Géographie physique et Quaternaire

The Quaternary History of Banks Island, N.W.T., Canada
Le Quaternaire de l'île de Banks, T.-N.-O., Canada
Четвертичный период на острове бэнкс. Канада

Jean-Serge Vincent

Volume 36, numéro 1-2, 1982

URI : https://id.erudit.org/iderudit/032478ar
DOI : https://doi.org/10.7202/032478ar

Aller au sommaire du numéro

Éditeur(s)

Les Presses de l'Université de Montréal

ISSN

0705-7199 (imprimé)
1492-143X (numérique)

Découvrir la revue

Citer cet article

Vincent, J.-S. (1982). The Quaternary History of Banks Island, N.W.T., Canada. *Géographie physique et Quaternaire*, *36*(1-2), 209–232. https://doi.org/10.7202/032478ar

Résumé de l'article

L'île de Banks est un désert polaire où les islandsis continentaux venant du sud-est ont atteint au moins à trois reprises leur extension maximale. La plus vieille Glaciation de Banks a submergé toute l'île sauf le nord-ouest. La mer pré-Banks a précédé I'englaciation, tandis que la mer post-Banks existait au moment de la déglaciation. Après I'lnterglaciaire de Morgan Bluffs, caractérisé par un climat semblable à celui d'aujourd'hui, le sud, l'est et le bassin de la rivière Thomsen ont été submergés au cours de la Glaciation de Thomsen. La mer pré-Thomsen a précédé I'englaciation, tandis que la mer Big a submergé de vastes régions lors de la déglaciation. À la suite du dernier Interglaciaire de Cape Collinson, des lobes de glace laurentidiens ont empiété sur les régions côtières de l'île, au cours du Stade de M'Clure de la Glaciation d'Amundsen. Les lobes de Prince of Wales et de Thesiger, émanant du golfe d'Amundsen, ont respectivement progressé dans le détroit du Prince-de-Galles et la baie Thesiger, empiétant sur les côtes orientales et sud-ouest. Au même moment, le lobe de Prince Alfred, a progressé vers l'ouest dans le détroit de M'Clure en empiétant sur la côte nord. La mer pré-Amundsen a précédé I'englaciation de la côte sud, tandis que la mer d'East Coast a submergé l'est jusqu'à 120 m, la mer de Meek Point, l'ouest jusqu'à 20 m et la mer Investigator, Ie nord jusqu'à 30 m, lors de la déglaciation. Un complexe morainique a été édifié sur la côte sud-ouest par l'avancée tardive de Sand Hills du Lobe de Thesiger. Plus tard, le nord-est a été recouvert par le Lobe de Viscount Melville, lors du Stade de Russell de la Glaciation d'Amundsen, et la côte est a été submergée jusqu'à 25 m par la mer de Schuyter Point. On propose également les limites d'avancée du glacier laurentidien, dans le sud-ouest de l'archipel Arctique, au cours des deux stades de la glaciation du Wisconsinien.

Géographie physique et Quaternaire, 1982, vol. XXXVI, nos 1-2, p. 209-232, 11 fig. (dont 1 en pochette), 3 tabl.

THE QUATERNARY HISTORY OF BANKS ISLAND, N.W.T., CANADA

Jean-Serge VINCENT, Geological Survey of Canada, 601, Booth Street, Ottawa Ontario K1A 0E8.

ABSTRACT Banks Island is a polar desert where continental ice sheets, spreading from a dispersal centre to the southeast, reached their maximum extent on at least three occasions. The oldest Banks Glaciation affected all but the northwest. The Pre-Banks Sea preceded glacierization while the Post-Banks Sea formed during deglaciation. Following Morgan Bluffs Interglaciation, characterized by a climate similar to that of today, the south, the east, and the Thomsen River basin were covered during Thomsen Glaciation. The Pre-Thomsen Sea preceded the glacierization, while the Big Sea inundated much of the Island during deglaciation. Following the last or Cape Collinson Interglaciation, characterized by a climate warmer than that of the hypsithermal, Laurentide glacial lobes impinged on the coastal areas, during the M'Clure Stade of Amundsen Glaciation. Prince of Wales and Thesiger lobes, emanating from Amundsen Gulf, respectively advanced in Prince of Wales Strait and Thesiger Bay impinging on the east and southwest coasts. At the same time, Prince Alfred Lobe, originating in Viscount Melville Sound, advanced in M'Clure Strait and impinged on the north coast. The Pre-Amundsen Sea preceded the glacierization of the south coast, while the East Coast Sea submerged the east coast up to 120 m, the Meek Point Sea the west up to 20 m and the Investigator Sea the north up to 30 m, during deglaciation. The late Sand Hills Readvance of Thesiger Lobe built a morainic system on the southwest coast. Later, the northeast was covered, during the Russell Stade of Amundsen Glaciation, by Viscount Melville Lobe, emanating from Viscount Melville Sound, and the east coast was drowned up to 25 m by the Schuyter Point Sea. Limits of extent of Laurentide ice in the southwestern Archipelago are proposed for the two stades of the last or Wisconsinan Glaciation.

