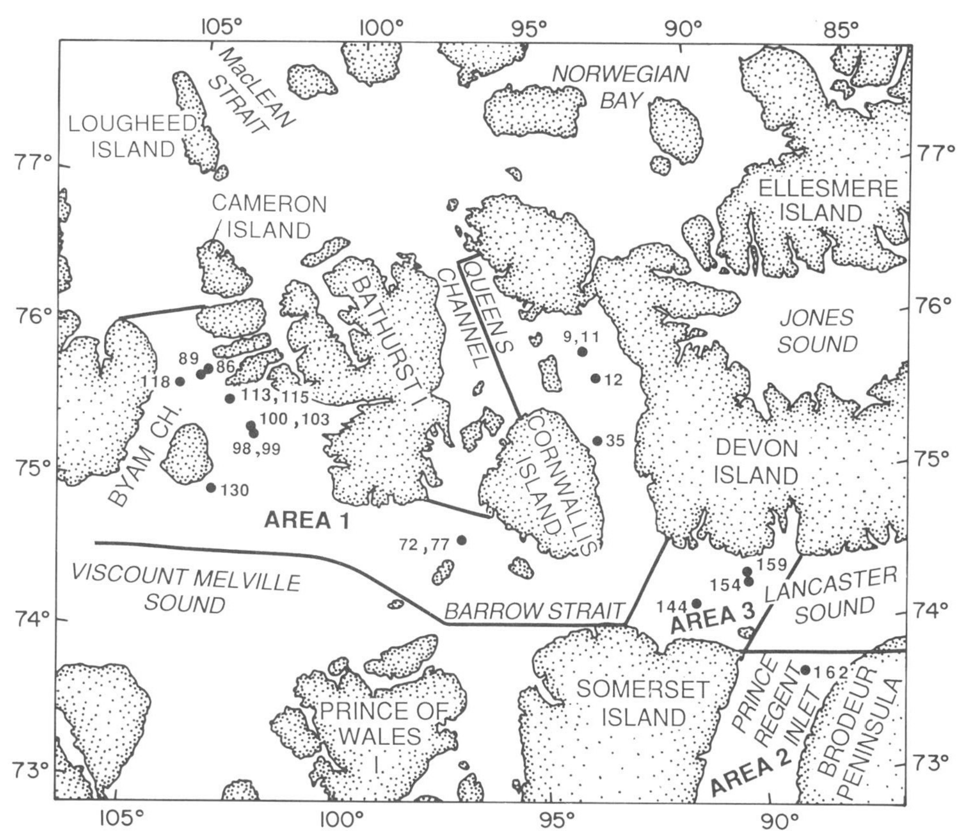


Figure 49. Map showing locations of cruise 86-027 core stations. Areas 1-3 are those recognized and discussed in relation to magnetic susceptibility.

As in Byam Martin Channel, the data set for interpretation of the surficial physical properties is sparse. Available data, however, indicate that the sediments sampled are predominantly dense and could be the result of an eroded or ice loaded environment. The latter is consistent with the texture of the sediments as indicated by X-radiography and with the character of the sediments on acoustic profiles.

Western Barrow Strait

Geotechnical measurements on Cores 72 and 77 from western Barrow Strait (Fig. 49) displayed marked increases in bulk density and shear strength and a corresponding reduction in water content in the glacial drift versus the overlying acoustically stratified glaciomarine sediments (Fig. 56).

BIOSTRATIGRAPHY

Introduction

The Quaternary marine biostratigraphy of the interisland channels of the Canadian Arctic is based on foraminifera preserved in sediments. The abundance and characteristics of foraminifera in the surface sediments of the Arctic Archipelago depend on the environmental conditions and water depth at any given locality. Foraminifera are sparse in the surface sediments in Viscount Melville Sound, in Barrow Strait, and in some localities farther north in Prince Gustaf Adolf Sea, where the channels act as conduits for the water flowing from the Arctic Ocean to Baffin Bay (Vilks, in press). More environmental studies are needed to explain the sparse fauna in these areas. Agglutinated species dominate the sediments in water depths shallower than 200 m in

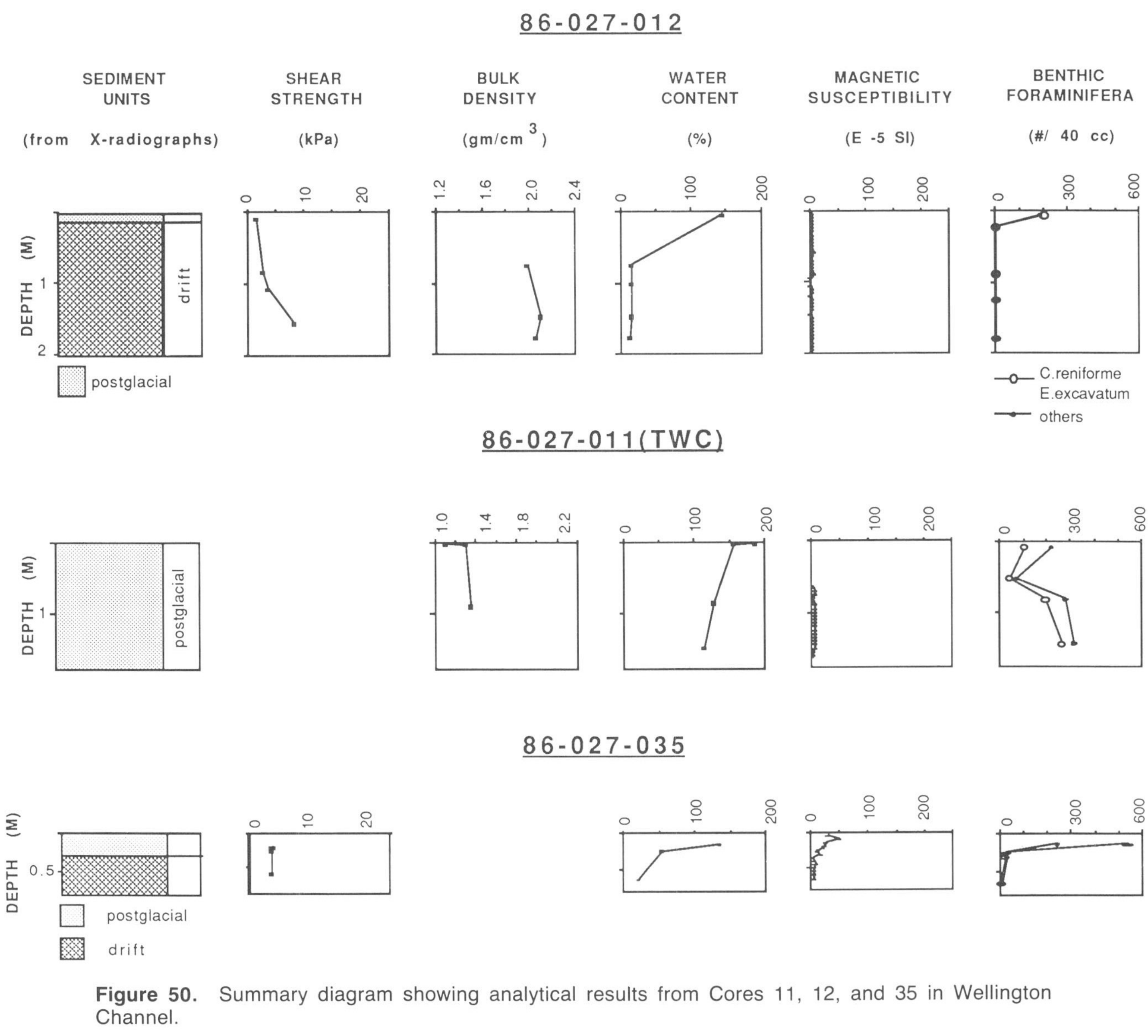


Figure 50. Summary diagram showing analytical results from Cores 11, 12, and 35 in Wellington Channel.

the channels to the west of longitude 100° W in western Barrow Strait (Vilks, 1969), but not to the east. The agglutinated faunas occur in areas of Arctic Surface Water and more extensive perennial sea ice in the western channels (Vilks, 1964, 1969, 1976). Calcareous species are found in large numbers in the fine sediments of basins and bays at water depths greater than 200 m in the western channels, but east of longitude 100° W in western Barrow Strait they occur in all deposits of fine sediment regardless of water depth.

Previous downcore studies of foraminifera are few, owing to the difficulty in collecting cores in areas of persistent sea ice, and the remoteness of the region. In several channels where there is perennial sea ice, gravity cores have been taken through holes in the ice using aircraft for transportation (Marlowe and Vilks, 1963; Vilks, 1964, 1969; Marlowe, 1968; MacLean and Vilks, 1986). These relatively short cores collected basically muddy sediments of the postglacial unit with an underlying subsurface zone barren of fauna, suggesting more severe marine conditions prior to the present oceanographic setting (Marlowe, 1968). In Parry Channel, piston cores have been taken from ships, and foraminifera in a few of these cores have been studied (Vilks and Joyce, 1976; Vilks, 1977). The cores have been difficult to interpret due to paucity of preserved fauna. Vilks (1977) related an increase in foraminiferal occurrence downcore in Lancaster Sound to the period when the central Arctic Archipelago was occupied by glacial ice and the paleocirculation was different than the present.

In this paper we report on foraminiferal content in piston cores collected during Cruise 86027. The data are summarized to show faunal boundaries that are related to different depositional environments as indicated by textural and goetechnical properties of the sediment units and to the setting at the coring sites as shown by seismic profiles.

Methods

Approximately 40 cm^3 subsamples of sediment were taken at 30-40 cm intervals from 20 cores (Fig. 49, Table 1) on board ship shortly after core recovery, and washed through a 0.063 mm sieve a few months later. The total fauna was identified, but only the major species are considered here.

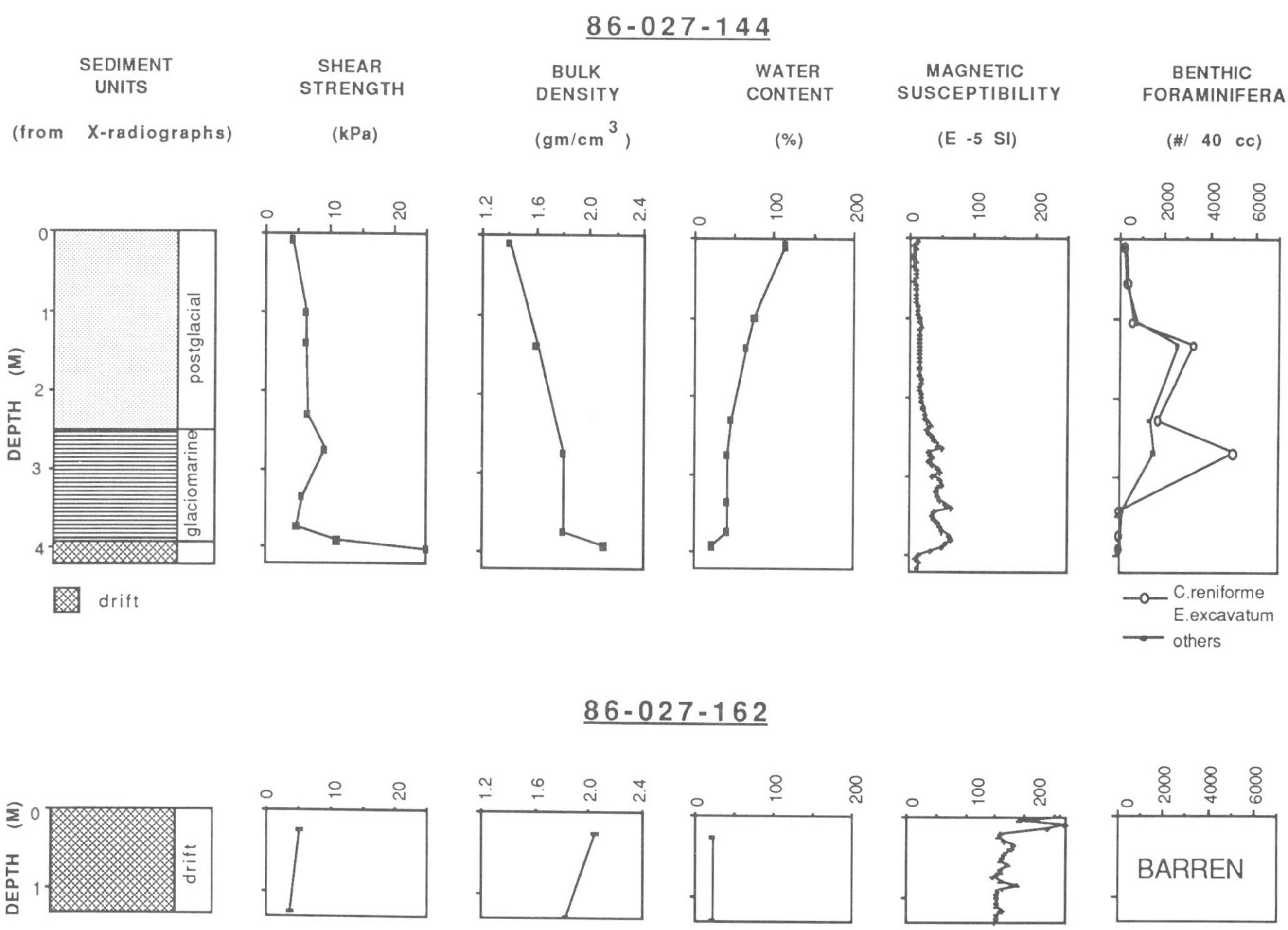


Figure 51. Summary diagram showing analytical results from Core 144 in eastern Barrow Strait and Core 162 in northern Prince Regent Inlet.

Major species are those that rank to 90 % of total fauna identified. Samples that contain less than one test per cm^3 of sediment are considered as barren and were excluded from the analysis. Species diversity in samples was calculated using the information function H as discussed in Buzas and Gibson (1969):

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where p is the proportion of the ith species, and S is the number of species observed.

Results

Thirty-nine benthic foraminifera were identified as major species (Table 2); 13 species are agglutinated and the remainder are calcareous. On average 376 specimens per sample were counted or estimated in 137 samples (Table 3). Many samples were barren of foraminifera, especially toward the bottom of the cores. *Neogloboquadrina pachyderma* (Ehrenberg) is the only planktonic species present, and is shown in Table 3 as percent of total number of foraminifera present in the sample.

The accuracy of sample depths in piston cores is not certain due to loss of surface sediments during coring. The gravity cores used as trigger weight most likely collected a reasonably complete sample of surface sediments, and are therefore considered in a continuous sequence with the piston core samples. The recorded subsample depths in piston cores in Tables 3 and 4 do not accurately represent depths below the seabed, but do indicate relative distances between subsamples.

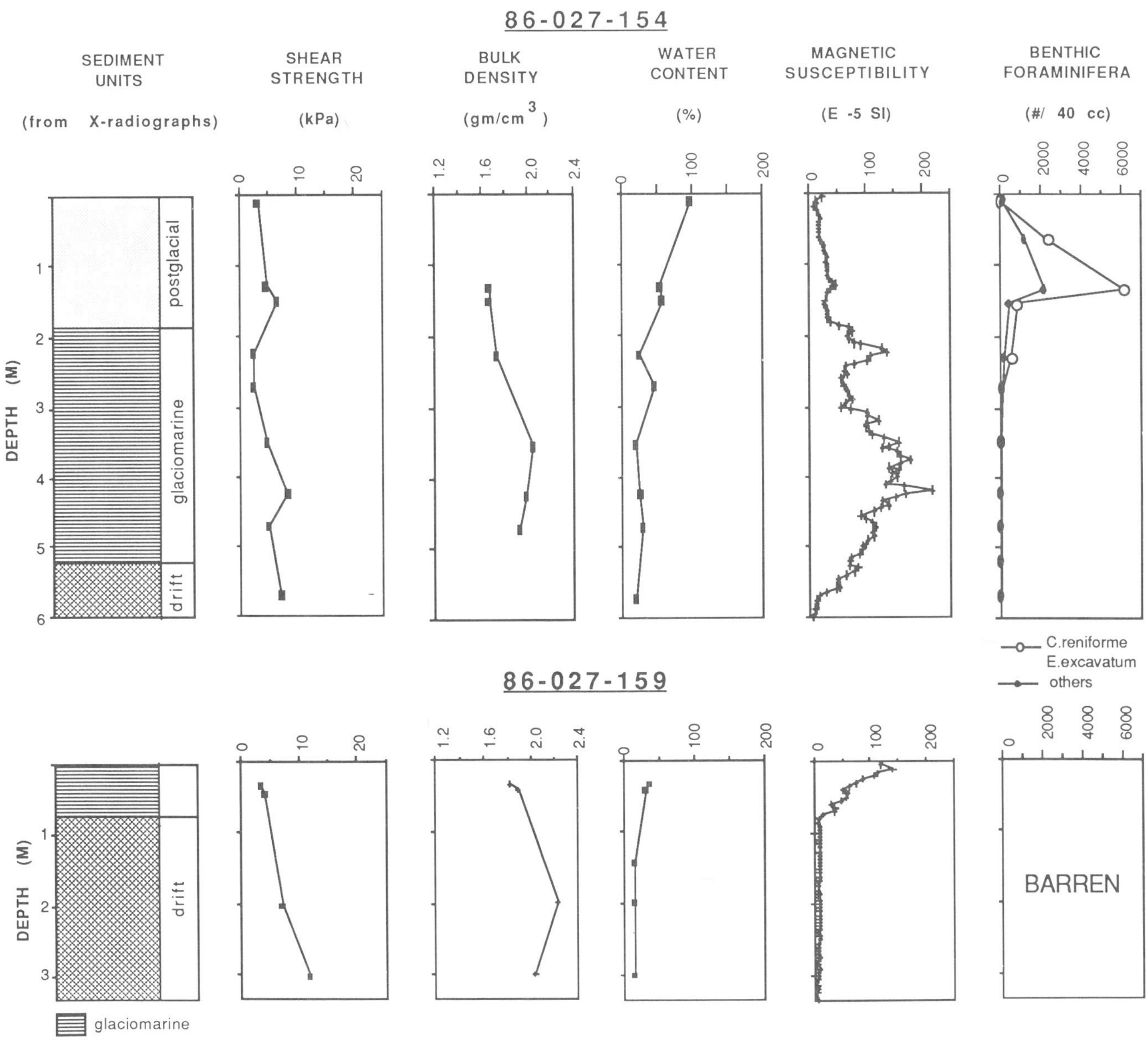


Figure 52. Summary diagram showing analytical results from Cores 154 and 159 in eastern Barrow Strait-western Lancaster Sound.

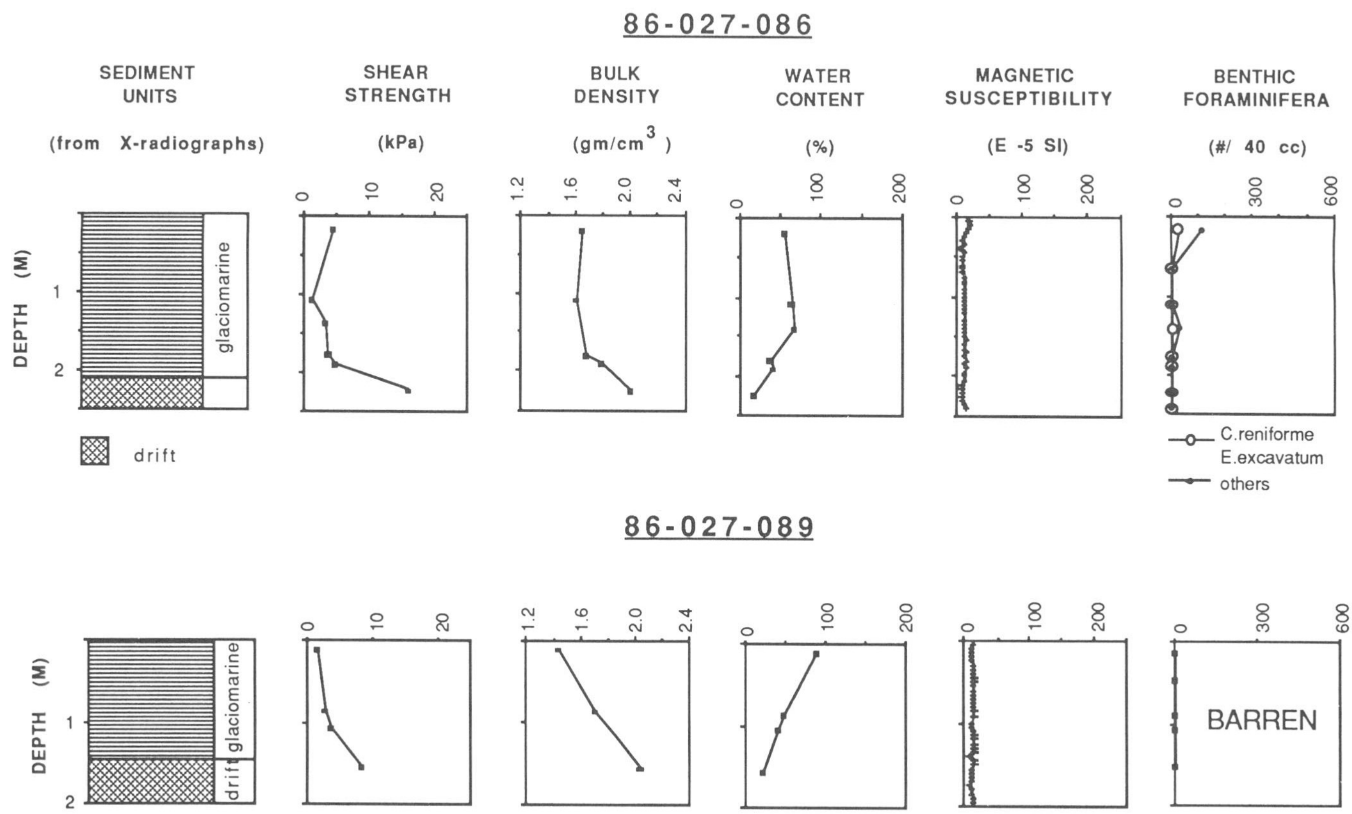


Figure 53. Summary diagram showing analytical results from Cores 86 and 89 in Byam Martin Channel.