RÉSUMÉ *Le Quaternaire de l'île de Banks, T.-N.-O., Canada.* L'île de Banks est un désert polaire où les islandsis continentaux venant du sud-est ont atteint au moins à trois reprises leur extension maximale. La plus vieille Glaciation de Banks a submergé toute l'île sauf le nord-ouest. La mer pré-Banks a précédé l'englaciation, tandis que la mer post-Banks existait au moment de la déglaciation. Après l'Interglaciaire de Morgan Bluffs, caractérisé par un climat semblable à celui d'aujourd'hui, le sud, l'est et le bassin de la rivière Thomsen ont été submergés au cours de la Glaciation de Thomsen. La mer pré-Thomsen a précédé l'englaciation, tandis que la mer Big a submergé de vastes régions lors de la déglaciation. À la suite du dernier Interglaciaire de Cape Collinson, des lobes de glace laurentidiens ont empiété sur les régions côtières de l'île, au cours du Stade de M'Clure de la Glaciation d'Amundsen. Les lobes de Prince of Wales et de Thesiger, émanant du golfe d'Amundsen, ont respectivement progressé dans le détroit du Prince-de-Galles et la baie Thesiger, empiétant sur les côtes orientales et sud-ouest. Au même moment, le lobe de Prince Alfred, a progressé vers l'ouest dans le détroit de M'Clure en empiétant sur la côte nord. La mer pré-Amundsen a précédé l'englaciation de la côte sud, tandis que la mer d'East Coast a submergé l'est jusqu'à 120 m, la mer de Meek Point, l'ouest jusqu'à 20 m et la mer Investigator, le nord jusqu'à 30 m, lors de la déglaciation. Un complexe morainique a été édifié sur la côte sud-ouest par l'avancée tardive de Sand Hills du Lobe de Thesiger. Plus tard, le nord-est a été recouvert par le Lobe de Viscount Melville, lors du Stade de Russell de la Glaciation d'Amundsen, et la côte est a été submergée jusqu'à 25 m par la mer de Schuyter Point. On propose également les limites d'avancée du glacier laurentidien, dans le sud-ouest de l'archipel Arctique, au cours des deux stades de la glaciation du Wisconsinien.

РЕЗЮМЕ *Четвертичный период на острове Бэнкс, Канада.* Остров Бэнкс это полярная пустыня, где континентальный ледяной покров, исходящий из юго-востока, достиг своих максимальных пределов по меньшей мере в трех случаях. Древнейшее оледенение острова Бэнкс охватило всю его территорию, за исключением северо-запада. Море pre-Banks предшествовало оледенению, в то время как море post-Banks образовалось во время таяния. После межледникового периода Морган Блаффс, юг, восток и бассейн реки Томсен покрылись льдом во время томсенского оледенения. Море pre-Thomsen предшествовало оледенению, в то время как море Биг затопило большую часть острова во время таяния ледника. После последнего межледникового периода, или периода Кейп Коллинсона, выступы лаврентьевского ледника надвинулись на прибрежные районы во время стадии МакКлюра амундсенского оледенения. Выступы принца Уэльского и Тезигера, исходящие из залива Амундсена, продвинулись соответственно в пролив Принца Уэльского и залива Тезигера, надвигаясь на восточное и Юго-западное побережья. В то же время выступ Принца Альфреда, образовавшийся в проливе Виконта Мелвилла, продвинулся в пролив МакКлюра и надвинулся на северное побережье. Море pre-Amundsen предшествовало обледенению южного побережья, в то время как море Восточного Берега затопило восточный берег до 120 м, море Мик Пойнт до 20 м и море Инвестигейтор до 30 м во время таяния ледника. Позднее повторное наступление Сэнд Хиллз выступа Тезигера образовало морены на юго-западном побережье. Позже, во время стадии Рассела амундсенского оледенения, северо-восток был покрыт льдами выступа Виконта Мелвилла, а восточное побережье было затоплено до 25 метров морем Шуйтер Пойнт. Предлагаются пределы распространения лаврентьевского ледника в юго-западном архипелаге для двух стадий последнего висконсинского оледенения.

INTRODUCTION

Banks Island is situated along the northwestern margin of the North American continent where the Quaternary ice sheets reached their maximum limits on several occasions. These events, recorded in sediments of both glacial and nonglacial origin, probably span the longest period of time presently known in the Canadian Arctic Archipelago, and they make Banks Island an extremely important area for Quaternary studies.

The purpose of this paper is to describe aspects of the Quaternary history of Banks Island determined during surficial geology mapping and stratigraphic investigations. Much of the data pertaining to this study are contained in more lengthy reports (VINCENT, 1980a; and in press) or surficial geology maps (VINCENT, 1980b). Names for the events mentioned in this paper were established by VINCENT (1978a, 1980a and in press).

STUDY AREA

Banks Island (60,165 km^2) is located at the southwestern extremity of the Canadian Arctic Archipelago (Fig. 1). It faces the Beaufort Sea to the west and it is separated from the mainland to the south by Amundsen Gulf; from Victoria Island to the east by Prince of Wales Strait; and from Melville and Prince Patrick islands to the north by M'Clure Strait. Sachs Harbour, on the southwestern coast, is the only settlement.

PREVIOUS WORK

Until J.G. Fyles of the Geological Survey of Canada (GSC) undertook a reconnaissance survey of the surficial geology in 1959, work was centred on establishing if certain areas were or were not glaciated, and on delineating the extent of the latest ice advance. WASHBURN (1947), having identified till near De Salis Bay in 1938, proposed that southern Banks Island was once

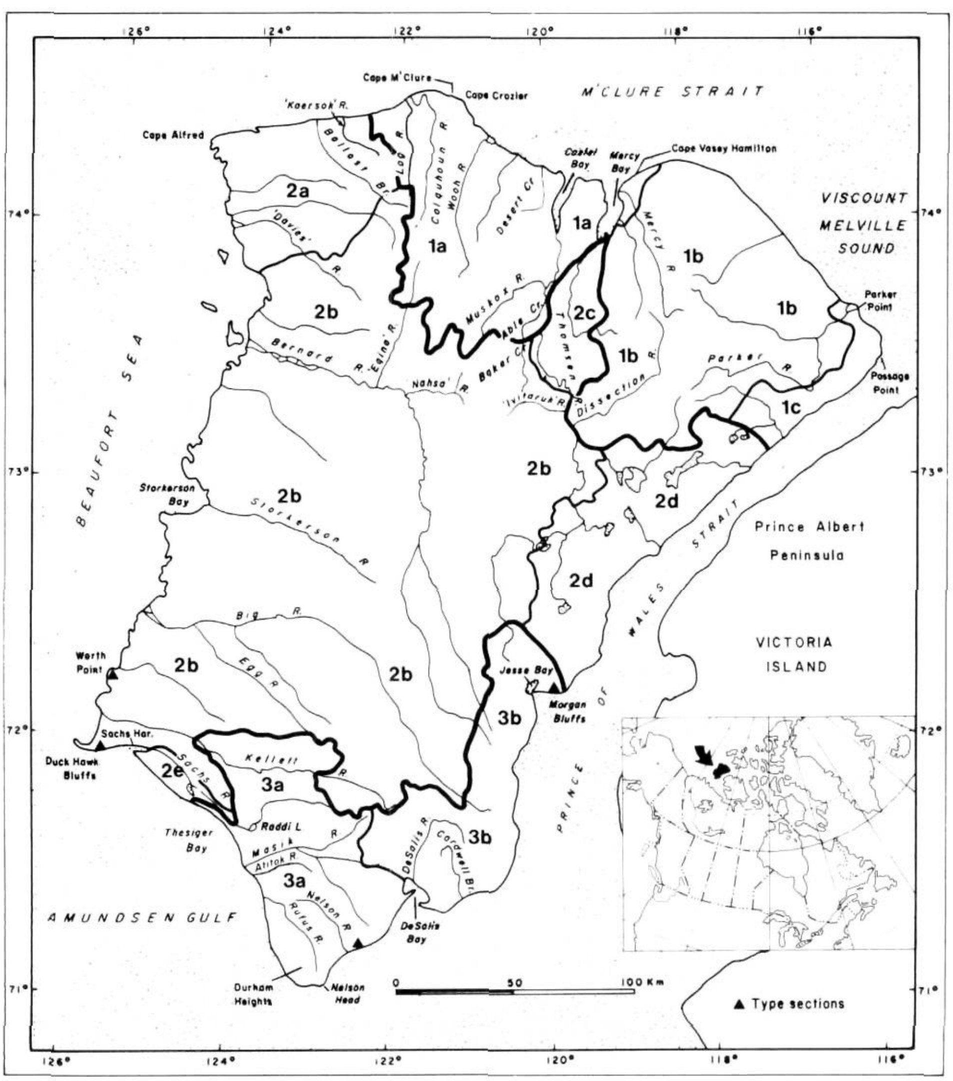


FIGURE 1. Location map and topography of Banks Island. 1. Northern Uplands: 1a) Colquhoun Dissected Uplands; 1b) Pim Dissected Plateau, 1c) Prince of Wales Morainal Belt. 2. Central Lowlands: 2a) Ballast Coastal Plain; 2b) Bernard Rolling Lowlands; 2c) Thomsen Glacially Scoured Lowlands; 2d) Prince of Wales Morainal Belt; 2e) Sachs Outwash Plain. 3. Southern Uplands: 3a) Nelson Dissected Uplands; 3b) Prince of Wales Morainal Belt.

Carte de localisation et topographie de l'île de Banks. 2. Hautes terres septentrionales: 1a) hautes terres disséquées de Colquhoun; 1b) plateau disséqué de Pim; 1c) ceinture morainique du Prince-de-Galles. 2. Basses terres centrales: 2a) plaine côtière de Ballast; 2b) basses terres ondulées de Bernard; 2c) basses terres décapées de Thomsen; 2c) ceinture morainique du Prince-de-Galles; 2e) plaine d'épandage de Sachs. 3. Hautes terres méridionales: 3a) hautes terres disséquées de Nelson; 3b) ceinture morainique du Prince-de-Galles.

glaciated. HOBBS (1945) showed a boundary for "Wisconsin" ice crossing the island northeastward from Thesiger Bay to Parker Point as marked by chains of lakes. PORSILD (1950) found evidence of glaciation in the south and the east but believed that the northeastern plateau and the northern and western coastal areas were not glaciated. JENNESS (1952) drew a line similar to that of Hobbs but indicated it marked the limit of "Continental Ice". He also surmised that the north was untouched by continental ice although it was possibly subjected to local glaciation and that the glacial history of the west was uncertain. MANNING (1956) also believed that eastern Banks Island was glaciated and did not exclude glaciation of the west since he mentioned observing till in that area. The first *Glacial Map of Canada* (WILSON *et al.*, 1958) summarizes the information available up until the late 1950's. The east and south is shown on this map as having been glaciated, probably during the last glaciation, and the west and north is shown as unglaciated.