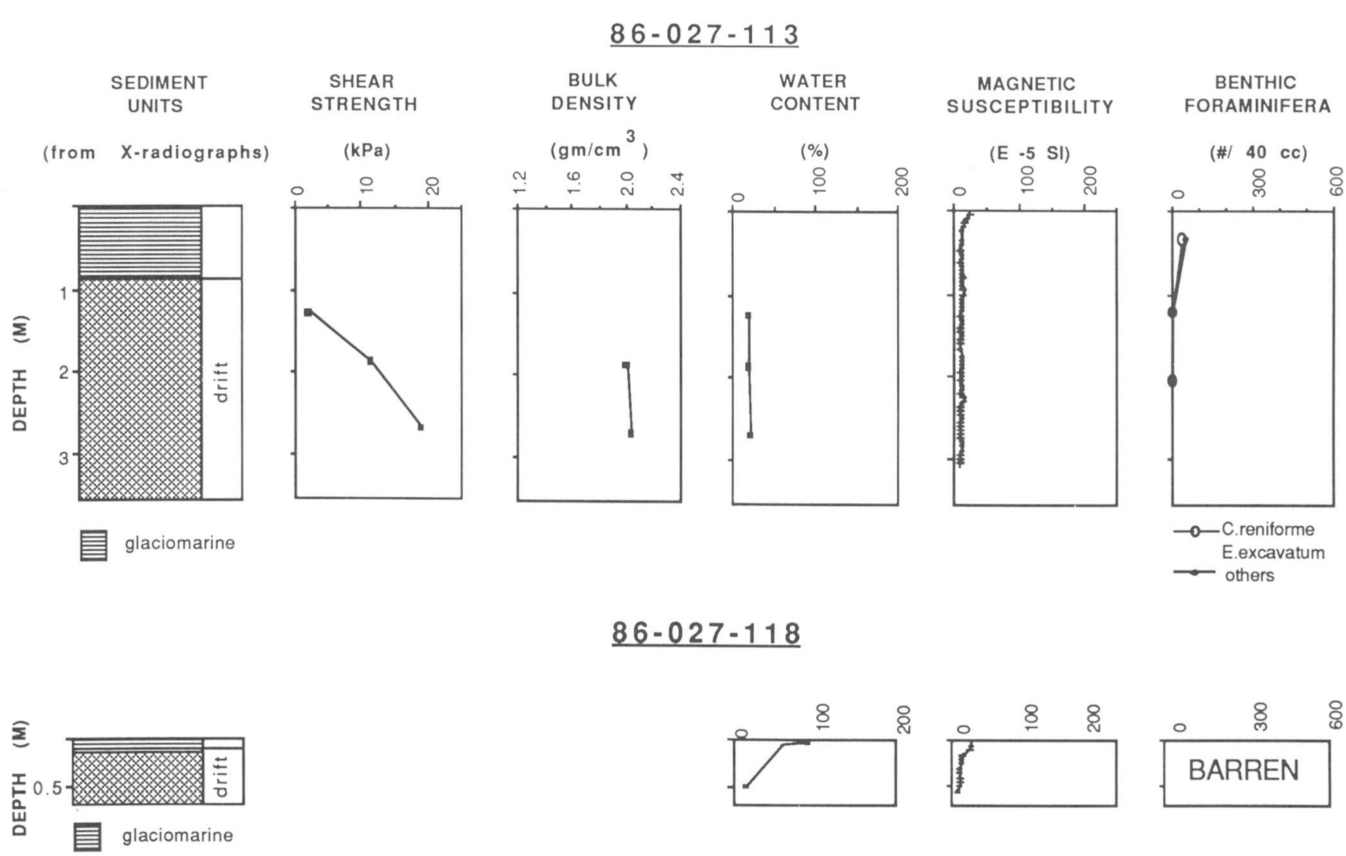


Figure 54. Summary diagram showing analytical results from Cores 113 and 118 in Byam Martin Channel.

The depth of the uppermost subsamples in trigger-weight cores varies between 1 and 51 cm, therefore, only approximate relationships between foraminifera and the present-day environment are considered. The distribution of species within the study area varies as follows.

Surface sediments

Wellington Channel: Agglutinated species are few and occur in small numbers. The ranking calcareous species are:

C. reniforme	28.5 %
B. frigida	19.5 %
E. excavatum clavatum	12.8 %
I. norcrossi	11.5 %
I. helenae	8.5 %

Western Lancaster Sound: Agglutinated species are few and occur in small numbers. The ranking calcareous species are:

B. frigida	19.7 %
C. reniforme	17.7 %
I. norcrossi	12.0 %
I. helenae	8.7 %
E. takayanagii	7.3 %

Western Barrow Strait: Surface samples were barren of foraminifera.

Viscount Melville Sound: Agglutinated species are few; the ranking calcareous species are:

E. excavatum clavatum	29.0 %
C. reniforme	22.0 %
B. frigida	11.0 %

Austin Channel: Calcareous species are absent; the ranking agglutinated species are:

A. glomerata	46.3 %
T. nana	22.7 %
S. biformis	8.0 %

Byam Martin Channel: Calcareous species are rare; the ranking agglutinated species are:

A. glomerata	36.0 %
T. nana	29.0 %
S. biformis	4.4 %
T. atlantica	4.0 %

Foraminifera in surface sediments are basically similar in Wellington Channel, western Lancaster Sound, and Viscount Melville Sound and are dominated by the calcareous species *C. reniforme* and *B. frigida*. The Byam Martin and

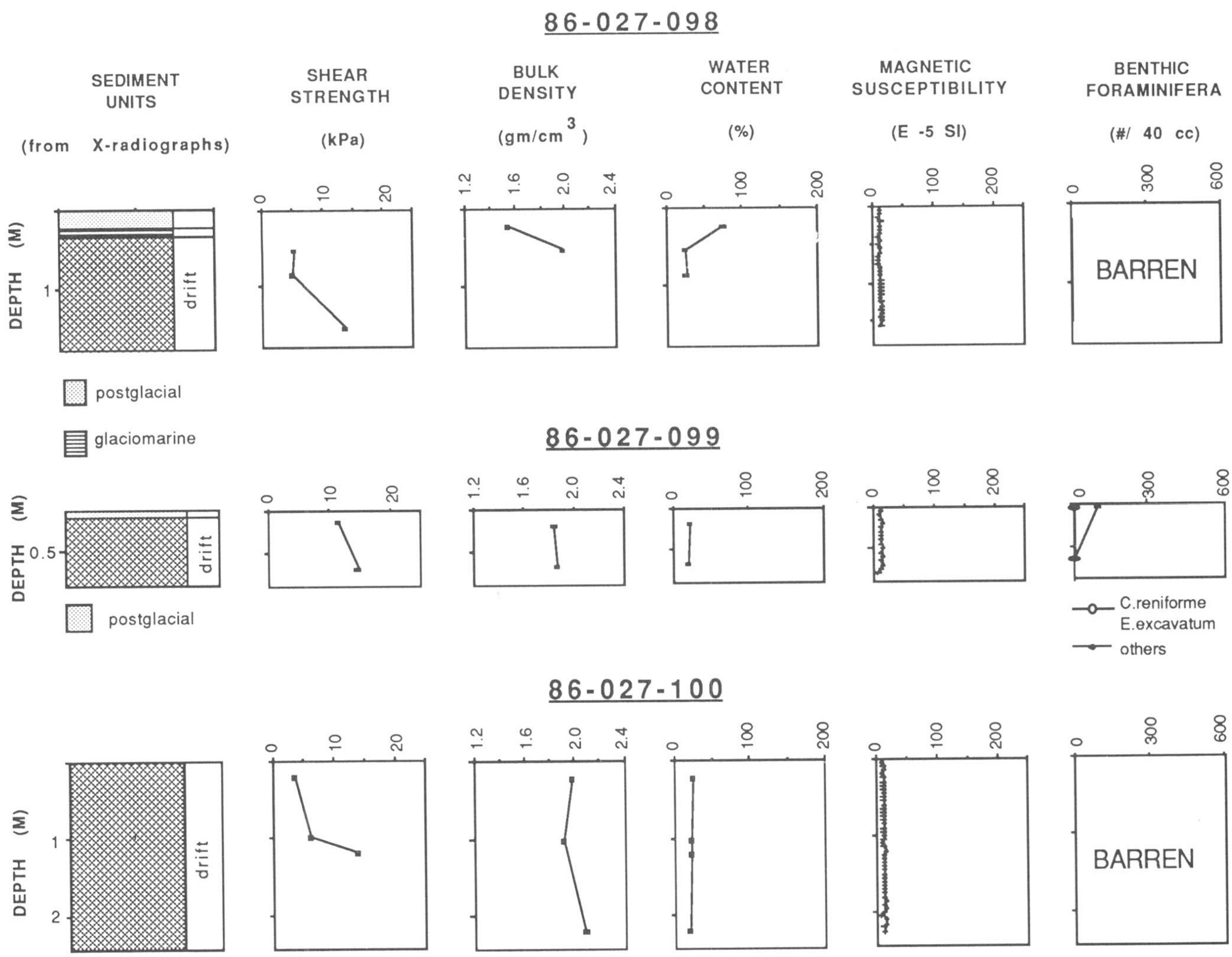


Figure 55. Summary diagram showing analytical results from Cores 98, 99, and 100 in Austin Channel.

Austin Channel surface faunas are different and are dominated by agglutinated species *A. glomerata* and *T. nana*. The surface sediments in two cores from western Barrow Strait are barren of foraminifera. The presence of agglutinated versus calcareous species is not related to present water depth.

Average diversities of the calcareous fauna range between 2.06 and 2.30 in Wellington Channel, Lancaster Sound, and Viscount Melville Sound. The diversities of the agglutinated fauna in Austin Channel and Byam Martin Channel are 1.56 and 1.89 respectively. Species diversity and faunal abundance are not related, although species do occur in low diversities in samples close to the limit of being barren.

Sediment cores

Species distribution

In all cores, species are more abundant in surface sediments sampled by the trigger-weight cores (TWC) than in the piston cores (PC) (Table 3). The overlap between the trigger-weight cores and piston cores is not known, but the distribution of faunas suggests that in most cases it is negligible. For each coring site the uppermost interval of the trigger-weight core is considered to be the surface sample. Cores 72 and 77 taken in western Barrow Strait are examples of the differences between the sections sampled by the trigger weight cores and that in the piston cores. There, the upper 50 cm of the postglacial sediments in the trigger weight cores are barren of foraminifera, but foraminifera are present downcore between 50 and 150 cm. These fauna are absent throughout the total lengths of the two piston cores.

The comparison of the surface and subsurface distribution of species in the postglacial sediments shows a regional trend from east to west (Table 5). The agglutinated species are more common to the west of Barrow Strait, especially *T. nana*, which is absent in the east. *A. glomerata* is common in the surface samples in the west, but occurs in subsurface samples in the east. The most common calcareous

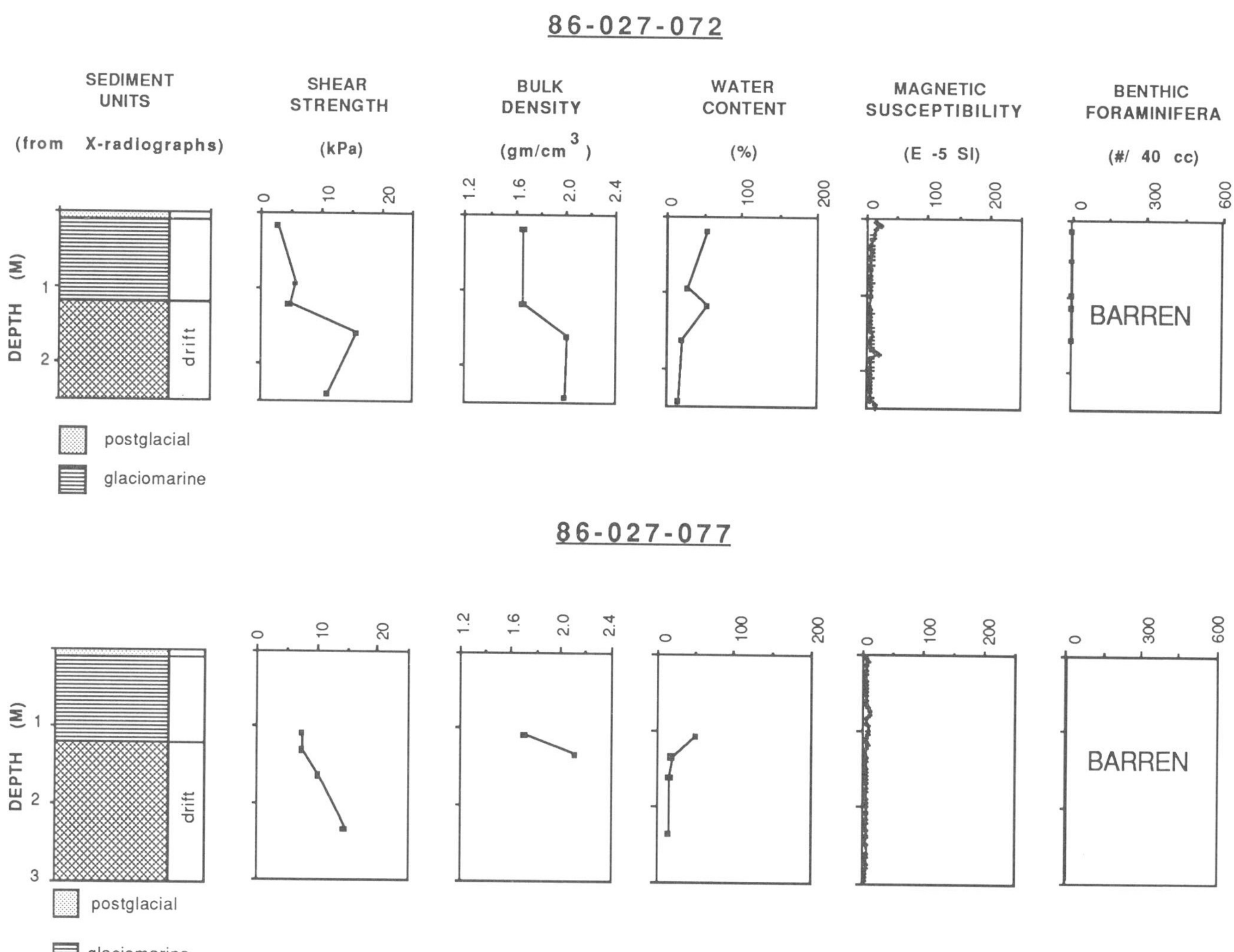


Figure 56. Summary diagram showing analytical results from Cores 72 and 77 in western Barrow Strait.

species that occur in the east are rare in surface samples in the west, but are common in subsurface samples, especially in Core 86 (Table 5). The change from agglutinated to calcareous faunas downcore has interesting paleoceanographic connotations that will be discussed later.