With the subsequent work of J.G. Fyles, a better understanding of the Quaternary history of Banks Island was gained (FYLES, 1962 and 1969; CRAIG and FYLES, 1960 and 1965). Results of this work are summarized on the second *Glacial Map of Canada* (PREST *et al.*, 1968) which shows that the southwest, south and east coastal areas as well as the extreme north along M'Clure Strait were glaciated during the Late Wisconsinan Stade. Based on field observations of glacial deposits in many areas, the remainder of the island is shown as having been glaciated entirely in pre-"Wisconsin" time. This interpretation has been generally accepted since the publication of this map and appears on most recent maps that depict the limit of the Late Wisconsinan ice sheet (HUGHES *et al.*, 1977). Marine and lake limits were not mapped but Fyles recognized the existence of a low marine transgression on the west coast (CRAIG and FYLES, 1960, p. 10) and the presence of glacial lake sediments in the Parker River (FYLES, 1962, p. 8) and Ballast Brook (FYLES, 1969, p. 155) drainage basins. The history of the extreme northwest was investigated by FRENCH (1972) who attempted to explain the complex glacial drainage in the area. Fyles also investigated numerous sections, such as the Worth Point Bluffs and Duck Hawk Bluffs, and showed that sediments, possibly interglacial in nature, existed on Banks Island (CRAIG and FYLES, 1965). KUC (1974) described the peats in the Worth Point Bluffs and concluded that they accumulated in an open subarctic forest tundra environment during an interglaciation.

PRESENT STUDY

The approach used is a typical one employed when studying a large area where deposits have not been mapped. A surficial geology map was first prepared based on airphoto interpretation and field observations acquired during helicopter traverses in 1974 and 1975. Deposits both of different genesis, and of similar genesis but having different characteristics, were distinguished. Secondly, the better sections were studied and an attempt was made to correlate the sediments in these with those mapped on the surface. Finally, sedimentological, geochronological and paleoecological studies were completed on various sediments. Sedimentological analyses, mainly on tills, involved obtaining data on grain size, and on carbonate content, various clays, heavy minerals and trace elements. Geochronological analyses involved dating wood and shells by radiocarbon and amino acid techniques. Paleoecological investigations mainly involved identifying floral remains such as pollen or wood, or faunal remains such as arthropods, molluscs, or vertebrates. Some results of the work have already been published (VINCENT, 1978a, d, 1980a,b, in press; MORRIS and VINCENT, 1979; VINCENT and EDLUND, 1978; PISSART *et al.*, 1977).

PHYSICAL SETTING

TOPOGRAPHY

Banks Island is subdivided into three topographic regions: two upland regions, one to the north and one to the south, separated by a central lowland area. The main regions are further divided into smaller subregions on the basis of the geological processes which are mainly responsible for their formation (Fig. 1). The highest points in the upland areas to the north and to the south are respectively *ca.* 475 and 675 m a.s.l. Prince of Wales Strait is shallow with few areas deeper than 100 m. M'Clure Strait is generally more than 400 m deep while Amundsen Gulf is more than 300 m deep and both bodies of water have closed basins more than 500 m deep.

BEDROCK GEOLOGY

The pre-Quaternary geology of the study area is discussed in detail by MIALL (1976, 1979). The Glenelg Formation in the south, and the Weatherall and Parry Islands formations in the north, are mainly made up of horizontally bedded or slightly inclined, well-lithified sandstones with shales, siltstones, limestones and dolomites (Fig. 2). Some gabbroic intrusive bodies occur in the Glenelg Formation. The other pre-Quaternary formations are mainly unlithified to poorly lithified clays and silts (Christopher and Kanguk formations), sands (Isachsen, Hassel and Eureka Sound formations) and sand and gravels (Beaufort Formation).

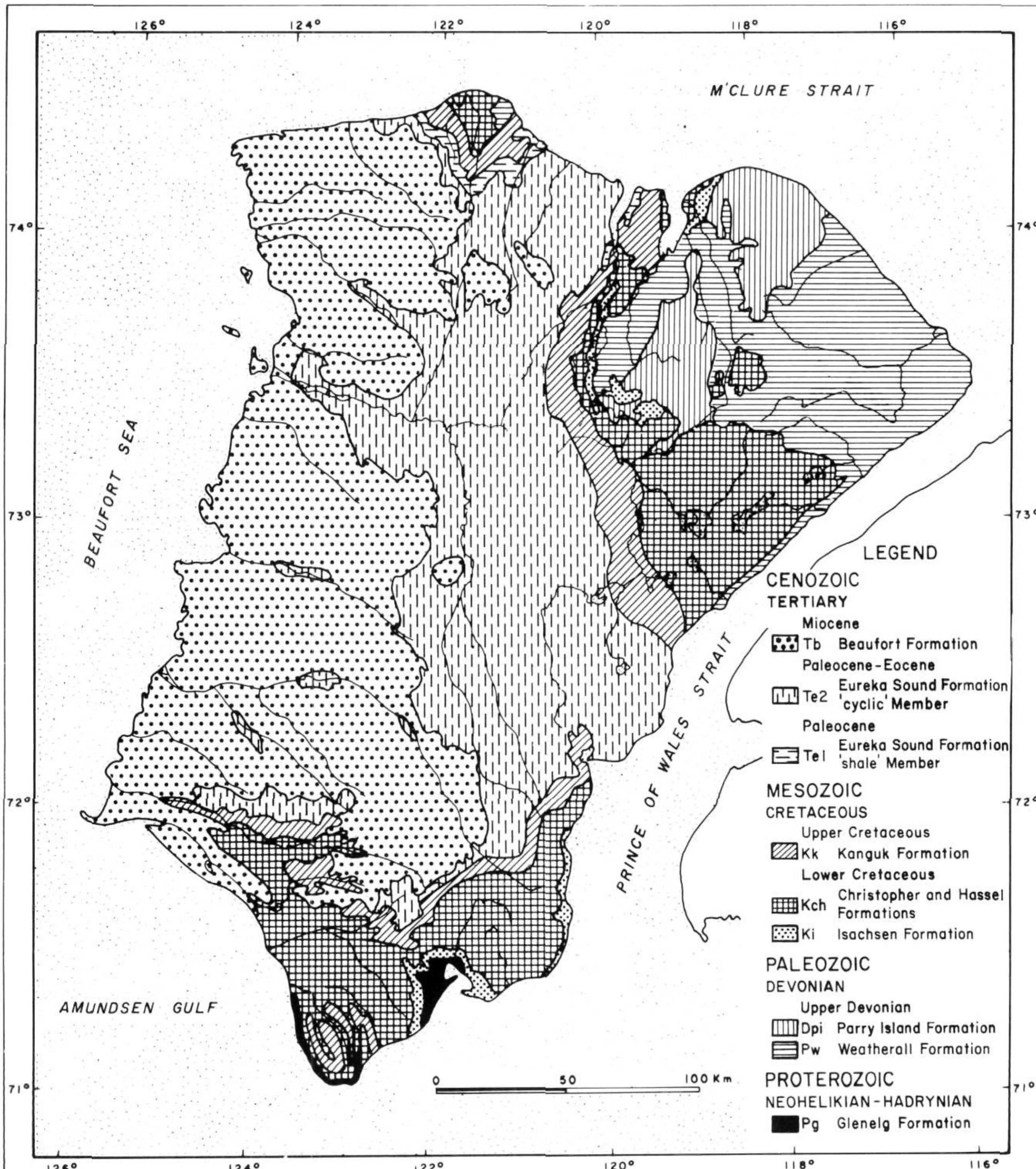


FIGURE 2. Geological map of Banks Island (after MIALL, 1979). *Carte géologique de l'île de Banks (d'après MIALL, 1979).*

CLIMATE, VEGETATION AND PERMAFROST

Banks Island is a polar desert. At the coastal Sachs Harbour station, the mean annual temperature is −14°C and the mean annual precipitation is 100 mm (BURNS, 1973). The mean temperature for June, July and August is respectively 2.2°C, 5.6°C and 4.3°C and half of the precipitation falls during these months (BURNS, 1973). The vegetation is characteristic of tundra areas. The Low, Mid and High Arctic ecological regions are represented. Species diversity is highest in the Low Arctic area with more than 200 vascular species, and lowest in the High Arctic areas with less than 100 species present (S.A. Edlund, pers. comm.). The island is underlain by continuous permafrost which was estimated to be 500 m thick at a well site near Storkerson Bay on the west coast (TAYLOR and JUDGE, 1974).

QUATERNARY HISTORY

Mapping of surficial deposits and landforms including well defined ice-marginal features, together with the identification of major textural and other differences in tills, permits the delienation of three glaciations on Banks Island. Ice limits during each of these successive glaciations (named from oldest to youngest, the Banks, Thomsen and Amundsen glaciations), and the distribution of 11 named and geographically separated till sheets, are shown in Figure 3. Mapping also led to the recognition of 12 glacial lakes and 3 distinct marine episodes. Lateral stratigraphic relationships between till sheets and marine and lacustrine sediments and features establish the relative age of events.

The till sheets were differentiated on the basis of stratigraphic position, surface form, texture, colour and other properties. An example of two adjoining till sheets is shown on Figure 4. The type of observations used in this example for differentiating the till sheets is similar to that used for separating all other till sheets on Banks Island or on adjacent areas. The surface of Jesse Till is characterized by a network of high centred polygons and relatively fresh looking glacial topography. Surfaces of the Kellett Till, on the other hand, have been subdued to a greater extent by periglacial processes. The matrix of Jesse Till is finer (*ca.* 60% silt and clay) than that of the Kellett Till (*ca.* 40% silt and clay) and is characterized by its pinkish grey colour in comparison to the pale brown colour of Kellett Till. The distinct nature of the two till sheets can also be unequivocally demonstrated since they are separated in one bluff by interglacial sediments. It should also be noted that many of the separately named till sheets were probably laid down during a common glacial event. However, since they are not contiguous, equivalence of age has not yet been proven and they are presently related simply by comparing their properties and extensiveness. In all cases the limits of the correlated till sheets are thought to coincide with the limits of the three individual glaciations. For example, the limit of the ice advance responsible for deposition of Jesse Till is well defined by the controlling effect of minor topographic obstacles on the distribution of the till and by the presence of features such as terminal moraines and proglacial meltwater channels (Fig. 4). Also, the correlated Kellett, Baker and Kange tills appear to have a similar, discrete cross-cutting relationship equivalent to a common glacial event: the Thomsen Glaciation.