A number of species are present only in the subsurface samples of the postglacial sediments throughout the region. *C. laevigata* occurs in seven cores, mostly in piston cores and not shallower than one metre in the two trigger weight cores in whish they are present. The species is sufficiently common in subsurface sediments to make its absence in surface sediments significant. Ten other less common species are present only downcore, but their absence in surface sediments may be due to spotty occurrence.

Biostratigraphic boundaries

Redistribution of sediments by currents and ice rafting mixes sediments of different ages, modifying or destroying the level in the sediment where species last occurred. Therefore, the level of species first occurrence is a more reliable indicator of a biostratigraphic boundary than is its last occurrence.

Stratigraphic boundaries in the study area were established by considering in each core the first occurrence of only those species that are present continuously in at least three subsamples or approximately one metre of sediment (Table 6). This criterion is intended to diminish inclusion of spurious occurrences.

Comparison of *C. reniforme* and *E. excavatum* with other benthic foraminiferal populations from the sediment units in cores throughout the region are illustrated in Figures 50-56. Because of the relatively short cores and the discontinuous occurrence of species, only three cores are useful for establishing regional type sections. Table 6 shows the order of the first occurrence of species in Core 35 from Wellington Channel and Cores 144 and 154 from eastern Barrow Strait-western Lancaster Sound. *E. excavatum* and *C. reniforme* appear before the other species in all three cores. The first appearance of the two species is therefore a useful stratigraphic marker. The first occurrence of the other species is not in the same order in all the cores. Because of the inconsistant sequences or crossovers, those species are not useful boundary indicators. For example, in Cores 154 and 144 *C. complanata* occurs after I. helenae has appeared, but in core 35 *C. complanata* occurs first.

On the basis of foraminiferal evidence two biostratigraphic boundaries are recognized: 1) the first appearance of foraminifera, which are *C. reniforme* and *E. excavatum*

Table 1. Station locations, water depths, and core recoveries.

Core	Latitude N	Longitude W	Water Depth (m)	Core Length (cm)	
				Piston	TWC
9	75° 54.50'	93° 43.00'	350	13	190
11	75° 55.48'	93° 41.77'	311	28	176
12	75° 49.26'	93° 22.93'	265	200	131
35	75° 24.70'	93° 26.50'	271	81	150
72	74° 45.55'	97° 04.00'	287	262	161
77	74° 45.72'	97° 03.74'	278	305	165
86	75° 49.16'	103° 59.90'	183	253	103
89	75° 46.18'	104° 11.20'	170	201	140
98	75° 25.05'	102° 36.90'	166	182	117
99	75° 25.07'	102° 34.70'	166	117	65
100	75° 27.75'	102° 40.90'	210	244	78
103	75° 27.75'	102° 41.20'	201	341	35
113	75° 37.80'	103° 21.80'	271	356	161
115	75° 37.80'	103° 21.00'	267	65	145
118	75° 42.60'	104° 42.70'	260	70	165
130	75° 00.95'	103° 34.20'	150	110	
144	74° 15.56'	91° 14.21'	330	438	166
154	74° 22.01'	89° 51.26'	329	621	156
159	74° 26.55'	89° 52.50'	287	375	115
162	73° 44.00'	88° 44.20'	404	137	5

Table 2. List of foraminiferal species.

Adercotryma	*glomerata* (Brady, 1878)
Astrononion	*gallowayi* (Loeblich and Tappan, 1953)
Bolivina	*arctica* (Hermann, 1973)
Bolivina	*pseudoplicata* (Heron-Allan and Earland, 1930)
Buccella	*frigida* (Cushman, 1922)
Buliminella	*borealis* (Haynes, 1973)
Cassidella	*complanata* (Egger, 1895)
Cassidulina	*laevigata* (d'Orbigny, 1826)
Cassidulina	*reniforme* (Norvang, 1945)
Cibicides	*lobatulus* (Walker and Jacob, 1798)
Cribrostomoides	*crassimargo* (Norman, 1892)
Cribrostomoides	*jeffreysi* (Williamson, 1858)
Eggerella	*advena* (Cushman, 1922)
Elphidiella	*groenlandica* (Cushman, 1933)
Elphidium	*excavatum clavatum* (Cushman, 1930)
Elphidium	*subarcticum* (Cushman, 1944)
Epistominella	*arctica* (Green, 1958)
Epistominella	*takayanagii* (Iwasa, 1955)
Fissurina	*marginata* (Montagu, 1803)
Fursencoina	*fusiformis* (Williamson, 1853)
Islandiella	*helenae* (Feyling-Hanssen and Buzas, 1976)
Islandiella	*islandica* (Norvang, 1945)
Islandiella	*norcrossi* (Cushman, 1933)
Melonis	*zaandami* (Van Voorthuysen, 1952)
Nonoinellina	*labradorica* (Dawson, 1860)
Quinqueloculina	*stalkeri* (Loeblich and Tappan, 1953)
Reophax	*arctica* (Brady, 1881)
Robertinoides	*charlottensis* (Cushman)
Saccammina	*atlantica* (Cushman, 1944)
Sprioplectammina	*biformis* (Parker and Jones, 1865)
Stetsonia	*horvathi* (Green, 1958)
Textularia	*earlandi* (Phleger, 1952)
Textularia	*torquata* (Parker, 1952)
Trifarina	*fluens* (Todd, 1947)
Triloculina	*trihedra* (Loeblich and Tappan, 1953)
Tritaxis	*atlantica* (Parker, 1952)
Trochammina	*bullata* (Takayanagi, 1960)
Trochammina	*nana* (Brady, 1881)
Trochammina	*quadriloba* (Hoglund, 1948)

Table 3. Relative percent of major foraminiferal species.

	TWC 86027-9			
Interval (cm)	10	82	109	175
Total /10	20	32	38	48
Diversity x 100	163	141	209	154
Planktonic %		1	1	6
A. glomerata			3	
B. pseudoplicata			4	
B. frigida	32	7	6	
C. complanata			4	5
C. reniforme	42	62	32	57
E. excavatum clavatum	6	13	7	12
E. takayanagii	3			
I. helenae	7	5	6	3
I. norcrossi	4	6	25	10
N. labradorica	2		6	6

	TWC 86027-11				PC 86027-11	
Interval (cm)	8	52	82	144	3	19
Total /10	32	11	47	58	53	10
Diversity x 100	245	202	225	195	208	191
Planktonic %				1		11
A. glomerata	4					
B. pseudoplicata			2			
B. frigida	14	7	8	5	8	
C. complanata	5	8	3	10	3	
C. laevigata						14
C. reniforme	24	19	30	33	42	34
E. excavatum clavatum	9	18	11	12	13	15
E. takayanagii				3		
F. fusiformis			3			
I. helenae	12	18	8		6	6
I. islandica						4
I. norcrossi	10	22	20	23	9	17
N. labradorica	2		3	5	2	
S. biformis	4					
T. torquata	3		3		3	
T. atlantica	4					

Table 3. (cont'd)

	TWC 86027-12			PC 86027-12				
Interval (cm)	10	55	105	6	23	90	126	180
Total /10	54	29	114	39				
Diversity x 100	230	172	203	199				
Planktonic %			3	2				
A. glomerata				2				
A. gallowayi	2							
B. pseudoplicata	2							
B. frigida	15	8	8	6				
C. complanata	2	4	2	2				
C. laevigata			4					
C. reniforme	23	28	19	42				
E. excavatum clavatum	22	9	29	10				
E. pulchella	2							
E. takayanagii	4			3				
I. helenae	5	5	7					
I. norcrossi	10	40	22	21				
N. labradorica	4			3				
S. biformis	2							
T. torquata	2			2				

	TWC 86027-35			PC 86027-35			
Interval (cm)	8	126	156	14	25	31	66
Total /10	66	59	92	78	4	4	1
Diversity x 100	200	230	199	183	191	190	
Planktonic %					2		
A. gallowayi					2		
B. frigida	17	8	13	7	2		
C. complanata	4	8	7	4	2		
C. laevigata					2	2	
C. reniforme	25	27	23	45	32	22	
C. lobatulus		2		2	15	29	
E. groenlandica						2	
E. excavatum clavatum	14	18	27	24	24	12	
E. subarcticum		2					
F. fusiformis		4		2		10	
I. helenae	10	4	5				
I. norcrossi	22	16	15				
N. labradorica		3	5				

Table 3. (cont'd)

	TWC 86027-72				PC 86027-72				
Interval (cm)	8	68	84	148	15	53	99	115	158
Total /10	1	3	4	55		1			1
Diversity x 100	108	245	230	190					
Planktonic %				1					
A. gallowayi			6						
B. pseudoplicata			6						
B. frigida			22	4					
C. complanata			14						
C. reniforme				19					
C. lobatulus				5					
E. excavatum clavatum			6	20					
I. helenae			8	20					
I. norcrossi			17	25					
N. labradorica			8						

	TWC 86027-77				PC 86027-77						
Interval (cm)	7	56	88	128	3	20	105	137	159	229	295
Total /10	1	4	24	135	1		2	2	1		
Diversity x 100	115	188	259	170							
Planktonic %				31							
A. glomerata		14	6								
B. pseudoplicata			2								
B. frigida			2								
C. complanata			8								
C. laevigata				23							
C. reniforme			15	34							
C. lobatulus			2								
E. advena		9									
E. excavatum clavatum			9	21							
E. pulchella			3								
E. arctica				3							
E. takayanagii			3								
I. helenae		5	15								
I. norcrossi			5	6							
M. zaandami			2								
N. labradorica			18								
S. atlantica		6									
S. biformis		14									
T. torquata		40									
T. atlantica		6									

Table 3. (cont'd)

	TWC 86027-86		PC 86027-86							
Interval (cm)	18	82	16	65	111	142	177	189	223	243
Total /10	4	2	14	1	1	4	1			
Diversity x 100	130	69	236			252				
Planktonic %			51							
A. glomerata	49					9				
A. gallowayi			10							
B. arctica						3				
B. pseudoplicata						6				
C. complanata			8							
C. laevigata			11			3				
C. reniforme			12			9				
E. excavatum clavatum			8			3				
E. pulchella						9				
F. fusiformis						6				
I. helenae			7			3				
I. norcrossi			23							
M. zaandami			7							
R. arctica						3				
S. atlantica						3				
S. biformis	11					6				
T. torquata	5					11				
T. fluens						3				
T. bullata						3				
T. nana	30					23				

	TWC 86027-89			PC 86027-89				
Interval (cm)	11	38	120	14	46	89	108	153
Total /10	22							
Diversity x 100	169							
Planktonic %								
A. glomerata	42							
C. crassimargo	8							
T. nana	30							

Table 3. (cont'd)

	TWC 86027-98			PC 86027-98			
Interval (cm) Total /10 Diversity x 100 Planktonic %	8 14 203	50 144 112 13	104 1	20 1	57 2	84 2	154 1
A. glomerata	32						
B. frigida	3						
C. reniforme		60					
C. crassimargo	4						
I. helenae		29					
I. norcrossi		4					
R. fusiformis	2						
S. biformis	9						
T. earlandi	3						
T. torquata	8						
T. nana	24						

	TWC 86027-99		PC 86027-99	
Interval (cm) Total /10 Diversity x 100 Planktonic %	8 15 157	55 2	3 4 111	64
A. glomerata	42		60	
S. biformis	15		10	
T. earlandi	5			
T. torquata	8		23	
T. nana	23			

	TWC 86027-100		PC 86027-100			
Interval (cm) Total /10 Diversity x 100 Planktonic %	25	59	20	99	125	224

Table 3. (cont'd)

Interval (cm) Total /10 Diversity x 100 Planktonic %	TWC 86027-103		PC 86027-103				
	1 6 108	20	15	60	110	170	208
A. glomerata	65						
C. jeffreysi	6						
T. nana	21						

Interval (cm) Total /10 Diversity x 100 Planktonic %	TWC 86027-113				PC 86027-113		
	5 3 141	10 18 177	38 16 189	131 1 142	33 9 98	121	203
A. glomerata		32	8				
C. reniforme			6		40		
C. crassimargo			14				
C. jeffreysi		7					
E. excavatum clavatum			41				
F. fusiformis					53		
S. biformis			4				
T. earlandi		3					
T. torquata		2	5				
T. atlantica		20					
T. nana		27	15				

Interval (cm) Total /10 Diversity x 100 Planktonic %	TWC 86027-115		PC 86027-115		
	8 30 208	117 4 124	2 9 194 2	18	52
A. glomerata	35	36	36		
B. frigida	3		4		
C. reniforme			5		
E. excavatum clavatum	14		11		
E. subarcticum			4		
S. biformis	11				
T. torquata	8				
T. atlantica	5	14	8		
T. nana	13	43	22		

Table 3. (cont'd)

Interval (cm) Total /10 Diversity x 100 Planktonic %	TWC 86027-118				PC 86027-118	
	1 28 181	69 5 202	122 1 195	142 9 156 19	1	48
A. glomerata	22	20				
B. frigida		6				
C. complanata						
C. reniforme		4				
C. lobatulus		4				
C. jeffreysi	2					
E. excavatum clavatum		4				
I. helenae						
R. turbinatus	2					
S. atlantica	4					
T. torquata	4					
T. atlantica	9	4				
T. bullata		6				
T. nana	45	38				
T. quadriloba	3					

Interval (cm) Total /10 Diversity x 100 Planktonic %	GC 86027-130	
	25 7 206	88 9 253 4
A. glomerata	9	23
B. frigida	11	5
C. complanata	3	6
C. reniforme	22	21
C. lobatulus	3	4
E. excavatum clavatum	29	5
I. helenae	3	3
I. norcrossi	9	3
R. fusiformis		3
S. biformis		3
T. earlandi		3
T. nana	5	4
T. quadriloba		4

Interval (cm) Total /10 Diversity x 100 Planktonic %	TWC 86027-144			PC 86027-144								
	33 16 256	88 32 205	152 33 214	10 48 217	55 64 218	104 132 218	133 579 193 1	226 302 173 8	269 658 150 21	342 16 160	375 5 94	391
A. gollowayi	3		2							3		
B. pseudoplicata	5		2		2	3						
B. frigida	11	18	10	14	8	4	4					
B. borealis					2	4						
C. complanata	4	4	7	3	7	10						
C laevigata									3			
C. reniforme	22	20	35	32	45	38	45	43	49	35	37	
C. lobatulus							13	8				
E. excavatum clavatum	3	31	17	21	8	5	12	13	28	5		
E. fulchella				2								
E. takayanagii	15	3	4	2	2							
F. fusiformis	3			3	2							
I. helenae	8	12	11	8	6	8	5	5	6			
I. norcrossi	8	3	4	4	5	10	6	22				
N. labradorica		3	2		3	7	6					
R. charlottensis										3		
S. biformis	4											
S. horwathi										33	54	
T. trihedra										8		
T. torquata	3											

Table 3. (cont'd)

	TWC 86027-154		PC 86027-154											
Interval (cm) Total /10 Diversity x 100 Planktonic %	51 12 212	128 49 219	8 25 210	10 10 223	63 352 159 1	134 826 151 5	154 122 150 26	229 75 158	274 25 117	348 4 134	422 1 137	468	518	568
A. glomerata				2										
A. gallowayi				2				3						
B. frigida	33	17	23	25										
B. borealis			3											
C. complanata	3	7	6	4										
C. laevigata							11							
C. reniforme	15	16	22	14	56	40	61	43	20	49				
C. lobatulus	3			2	4									
E. excavatum clavatum	7	7	7		10	34	5	29	18	33				
E. fulchella	3	5		6										
E. takayanagii	7		2	3										
F. marginata										5				
F. fusiformis					4		5	12						
I. helenae	13	23	20	26	12	12	5	3						
I. norcrossi	3	13			7	7	6	3						
N. labradorica		6												
Q. stalkeri				2					56					
S. horvathi	7													
R. arctica				2										
T. torquata				3										

	TWC 86027-159			PC 86027-159					
Interval (cm) Total /10 Diversity x 100 Planktonic %	8 218 223	28 37 124	101	23	40	95	147	204	304
A. gallowayi	5								
B. frigida	15								
C. complanata	4								
C. reniforme	16	18							
C. lobatulus	9								
E. excavatum clavatum	10	54							
F. fusiformis		22							
I. helenae	5								
I. norcrossi	25								

Table 4. Major foraminiferal species in cores.

CORE 86027-9

	INTERVAL (m) TWC 0 ↓ 1 ↓
A. glomerata	
B. frigida	XXX
C. complanata	
C. reniforme	XXXXX
C. lobatulus	
E. excavatum	XXXXX
E. takayanagii	
I. helenae	XXXXX
I. norcrossi	XXXXX
N. labradorica	
T. atlantica	
T. nana	
	↑ 0 ↑ 1

CORE 86027-11

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓
A. glomerata	
B. frigida	XXXXXXXX
C. complanata	XXXXXXXX
C. reniforme	XXXXXXXXX
C. lobatulus	
E. excavatum	XXXXXXXXX
E. takayanagii	
I. helenae	XXXXXX XX
I. norcrossi	XXXXXXXXX
N. labradorica	X XXXX
T. atlantica	
T. nana	
	↑ 0 ↑ 1 ↑ 0

CORE 86027-12

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓
A. glomerata	
B. frigida	XXXXXXX
C. complanata	XXXXXXX
C. reniforme	XXXXXXX
C. lobatulus	
E. excavatum	XXXXXXX
E. takayanagii	
I. helenae	XXX
I. norcrossi	XXXXXXX
N. labradorica	
T. atlantica	
T. nana	
	↑ 0 ↑ 1 ↑ 0

CORE 86027-35

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓
A. glomerata	
B. frigida	XXXXXXXX
C. complanata	XXXXXXXX
C. reniforme	XXXXXXXXX
C. lobatulus	XXX
E. excavatum	XXXXXXXXX
E. takayanagii	
I. helenae	XXXXXX
I. norcrossi	XXXXXX
N. labradorica	
T. atlantica	
T. nana	
	↑ 0 ↑ 1 ↑ 0

Table 4. (cont'd)

CORE 86027-113

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓
A. glomerata	XXXXXX
B. frigida	
C. complanata	
C. reniforme	
C. lobatulus	
E. excavatum	
E. takayanagii	
I. helenae	
I. norcrossi	
N. labradorica	
T. atlantica	XXXXXX
T. nana	XXXXXX
	↑ 0 ↑ 1 ↑ 0

CORE 86027-144

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓ 1 ↓ 2 ↓ 3 ↓ 4 ↓
A. glomerata	
B. frigida	XXXXXXXXXXXX
C. complanata	XXXXXXXXXXX
C. reniforme	XXXXXXXXXXXXXXXXXXXXX
C. lobatulus	
E. excavatum	XXXXXXXXXXXXXXXXXXXX
E. takayanagii	XXXXXXXXXX
I. helenae	XXXXXXXXXXXXXXXXXX
I. norcrossi	XXXXXXXXXXXXXXXXX
N. labradorica	XXX XXXXXXXX
T. atlantica	
T. nana	
	↑ 0 ↑ 1 ↑ 0 ↑ 1 ↑ 2 ↑ 3 ↑ 4

CORE 86027-154

	INTERVAL (m) TWC | PC 0 ↓ 1 ↓ 0 ↓ 1 ↓ 2 ↓ 3 ↓ 4 ↓
A. glomerata	
B. frigida	XXXXXX
C. complanata	XXXXXX
C. reniforme	XXXXXXXXXXXXXXXXXXX
C. lobatulus	
E. excavatum	XXXXXXXXXXXXXXXXXXX
E. takayanagii	
I. helenae	XXXXXXXXXXXXXXX
I. norcrossi	XXX XXXXXXXXXX
N. labradorica	
T. atlantica	
T. nana	
	↑ 0 ↑ 1 ↑ 0 ↑ 1 ↑ 2 ↑ 3 ↑ 4

Table 5. Comparison of foraminiferal species in surface versus subsurface sediments. X = absent in surface sediments, present in subsurface; and O = present in surface sediments.

	WELLINGTON CHANNEL				LANCASTER SOUND			BARROW STRAIT		AUSTIN CHANNEL					BYAM MARTIN CHANNEL				
CORES	9	11	12	35	144	154	159	72	77	130	98	99	100	103	118	113	115	86	89
A. glomerata	X	O	X			X		X	X	O	O	O		O	O	O	O	O	O
A. gallowayi			O	X	O	X	O	X										X	
B. arctica																		X	
B. pseudoplicata	X	X	O		O				X									X	
B. frigida	O	O	O		O	O	O	X	X	O	O				X		O		
B. borealis					X	X													
C. complanata	X	O	O		O	O	O	X	X	O					X			X	
C. laevigata		X	X	X	X	X			X									X	
C. reniforme	O	O	O		O	O	O	X	X	O	X				X	X	X	X	
C. lobatulus				X	X	O	O	X	X	O					X				
C. crassimargo											O					X			O
C. jeffreysi														O	O	O			
E. advena									X										
E. groenlandica				X															
E.excavatum clavatum	O	O	O		O	O	O	X	X	O					X	X	O	X	
E. subarcticum				X													X		
E. arctica									X										
E. takayanagii	O	O	O		O	O			X										
F. marginata						X													
F. fusiformis					O					X						X		X	
I. helenae	O	O	O		O	O	O	X	X	O	X				X			X	
I. islandica		X																	
I. norcrossi	O	O	O		O	O	O	X	X	O	X							X	
M. zaandami									X									X	
N. labradorica	O	O	O	X	X	X		X	X										
Q. stalkeri						X													
R. arctica						X												X	
R. charlottensis					X														
S. atlantica									X						O				
S. biformis		O			O				X	X	O	O				X	O	O	
S. horvathi						O													
T. earlandi										X	O	O				O			
T. torquata		O			O	X			X		O	O			O	O	O	O	
T. fluens																		X	
T. trihedra					X														
T. atlantica		O							X						O	O	O	X	
T. bullata															X			X	
T. nana										O	O	O		O	O	O	O	O	O
T. quadriloba										X					O				

Table 6. Order of first occurrence of foraminiferal species.