More than 200 sections were examined along major rivers and marine coasts. The Duck Hawk Bluffs, the Worth Point Bluffs, the sections east of Nelson River and the Morgan Bluffs (Fig. 1) provide the most complete records. The many sections in each of these bluffs were correlated by lithology and composite sections of each were drawn (Fig. 5, inset) in order to be correlated one to the other. Some of the inter-bluff correlations are supported by amino acid ratios in fossil wood and shells. A provisional correlation chart for Banks Island has been made (Table 1). 'Formation'' rank was restricted to the various members collectively laid down either during a specific glacial stage or an interglaciation. ''Member'' rank was given to the glacial and marine lithostratigraphic units laid down during a glacial stage. Some marine units resulted from glacio-isostatic depression of the crust and are therefore considered to be related to a glacial event. Others, of perimarine origin, contain organic matter which enable them to be associated with interglacial events. The chart provides the outline for the following discussion.

Pre-Banks Glaciation Events

BANKS ISLAND IN THE POST-MIOCENE

Following deposition of the Miocene Beaufort Formation (sands and gravels), a period of fluvial erosion occurred which produced terraces. These terraces, found in the unglaciated northwest (Fig. 3), necessarily predate the Banks Glaciation since they are crosscut by glacial meltwater channels. The absence of pre-Quaternary marine deposits on the Beaufort Formation in this area indicates that it was above sea level and relatively stable in the Late Tertiary even though Prince of Wales and M'Clure Strait may have been opening at this time by rift-faulting (MIALL, 1979, p. 178). The fluvial dissection of the northeastern Devonian Plateau is possibly associated to this rift-faulting and may also date from the Late Tertiary.

UNGLACIATED AREA

The northwest part of the island bears no indication of having been glaciated (Fig. 3 and FYLES, 1962, p. 17).

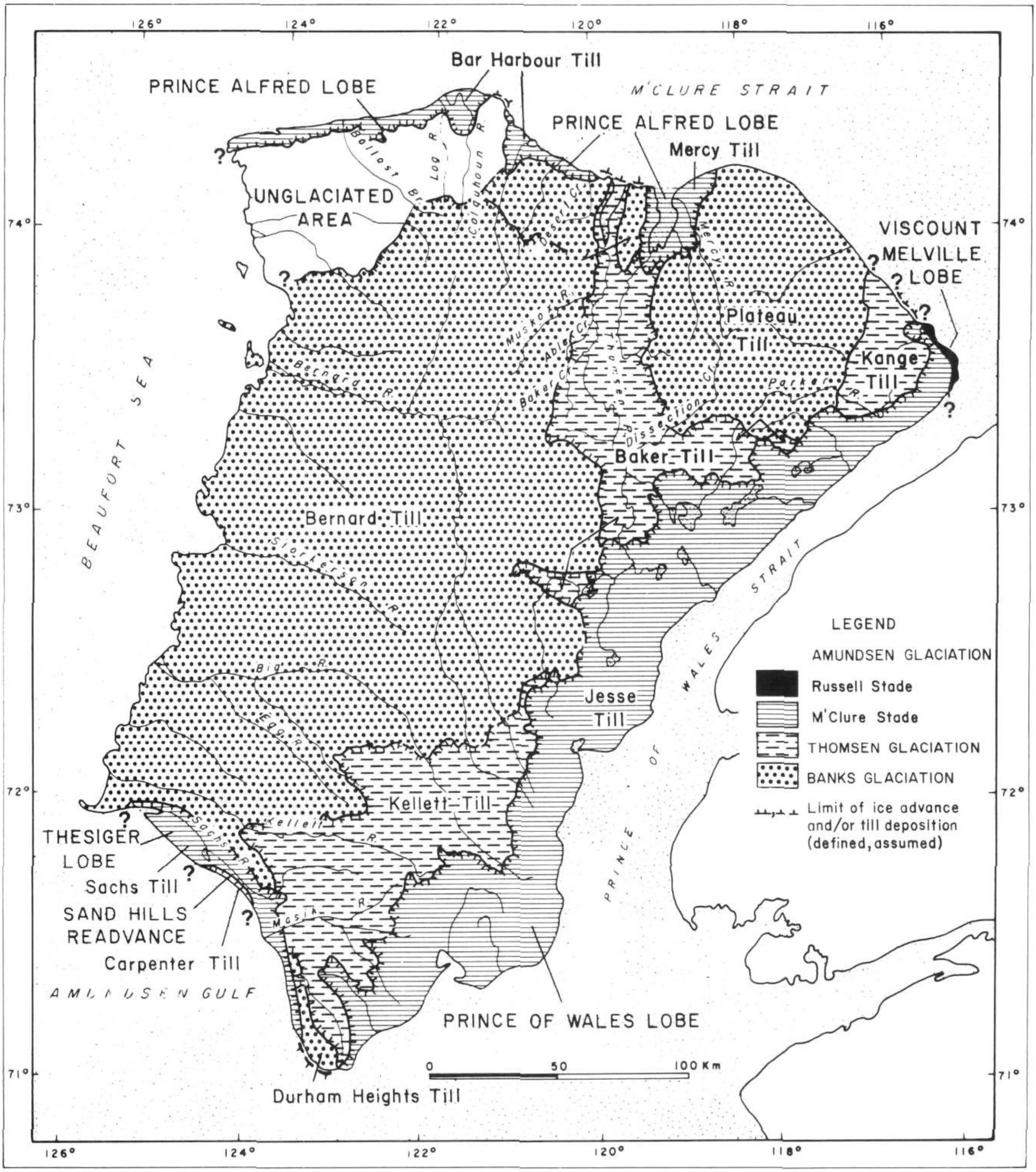


FIGURE 3. Glacial limit of Banks, Thomsen and Amundsen glaciations on Banks Island and distribution of till sheets.