154	144	35
B. frigida	*E. takayanagii*	*I. helenae*
C. complanata	*C. complanata*	*I. norcrossi*
I. helenae	*B. frigida*	*B. frigida*
I. norcrossi	*N. labradorica*	*C. complanata*
	I. norcrossi	
	I. helenae	
C. reniforme	*E. escavatum*	*C. reniforme*
E. excavatum	*C. reniforme*	*C. lobatulus*
		E. excavatum

to the east of Barrow Strait; and 2) the first appearance of other species, which are *I. helenae* and *I. norcrossi* in Lancaster Sound and *B. frigida* and *C. complanata* in Wellington Channel. Thus, the first boundary is between the barren zone and the *C. reniforme-E. excavatum* zone, and the second boundary is between the latter and the first appearance of all the other species. These zone boundaries coincide with the change in texture, sediment structure, and geotechnical properties from glacial drift to glaciomarine sediments and from the glaciomarine to the overlying postglacial sediments as seen in the cores (Fig. 51 and 52). The *C. reniforme-E. excavatum* zone is less well represented in areas other than Wellington Channel and Lancaster Sound, although the two species are almost always present at the bottom of the fossiliferous zone. The barren zone is the most extensive throughout the study area. It correlates with sediments of the glacial drift unit.

Biostratigraphy related to acoustic/sediment units

In Wellington Channel, biostratigraphic information was provided by three cores, 11, 12, and 35 located in the basin in the northern part of the channel (Fig. 4, 49 and 50). Core 11 was taken within the acoustically transparent postglacial unit in the northern part of this basin. A thin surface layer of very watery sediments corresponds to maximum diversity of foraminifera (Table 4); this is comparable to the inner shelf of the western North Atlantic (Buzas and Gibson, 1969) and the Labrador Shelf (Vilks and Deonarine, in press). Core 12, 16 km to the southeast, penetrated sediments of both the acoustically transparent postglacial unit and the glacial drift. The postglacial sediments in the upper part of the core contained diverse faunas, but downcore (below 18 cm in the piston core) in sediments of the glacial drift unit, only traces of foraminifera were present (Tables 3 and 4). Similar results were obtained from Core 35 which sampled the postglacial and glacial drift units near the southern margin of the northern basin (Fig. 4 and 50, Table 3).

In Eastern Barrow Strait, sediments of both the glacial drift unit and the overlying lower part of the glaciomarine unit in Piston Core 159 were unfossiliferous (Fig. 52 and Table 4). In Core 154 the decrease in species diversity downcore (Fig. 52 and Table 3) exemplifies the typical relationships with the sediment units. The acoustically transparent postglacial sediments have the greatest species diversity, the acoustically stratified glaciomarine sediments have a much more limited diversity dominated by *C. reniforme* and *E. excavatum clavatum*, and the glacial drift is barren. The unit boundaries in the piston core occur at 1.8 and 5.2 m, respectively. A similar correlation is evident in Core 144 (Table 3, Fig. 51), which sampled these units in the western basin, 43 km to the southwest. Downcore boundaries between postglacial/glaciomarine and glaciomarine/glacial drift sediments in Core 144 are at 2.55 and 3.89 m, respectively.

In Byam Martin Channel, the cores are short and faunas are less well preserved. The trends in the relationships between the sediment units and foraminifera are still evident, although less obvious. Core 86 was collected within the acoustically stratified glaciomarine and glacial drift sediment units in the northeastern part of the channel (Fig. 31, 43 and 49). Major faunal characteristics are associated with each of these units. The glaciomarine sediments contain fossiliferous intervals, whereas the underlying sediments of the glacial drift unit are barren of fossils. Piston cores 89 and 118 to the southwest (Fig. 31, 38 and 49) are barren of foraminifera (Fig. 53 and 54). Both consist of glacial drift overlain by acoustically stratified glaciomarine sediments which at these localities are also barren (Table 3). Foraminifera are present, however, in the glaciomarine sediments of Core 113, 28 km to the southeast (Fig. 49 and 54). The underlying drift is barren (Table 3).

In Austin Channel, Core 98 sampled glacial drift and thin overlying sequences of acoustically stratified and acoustically transparent sediments. Core 99 penetrated 8 cm of acoustically transparent sediments and the underlying glacial drift while Core 100 was entirely in glacial drift (Fig. 49 and 55). Foraminifera were present in the trigger-weight cores from Stations 98 and 99 but only in the uppermost part of Piston Core 99. The glacial drift was barren in the three cores.

In summary, there is a relationship between the units identified on the basis of acoustical, textural, and physical property data, and the characteristics of the foraminifera in the sediments. The relatively diverse upper foraminiferal zone is related to the clayey sediments of the acoustically transparent postglacial unit with its high water content, low bulk density, and low shear strength. The zone of low faunal diversity, although not necessarily low numbers, is related to more compact and generally texturally coarser sediments of the acoustically stratified unit which represents deposition in glaciomarine ice proximal to ice distal environments. The compacted diamictic sediments of the glacial drift unit, which are interpreted to have been deposited beneath grounded glacial ice, are barren of foraminifera.

MAGNETIC SUSCEPTIBILITY

The volume magnetic susceptibility (MS) of sediment chiefly varies with its grain size, wet volume density, mineralogy, and concentration of magnetic material. Combined with other information such as lithological and textural variations, magnetic susceptibility logs are useful for delineating lithological and sedimentological changes in sediment cores and for inferring sediment source changes both geographically and temporally (Currie and Bornhold, 1983; Andrews and Jennings, 1987; Jennings, 1988). The MS measurements are used herein to determine whether there are differences in the MS of sediments from different areas in the Arctic Island channels, and whether the sources of sediment have varied during the different phases of sedimentation represented by the sediment cores.

Methods

Volume magnetic susceptibility was measured on piston and gravity cores and grab samples. On the cores, all measurements were made at 5 cm intervals using a Bartington Instruments M.S.1 meter linked to a microcomputer. A low-field loop-shaped sensor, 7 cm in diameter and 2 cm wide, was used. Wet sediment from grab samples was measured in 10 ml vials using a sensor that holds discrete samples. Volume MS is reported as x 10^{-5} SI units. The mass magnetic susceptibility of the surface sediments was obtained by dividing the volume MS by the sediment density. The mass MS units are x 10^{-8} m^3/kg. Arithmetic and log-transformed means and standard deviations of x were calculated for the entire group of measurements from each core and for the component sediment units (see Table 8). Unit boundaries were interpreted from visual core descriptions and X-radiography, not from the MS logs.

Results

Surface sediments

Volume and mass magnetic susceptibility were measured on grab samples from Wellington Channel, Queens Channel, western Barrow Strait, Byam Martin Channel, Austin Channel, Viscount Melville Sound, and Lancaster Sound (Table 7). No surface sample was taken in Prince Regent Inlet. In every case, the sediment from the grab samples appeared to represent the uppermost soupy sediment veneer.

Volume and mass magnetic susceptibility show the same trends in the surface samples. Both types of data are listed in Table 8. Volume MS ranges from 4 to 27. Samples from Wellington and Queens channels have the lowest MS values, ranging from 4 to 7. Only one grab sample was taken in Lancaster Sound. It had the highest MS in the group, 27. Samples from Viscount Melville Sound, Austin Channel, Byam Martin Channel, and western Barrow Strait have MS values intermediate between those from Wellington and Queens channels and those from Lancaster Sound. These values range from 10 to 16.

Subsurface data

Wellington Channel

MS measurements were completed on three cores from Wellington Channel; Station 9 trigger-weight core (TWC), Station 12 piston core (PC) and TWC, and Station 35 TWC and PC (Fig. 4, 49 and 50; Table 8). In cores from Stations 9, 12, and 35 the glacial drift and postglacial units are represented (Table 8). Overall, the MS is quite low in Wellington Channel. The drift unit at Stations 12 and 35 is characterized by low values (3.71 $\pm$ 1.12 and 8.20 $\pm$ 3.58, respectively). The postglacial unit also possesses low MS values except for Station 35 where higher values were recorded. Texturally, the cores range from pebbly mud to silty clay, but there is very little variation in the magnitude of the MS except at Station 35 (Fig. 50).

Eastern Barrow Strait-western Lancaster Sound

Sediments in eastern Barrow Strait and western Lancaster Sound were cored at Stations 144, 154, and 159 (Fig. 19 and 49). These cores variably sampled glacial drift, glaciomarine, and postglacial units. The lithological units in this area exhibit distinct MS distributions which correlate well from core to core (Table 8, Fig. 51 and 52).

In cores from Station 144 the mean magnetic susceptibility of the drift and postglacial sediments is low (< 15) and the distributions exhibit little variation (Table 8, Fig. 51). The mean values for these two units are similar to the mean values of those units in cores from the other areas to the west and north. The glaciomarine unit, however, has substantially higher and more variable MS values (Table 8, Fig. 51).

At Station 154 (TWC and PC) the MS distributions of the three acoustic/lithological units are all statistically different from one another. The glacial drift has a low MS, similar to that at Station 144 (Table 8, Fig. 52). The glaciomarine unit has a mean MS (102.7 $\pm$ 39.5) an order of magnitude higher than that of the drift and its values are more variable (Table 8, Fig. 52). The MS values in the glaciomarine unit at Station 154 are much higher than those in the glaciomarine unit at 144. Comparison of the MS logs suggests that the glaciomarine unit sampled at 144 correlates with the upper part of the glaciomarine unit cored at 154 (Fig. 51 and 52).

The postglacial unit was sampled in both the trigger-weight and piston cores at Station 154. The mean MS of the trigger-weight core is low (4.12 $\pm$ 1.56) with little variation (Table 8, Fig. 52). The postglacial unit in the piston core, however, has a higher (29.17 $\pm$ 15.17) and more variable MS distribution. At Station 159, only the glaciomarine and glacial drift units are represented. The relationships are similar to those displayed by samples from Station 154 (Fig. 52). The glacial drift section in this core is the longest (2.6 m) of those recovered in the study. This unit has a low mean MS (7.37 $\pm$ 1.10). As in Cores 144 and 154, the glaciomarine unit in Core 159 has a large mean MS (69.92 $\pm$ 37.22) (Table 8, Fig. 52)

Table 7. Magnetic susceptibility of surface grab samples.

LOCATION	STATION	VOLUME SUSCEPTIBILITY (10-5 SI)	WEIGHT (g)	MASS SUSCEPTIBILITY (x10-8 m3/kg)
Wellington Channel	1	5	20.24	3.041363
Wellington Channel	15	4	21.03	2.321532
Queens Channel	32	6	23.4	3.061224
Queens Channel	32	4	19.85	2.492212
Wellington Channel	40	5	18.02	3.516174
Wellington Channel	42	5	18.67	3.362475
Wellington Channel	44	5	18.22	3.467406
Wellington Channel	52	5	20.67	2.963841
Wellington Channel	53	6	20.91	3.506721
Wellington Channel	56	6	21.87	3.320421
Wellington Channel	58	6	21.71	3.350084
Wellington Channel	62	6	22.08	3.282276
Wellington Channel	64	7	22.37	3.769521
E. Barrow Strait	67	16	21.97	8.805724
Byam Martin Channel	78	12	21.27	6.868918
Byam Martin Channel	90	11	21.43	6.239365
Byam Martin Channel	95	10	23.41	5.099439
Byam Martin Channel	97	11	20.21	6.703230
Austin Channel	104	11	20.87	6.444054
Austin Channel	111	14	25.84	6.352087
Viscount Melville Sound	120 B	14	21.77	7.790762
Viscount Melville Sound	126	15	23.94	7.447865
Viscount Melville Sound	128	10	22.46	5.359057
Lancaster Sound	148	27	21.94	14.88423
Lancaster Sound	148	26	21.02	15.09872

Table 8. Magnetic susceptibility of core samples.