Limite glaciaire lors des glaciations de Banks, de Thomsen et d'Amundsen et répartition des nappes de tills.

Parts were modified by meltwater flowing from the Banks and Amundsen glaciers and parts were covered by glacial lakes Ballast and Ivitaruk, but no glacial deposits or erratics have been found in areas untouched by meltwater or glacial lakes. The presence, on Beaufort surfaces, of "V"-shaped valleys in the unglaciated area, and flat-bottomed and steep-walled valleys in glaciated areas, shows that nonglacial and glacial fluvial systems have existed in adjoining areas supporting the claim that the northwest is in fact unglaciated.

QUATERNARY EVENTS PRIOR TO BANKS GLACIATION

The oldest glacial event recognized from surface mapping is the Banks Glaciation. In the extensive west-

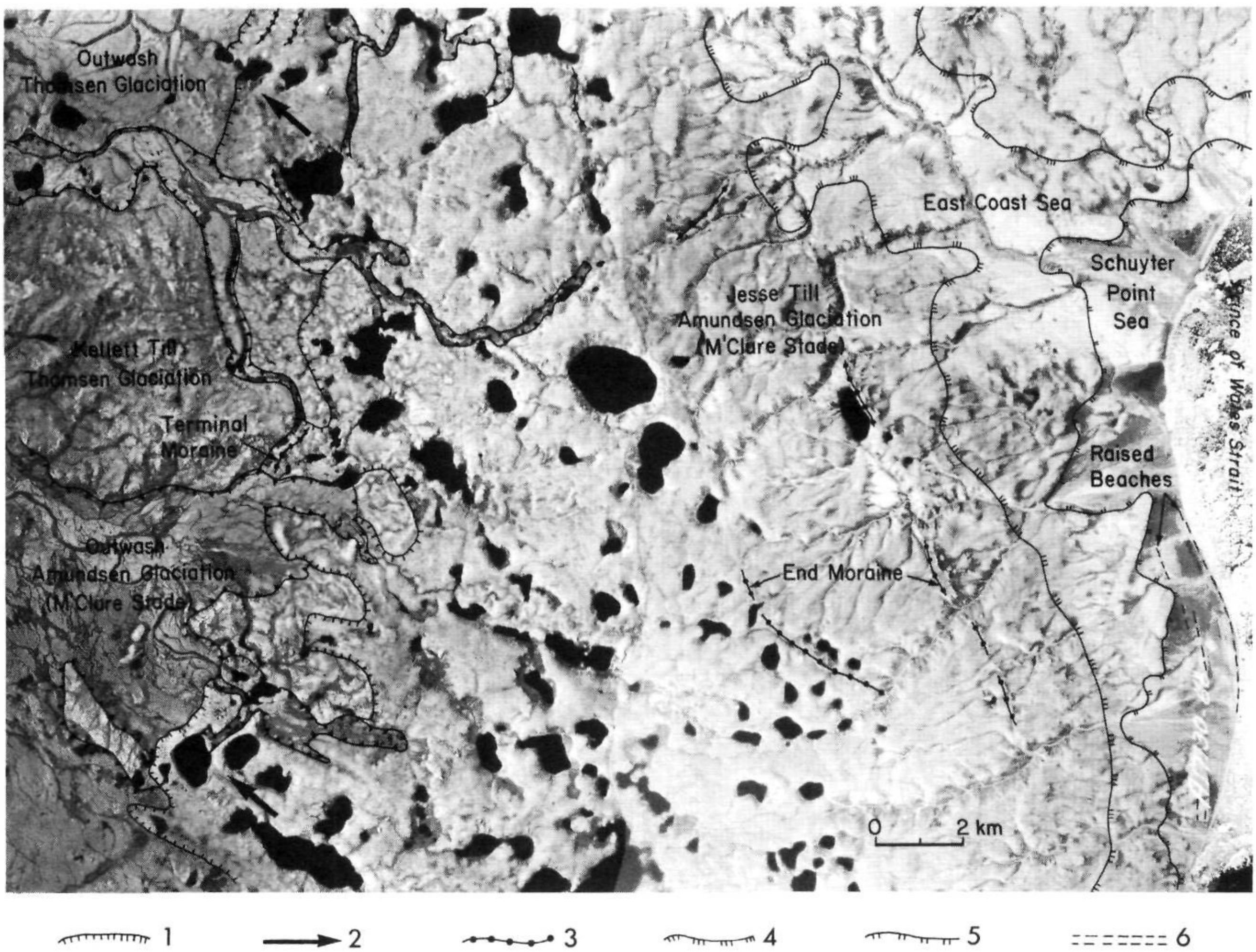


FIGURE 4. Areal view of the eastern area of Banks Island just south of Jesse Bay. Shown on the photograph are: the western limit of Prince of Wales Lobe (M'Clure Stade of Amundsen Glaciation (1); surfaces covered by Kellett Till (Thomsen Glaciation) and Jesse Till (M'Clure Stade of Amundsen Glaciation); glaciofluvial outwash associated with Thomsen and Amundsen glaciations; streamlined Jesse Till surfaces (2); end and terminal moraines built by Prince of Wales Lobe (3); marine limit of the East Coast (4) and Schuyter Point (5) seas, as well as surfaces covered by these; raised beaches built during retreat of Schuyter Point Sea (6). The contrast between the areas covered by Kellett Till and those covered by Jesse Till, as well as the contrast between Jesse Till surfaces situated above or below East Coast Sea limit of submergence are to be noted. Parts of air photographs A17057-93 and A17130-66, National Air Photo Library, Department of Energy, Mines and Resources.