Location	Core Station	Geological Unit	No. of Measurements	Mean Value	Standard Deviation
Wellington Channel	12 TWC	PG	23	10.11	1.91
	12 PC	GD	34	3.71	1.12
	35 TWC	PG	29	4.62	0.80
	35 PC	PG &GD	13	32.16	5.67
		GD	10	8.20	3.58
	09 TWC	PG	19	9.55	1.31
Western Barrow Strait	72 TWC	PG	28	8.16	3.57
	72 PC	GM & GD	49	7.96	2.82
		GM	23	9.23	3.03
		GD	26	8.85	3.38
	77 TWC	PG & GM	32	9.10	5.35
		PG	23	7.63	2.94
		GM	9	12.44	8.49
	77 PC	GM & GD	58	7.00	2.13
		GM	36	7.06	3.49
		GD	22	5.92	1.68
Byam Martin Channel	86 TWC	GM	21	11.55	2.33
	86 PC	GM & GD	47	12.41	2.80
		GM	40	12.12	2.45
		GD	7	10.30	2.94
	89 TWC	GM	26	11.70	2.38
	89 PC	GM & GD	38	12.73	1.64
		GM	26	13.22	1.36
		GD	12	11.23	1.99
	113 TWC	PG	29	11.56	1.61
	113 PC	PG, GM, GD	59	13.12	3.62
		GM	17	13.50	1.36
		GD	40	11.57	4.46
	115 TWC	PG	26	12.10	1.61
	115 PC	PG & GD	11	20.40	9.41
	118 TWC	PG & GM	28	12.60	2.17
		PG	21	11.60	1.35
		GM	7	15.64	0.85
	118 PC	GM & GD	11	15.84	6.30
Austin Channel	98 TWC	PG, GM, GD	21	12.24	1.88
	98 PC	PG, GM, GD	31	12.00	1.41
	99 TWC	PG & GD	10	10.20	1.28
	99 PC	GD	16	12.93	1.68
	100 TWC	GD	14	10.85	1.15
	100 PC	GD	45	10.72	1.58
	103 TWC	GD	5	9.60	0.75
	103 PC	GD	63	12.76	2.96
Viscount Melville Sound	130 GC	PG & GD	20	11.47	1.84
Lancaster Sound	144 TWC	PG	32	5.91	2.14
	144 PC	PG, GM, GD	82	24.70	16.60
		PG	68	13.06	3.61
		GM	30	44.59	6.68
		GD	4	11.95	3.20
	154 TWC	PG	29	4.12	1.56
	154 PC	PG, GM, GD	119	74.18	49.63
		PG	35	29.17	15.17
		GM	77	102.73	39.55
		GD	7	10.86	2.96
	159 TWC	GM	21	61.29	18.65
	159 PC	GM & GD	67	21.22	31.19
		GM	15	69.92	37.22
		GD	52	7.37	1.10
Prince Regent Inlet	162 PC	GD	27	171.76	32.58
		GD	23		

PG - Postglacial, GM - Glaciomarine, GD - Glacial Drift

Prince Regent Inlet

Core 162 from northern Prince Regent Inlet (Fig. 49) comprises a lower structureless diamict, interpreted to be glacial drift, overlain by ungraded gravelly sandy mud and graded sand. The MS of the drift is the highest of any of the sediments in the entire survey with a mean of 171.76 ± 32.6 (Table 8, Fig. 51). It is distinctive in that it has a high magnetic susceptibility similar to the glacial marine sediments at Stations 144, 154, and 159 in eastern Barrow Strait-western Lancaster Sound. This contrasts with the MS of the drift units, at those stations, which had very low values (Fig. 51 and 52).

Byam Martin and Austin Channels

Magnetic susceptibility was measured on cores from five stations in Byam Martin Channel, 86, 89, 113, 115, and 118, and on cores from five stations in Austin Channel, 98, 99, 100, 103, and 130 (Table 8, Fig. 31 and 49). As in Wellington Channel, the MS in these cores is low, generally < 15 (Table 8). The MS distributions calculated separately for each lithological unit overlap between cores at 1 standard deviation (Table 8). Thus, although the sediments range in texture from postglacial muds to glacial diamictons the magnetic susceptibility of these sediments in the Byam Martin-Austin channel region does not vary significantly (Fig. 53 to 55).

Western Barrow Strait

MS measurements were completed on cores from Stations 72 and 77 (Fig. 49). The three acoustic/lithological units described earlier in the other areas are also present here, but the cores are principally from the glacial drift and glaciomarine units (Fig. 56). Despite the dramatic changes in texture and colour that occur in the cores, MS is quite low and consistent within and between the acoustic/lithological units (Table 8, Fig. 56). The mean susceptibility is mainly less than 10, fairly similar to cores from Wellington Channel except that the MS distributions are more variable (Table 8). The glaciomarine unit in the western Barrow Strait cores has a slightly higher and more variable MS than that of the glacial drift (Table 8).

Interpretation of magnetic susceptibility data

Three separate geographical areas can be distinguished based on their MS characteristics (Fig. 49). Area 1 is the farthest north and west. It includes Wellington Channel, western Barrow Strait, Austin Channel, Byam Martin Channel, and Viscount Melville Sound. In that region, the MS of the sediments is low, generally < 15, and does not vary significantly between the sediment units despite changes in texture and colour. Area 2, Prince Regent Inlet, is represented by only one core, 162, but its MS distribution is sufficiently different from those of the other areas to warrant its separation. It is the only area in which the drift unit displays high MS values. In fact, it has the highest MS in the study area. Area 3, eastern Barrow Strait-western Lancaster Sound, displays elements in common with both of the other areas. The drift and postglacial units have low MS values as in Area 1, that do not vary with changes in sediment texture or colour. However, the glaciomarine unit in Area 3 has high MS values that are similar in magnitude to the MS of the glacial drift from Prince Regent Inlet.

Based on these observations, some interpretation of sediment sources can be made. In Area 1, sediments have been derived from bedrock areas with low MS values, such as the Paleozoic carbonate bedrock of the surrounding islands. Area 2 must have received at least some of its sediment from erosion of bedrock areas with high MS values, such as the Archean metamorphic rocks that border part of the Gulf of Boothia south of Prince Regent Inlet. The glacial drift in Prince Regent Inlet was likely deposited by Laurentide ice moving northward down Prince Regent Inlet into Lancaster Sound. The high MS of the glaciomarine unit in Area 3 suggests that it also received sediment from that source. The drift in Area 3, which has low MS values, may have been deposited mainly by glacial ice from the surrounding islands and/or by Laurentide ice from low MS Paleozoic terrains farther west.

The MS of the postglacial sediments both from grab samples and cores is close in magnitude in Areas 1 and 3, but was not measured in Area 2. The two areas are characterized by low MS values, similar to the drift units, indicating that the postglacial sediment is largely of derivation from low MS source areas. These probably were mainly the adjacent islands and land masses, which are composed principally of Paleozoic sedimentary rocks.

DISCUSSION AND CONCLUSIONS

The acoustic data and sample information indicate the widespread distribution of sediments interpreted to be glacial drift which overlie variably dipping sedimentary bedrock. The drift in turn is overlain locally by up to a few metres of acoustically stratified and acoustically transparent sediments that are considered to be glaciomarine and postglacial in origin, respectively. A thin (few centimetres) soupy mixture of silty, clayey, sandy, gravelly sediment is present at the immediate seabed in several areas. Of the areas surveyed, the greatest thicknesses of Quaternary sediments were encountered in eastern Barrow Strait.

The widespread presence of sediments interpreted to be glacial drift deposited by grounded ice indicates that glacial ice was present in the interisland channels during the Quaternary. Floating ice shelves may also have been present in some channel areas, and these may have delivered some of the glaciomarine sediments which locally overlie glacial drift. Despite the apparent complexity of the terrestrial deposits on the Arctic Islands, offshore the sediment sequences resemble those mapped at the margin of the Laurentide Ice Sheet off Baffin Island, Labrador, and Newfoundland by Praeg et al. (1986), Josenhans et al. (1986), and King and Fader (1986), respectively. The sedimentary environments also resemble those identified on the Norwegian Shelf (Vorren et al., 1983; King et al., 1987).

Geotechnical analyses of core samples indicate variations in shear strength, bulk density, and water content that correlate with the surficial sediment units recognized from high resolution seismic profiles, and the textural character of these sediments as revealed by X-radiography and visual examination of samples. The acoustically transparent sediments typically have high water content, low bulk density, and low shear strength. These contrast with the significantly lower water content and higher density and shear strength of the acoustically stratified sediments and glacial drift.

Studies of foraminifera also indicate a consistent relationship with the three main sediment units recognized in the region. The acoustically transparent postglacial unit contains a relatively diverse foraminiferal population whereas the acoustically stratified glaciomarine unit normally has a less diverse foram population; the lowermost unit, the glacial drift, is barren.

A distinct and consistent correlation exists among textural and geotechnical properties, foraminiferal assemblages, and acoustic character of the three main surficial sediment units recognized in the study areas of the Arctic Island channels, as exemplified in Figure 51. These characteristics all relate to the differing environmental conditions under which each of these sediment units was deposited. These are summarized below:

1. The unstructured, faunally barren, and compacted sediments of the glacial drift unit with their wide range of unsorted grain sizes, higher shear strength and bulk density, and low water content were deposited in a faunally inhospitable environment beneath a grounded ice sheet.
2. The laminated sandy and pebbly muds of the acoustically stratified unit,which overlie and locally are interbedded with glacial drift, have restricted faunal assemblages consisting predominantly of *C. reniforme* and *E. excavatum clavatum*, moderate shear strength and bulk density, and low water content. These characteristics are consistent with deposition in glaciomarine environments, proximal or distal to a glacial ice front, or beneath an ice shelf.
3. The faunally more diverse muds of the acoustically transparent unit with their low shear strength and bulk density and high water content are indicative of deposition in a relatively quiescent Arctic marine environment. Bottom currents have, however, influenced their distribution. There apparently have also been some variations in paleoceanographic conditions that prevailed during deposition of the postglacial sediments. The reduction in foraminiferal populations in the upper part of the postglacial unit, e.g. Figure 51, suggests a significant change in ice and/or water mass regimes. The cores in general exhibit no apparent associated change in the fine textural character of the sediments. Such a change as indicated by the foraminifera might be accounted for by a change from a largely open water condition to one in which the sea was mainly covered by immobile, essentially shore-fast ice; an environment conducive to neither extensive foraminiferal populations nor extensive ice rafting of sediments. A further change in conditions is indicated by the most recent seabed sediments that form the thin surface veneer. The wide range of grain sizes, from fine sediments to numerous gravel clasts, that compose this uppermost unit indicates a return to an environment in which ice rafting has been an important mechanism for sediment transport. This is compatible with the seasonally mobile ice pack and limited open water conditions that characterize the surveyed areas at present. Scattered clasts up to small pebble size in the upper 30-40 cm of the trigger weight cores from Stations 9, 11, and 12 in northern Wellington Channel, and in gravity cores obtained by MacLean and Vilks (1986) in the Byam Martin Channel-Lougheed Island region, appear to mark the onset of this change.

The distribution of foraminifera indicates regional and temporal variability in the environment. The present day dominance of agglutinated species to the west of Longitude 100° W in western Barrow Strait and calcareous species to the east may reflect differences in water masses or the more extensive cover of sea ice in the western channels. The shallower bathymetry in Barrow Strait obstructs the exchange of deep water between eastern Barrow Strait and channels to the west. Thus the eastern bottom water is under the influence of Baffin Bay and the western bottom water is under the influence of the Arctic Ocean. The foraminiferal assemblages in the subsurface of the postglacial sediments indicate that the east-west oceanographic difference was less prominent in the past. The subsurface calcareous species in Byam Martin Channel may reflect deeper water in Barrow Strait due to higher relative sea levels during that time interval, allowing the counterflow of bottom water from Baffin Bay to enter the western channels.

Downcore from the high diversity faunas of the acoustically transparent postglacial unit, the low diversity *E. excavatum-C. reniforme* fauna represent a glaciomarine environment or a marine setting proximal to tidewater glaciers (Elverhoi et al., 1980). This is well documented by these two species in cores from eastern Barrow Strait and Wellington Channel. In Byam Martin Channel the record is less complete, but it includes evidence of a glaciomarine environment.

Magnetic susceptibility (MS) data suggest variations in source areas of some of the sediments. Most of the sediments in the three main units appear to have been derived from rocks with low MS such as the Paleozoic rocks of the Arctic Islands. However, the higher MS signature of the glacial drift in northern Prince Regent Inlet indicates that at least some of these sediments have been derived from areas with higher MS. Archean rocks bordering parts of the Gulf of Boothia and southern Prince Regent Inlet are probable source areas, with transport of sediment northward by grounded glacial ice (presumably Laurentide) which deposited glacial drift in the floor of Prince Regent Inlet. The low MS of the drift in Area 3 compared with that in Area 2 and the spatial relationships suggest that the Area 3 sample sites in eastern Barrow Strait-western Lancaster Sound lay close to, but west of the confluence of Lancaster Sound-Prince Regent Inlet ice streams. However, the high MS values in the glaciomarine unit of Area 3 suggest that this area was receiving sediments from high MS Laurentide Ice Sheet areas to the south after the Lancaster Sound ice had retreated. Dyke and Prest (1987a) inferred that Lancaster Sound and Prince Regent Inlet were covered by an ice shelf from 18 000 BP to about 10 000 BP. Ice originating in the Prince Regent Inlet-Gulf of Boothia region may have been a source for much of this ice shelf and contributed to deposition of the glaciomarine sediments in eastern Barrow Strait and western Lancaster Sound. Dyke and Prest's (1987a) reconstructions indicate that drawdown of glacial ice into the Gulf of Boothia and Prince Regent Inlet from the adjacent land areas occurred throughout the Late Wisconsinan.

The terrestrial Quaternary record as deduced from deposits on the Arctic Islands was outlined earlier in the introductory section of this report. Figure 2 illustrates Late Wisconsinan ice limits as adapted from Dyke and Prest's (1987a,c) reconstructions. The Quaternary sediments offshore must be part of this setting, and although the exact relationships are not yet established the sediments offshore appear to present important implications for the glacial history of the region.

Datable material present in postglacial sediments in Core 144 in eastern Barrow Strait provides chronological information on part of the Quaternary section. The age date of 7970 $\pm$ 70 BP from mollusc shells in Core 144 is compatible with dates from similar sediments sampled previously by the authors in Jones Sound. Extrapolation of the 7970 BP date in Barrow Strait downcore, assuming a uniform sedimentation rate, yields an age of about 10 000 BP for the base of the postglacial unit at this locality. This agrees very well with Dyke and Prest's (1987a) estimate of between 9000 and 10 000 B.P. for disappearance of the ice shelf in Barrow Strait and Lancaster Sound. The age date from Core 144 indicates approximately when the change from glaciomarine to postglacial conditions occurred in the eastern Barrow Strait-western Lancaster Sound region. Inferences as to the possible ages of stratigraphically lower sequences and events recognized in the channels from the seismic data and core samples must depend largely on local and regional evidence from adjacent land areas, supplemented with possible implications and constraints from the offshore data.

The presence of glacial drift is virtually ubiquitous in the interisland channels throughout the region surveyed. Multiple sequences indicate that at least parts of the region have been affected by more than one glacial ice flow. These appear to have been more prevalent in the Byam Martin-Austin channel region than in Wellington Channel or eastern Barrow Strait-western Lancaster Sound. Though the Laurentide Ice Sheet was thought not to have extended north of Parry Channel during the Late Wisconsinan, except on southern Melville Island and Byam Martin islands, local ice caps existed on several of the Arctic Islands to the north, including Cornwallis, Bathurst, and Devon islands (Dyke and Prest, 1987 a,b). Thus Late Wisconsinan ice was present on land bordering Wellington, Byam Martin, and Austin channels, Barrow Strait, and Lancaster Sound (Fig. 2). Although there is no direct evidence on the age(s) of the drift deposits in the interisland channels, the proximity of onshore and offshore deposits suggests a possible correlation in a few areas. For example, two localities where moraines occur, near Read Bay and Snowblind Bay on eastern Cornwallis Island (Thorsteinsson, 1958), lie near where thick drift forms moraine-like accumulations in Wellington Channel, discussed earlier (Fig. 7, 9 and 10). It seems probable that these offshore features are related to those onshore and that they were deposited by an advance of a local glacial ice cap centred on Cornwallis Island during the Late Wisconsinan. In addition to these accumulations, thinner drift deposits occur throughout Wellington Channel. These and drift deposits in the other Arctic Island channels may include deposition by regionally extensive ice sheets as well as local ice caps of undetermined age.

In the western part of the region the ice surge which deposited the Winter Harbour Till on southern Melville and Byam Martin islands during the Late Wisconsinan [10 340-9670 BP as interpreted by Hodgson et al. (1984); or 11 300-11 000 BP as interpreted by Dyke (1987)] may have deposited some of the glacial drift in at least the southern part of the Byam Martin-Austin channel region and in adjacent northern Viscount Melville Sound. The ice possibly extended somewhat farther north in the channels. However, whether or not the ice configurations and the prevailing water depths would have permitted the surges which deposited the Winter Harbour and Bolduc tills to become grounded over extensive parts of this offshore area as opposed to remaining entirely as floating ice shelves, is uncertain.

Pronounced parallel orientation of ice keel marks recorded on sidescan sonograms of the seafloor extending across an observed distance of 7.5 km southwest of Byam Martin Island (Fig. 45) and a shorter distance southeast of Melville Island must have been formed by a large mass of ice, either an ice sheet, or very large bergs. Their location and northwest-southeast orientation suggest the possibility that they may relate to grounding of the ice shelf that deposited the Winter Harbour Till.

Farther north in the western part of the region glaciomarine sediments that have a minimum age of 10 500 $\pm$ 130 BP overlie till on Lougheed Island (Hodgson, 1981). The source and age of the underlying till has not been established, but the same glaciation may have deposited at least some of the drift seen on our seismic records in Byam Martin Channel. The age date from Lougheed Island and the age of the Winter Harbour Till, which represents the last ice advance known to have affected the Byam Martin region, suggest a probable minimum age in the order of about 10 000 BP for the glaciomarine sediments that occur offshore in that region. This age is similar to that extrapolated for the bottom of the postglacial sediments in Core 144 in Barrow Strait, and for glaciomarine sediments on Bathurst Island. This suggests that the change from glaciomarine to postglacial environments may have been approximately synchronous in those areas.

Deposits of glaciomarine and postglacial sediments overlying the drift in most areas are relatively thin and localized or discontinuous in their distribution. The sparse deposits of these sediments raise the question: if the drift in large parts of the surveyed channels is pre-Late Wisconsinan, why has more sediment not been deposited in the intervening time?; or conversely, is the drift in these areas largely Late Wisconsinan in age? First, the central Arctic Islands is a region of generally low and relatively gentle topography with climatic conditions that provide low precipitation amounts, a short run off season, and sub-freezing temperatures throughout much of the year. As a result, the annual input of sediment into the marine areas is low. Substantial submergence of the islands due to isostatic loading further reduced the available sediment source areas during at least part of the Late Wisconsinan. Bottom currents also have been a factor by limiting soft sediment accumulations to the deeper, sheltered basin areas. The sparse sediments therefore do not seem necessarily to point to a Late Wisconsinan age for the underlying drift, but neither are they incompatible with such a possibility.

Second, do the regional reconstructions from onshore favour or exclude the likelihood of widespread Late Wisconsinan glacial deposits in the interisland channels surveyed in this study? Some possible occurrences have already been mentioned. In addition, most of the land areas bordering Parry Channel and the other interisland channels under study in this report were covered by Laurentide Ice or local ice caps during at least part of the Late Wisconsinan as indicated by Dyke and Prest's (1987a) 18 ka reconstruction. If glacial ice was more extensive prior to 18 ka, local ice caps on, for example, Devon, Cornwallis, and Bathurst islands may previously have been of sufficient size to have deposited glacial drift in adjacent interisland channel areas, e.g. Wellington, Byam Martin, Austin, and Byam channels. Dyke and Prest's (1987a) reconstructions indicated the presence of grounded ice in Viscount Melville Sound and an ice shelf in Barrow Strait, Lancaster Sound, and Prince Regent Inlet. Dyke and Prest (1987b) also considered that ice shelves probably were present in other interisland channels north of the Laurentide Ice Sheet. If the glacial drift in eastern Barrow Strait and western Lancaster Sound is Late Wisconsinan in age, then the Laurentide Ice Sheet must at some time have been grounded farther east than the 18 ka position indicated by Dyke and Prest (1987a). Similarly, stratified glaciomarine deposits that are considered to be ice proximal on the basis of textural and paleontological data demand an adjacent grounded ice margin. Drift which locally overlies the lower part of the glaciomarine sequence in the vicinity of the Core 154 locality (Fig. 24) is a further indication of a nearby grounded ice sheet. Later, somewhat more ice distal parts of the glaciomarine sequence in Barrow Strait and Lancaster Sound may relate to the presence of the ice shelf postulated by Dyke and Prest (1987 a,b).

Taylor (1988) examined permafrost distribution in the Arctic Archipelago for evidence regarding the glacial history of the region. These investigations indicated that thick permafrost does not exist under the deep interisland channels, in contrast to thicknesses of 500 m or more onshore. The absence of permafrost offshore reflects either a long period of melting (25 000 years if permafrost originally was as thick as onshore), or conditions in which thick permafrost would not develop, such as beneath water filled channels, ice shelves, or warm based ice. Our interpretation of events suggests that any or all of the latter may have occurred at times in the interisland channels. If correct, these are factors that could affect estimates of the time required for the permafrost to decay.

The above speculations do not provide conclusive answers, but the possibility of Late Wisconsinan glacial deposits in the channels in this part of the archipelago, if anything, seems favoured. Multiple drift sequences which are more prevalent in Austin and Byam Martin channels indicate inundation of at least part of the western region by glacial ice on more than one occasion.

The origin of the interisland channels has been the subject of some discussion, and differing views have been held as to their age and whether they are mainly erosional (e.g. Fortier and Morley, 1956; Pelletier, 1966; Vilks et al., in press) or structural (e.g. England, 1987) features . Seismic reflection profiles acquired to date in the interisland channels in the central part of the Arctic Archipelago included in this study generally show little evidence of faulting or significant structural discontinuities except in the central part of eastern Barrow Strait. However, additional surveys of selected nearshore and other channel margin areas with small craft are desirable both in regard to this subject and to assist onshore/offshore correlations. Seismic profiles obtained in 1987 east and northeast of Lougheed Island north of the present study area (Sonnichsen and MacLean, 1988) similarly showed no evidence of major structural dislocation. However, preliminary examination of data recently obtained in Norwegian Bay farther east suggests a possibly greater structural influence on the morphology in part of that area (Praeg, 1987). This may reflect movements associated with the opening of Baffin Bay during the Paleogene. These findings suggest that variations may exist in the evolutionary history of the channels in the eastern part of the Arctic Archipelago compared to those in the central and western parts. However, differential erosion and in places planation of the underlying bedrock appears to be the principal control on the present seabed morphology in the interisland channels surveyed to date (e.g. Fig. 7, 8 and 43).

Future work in the Arctic interisland channels should include: additional sampling to obtain chronological information, in particular; more detailed seimic profile coverage across morainal and other features to establish trends, and where feasible, relationships with deposits and events recognized onshore; additional surveys of channel margin areas as indicated above; and extension of the studies into presently unknown areas.

APPLICATIONS

The marine studies reported in this paper provide new information on the surficial geology of the Arctic Archipelago, give further insight into the history of Quaternary events in the region, and contribute to the knowledge of global change. The studies provide information on the distribution, thickness, and geotechnical properties of the sediments and describe general depositional environments, as well as modifying processes. These indicate the regional occurrence and competence of the main sediment units, factors that have direct relevance to seabed engineering or other activities requiring knowledge of seabed composition, strength, and stability. Such information is required by government and industry for preliminary environmental assessment, developmental and regulatory planning for production and transportation of offshore and onshore resources in this region, and for military purposes.

The results of these studies serve as an important basis for further geological and allied research into the Quaternary and pre-Quaternary history and evolution of the Arctic Islands region, and of conditions during the present day and recent past. The data obtained also provide a basis for comparative equipment trials as acoustic and other technology is further developed in the future to meet the special needs of marine geoscience work in regions of permanent and semi-permanent ice cover.

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