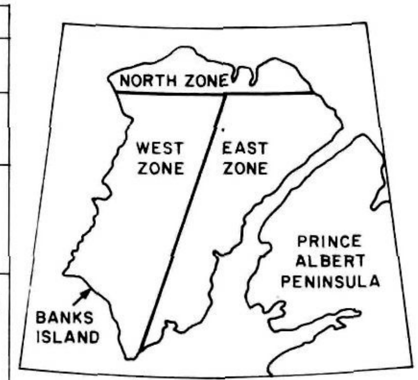
Vue aérienne du secteur oriental de l'île de Banks immédiatement au sud de la baie Jesse. On voit sur la photographie: la limite occidentale du Lobe de Prince of Wales (Stade de M'Clure de la Glaciation d'Amundsen) (1); des surfaces recouvertes du Till de Kellett (Glaciation de Thomsen) et du Till de Jesse (Stade de M'Clure de la Glaciation d'Amundsen); des épandages fluvio-glaciaires associés aux glaciations de Thomsen et d'Amundsen; des surfaces profilées du Till de Jesse (2); des moraines frontales et terminales mises en place par le Lobe de Prince of Wales (3); la limite marine des mers d'East Coast (4) et de Schuyter Point (5) ainsi que les surfaces recouvertes par celles-ci; des plages soulevées, édifiées lors du retrait de la mer de Schuyter Point (6). Le contraste entre les régions recouvertes du Till de Kellett et celles recouvertes du Till de Jesse, ainsi que le contraste entre les régions recouvertes du Till de Jesse sises au-dessus ou en-dessous de la limite de submersion de la mer d'East Coast, sont à noter. Parties des photographies aériennes A17057-93 et A17130-66, Photothèque nationale, ministère de l'Énergie, des Mines et des Ressources.

TABLE I

Correlation chart and Quaternary stratigraphy of Banks Island

Geological Events		Lithostratigraphy[1]			
			North Zone	East Zone	West Zone
Postglacial		Organic, eolian, alluvial, marine and colluvial sediments			
AMUNDSEN GLACIATION	RUSSELL STADE	Prince of Wales Fm.		Schuyter Point Sea Sediments Passage Point Sediments (Viscount Melville Lobe)	
	M'CLURE STADE		Investigator Sea and Meek Point Sea Sediments *Lake Ivitaruk and Lake Ballast* Bar Harbour Till and Mercy Till (Prince Alfred Lobe)	East Coast Sea Sediments *Lake Cardwell, Lake De Salis and Lake Sarfarssuk* Jesse Till (Prince of Wales Lobe) Pre Amundsen Sea Sediments	Carpenter Till (Sand Hills Advance) Meek Point Sea Sediments *Lake Rufus, Lake Masik and Lake Raddi* Sachs Till (Thesiger Lobe)
CAPE COLLINSON INTERGLACIATION				Cape Collinson Formation	
THOMSEN GLACIATION		Nelson River Fm.	Big Sea Sediments Baker Till	Big Sea Sediments *Lake Parker and Lake Dissection* Kellett Till, Baker Till and Kange Till Pre Thomsen Sea Sediments	Big Sea Sediments Kellett Till
MORGAN BLUFFS INTERGLACIATION				Morgan Bluffs Formation	
BANKS GLACIATION		Duck Hawk Bluffs Fm.	Bernard Till and Plateau Till	Post Banks Sea Sediments Bernard Till and Plateau Till Pre Banks Sea Sediments	Post Banks Sea Sediments *Lake Egina and Lake Storkerson* Bernard Till and Durham Heights Till Pre Banks Sea Sediments
ITERGLACIATION OR PREGLACIAL					Worth Point Formation

well as the formally named lithostratigraphic units, the position of the glacial lakes (in italics) is indicated in the stratigraphic sequence.



ern area of the island covered by the Banks Glacier, numerous sections reveal the presence of only one till. However, at least five tills, some of which are separated by probable glacio-marine sediments or boulder pavements, are exposed in a coastal bluff east of Nelson River (Units 1-6, Column A, Fig. 5). These tills, all closely resembling Bernard Till of the Banks Glaciation. These tills could record several pre-Banks glaciations or a lengthy period of complex events during the Banks Glaciation.

Nonglacial sediments underlie the Bernard Till in both the Duck Hawk Bluffs and Worth Point Bluffs (Fig. 5). At Duck Hawk Bluffs up to 12 m thick complex units of organic-bearing sands, gravels and silts occur between the Beaufort sands and gravels and Bernard Till (Unit 3, Column C, Fig. 5). In the Worth Point sections, a > 5 m thick unit of woody peats, containing trunks of *Larix laricina* occur between Beaufort sediments and Bernard Till (CRAIG and FYLES, 1960) (Unit 5, Column C, Fig. 5). The floristic composition of the peat has been studied in detail by KUC (1974) who concluded that the peat accumulated during an "Interglaciation", in an open, Subarctic forest-tundra environment similar to that of the northern part of the boreal forest today. Four radiocarbon determinations on wood or peat gave ages of >35 000 (I-GSC-19; CRAIG and FYLES, 1960, p. 4), > 43 000 (GSC-1293; KUC, 1974), >52 000 (GSC-2072; Kuc, unpubl.) and >54 600 (GSC-1236; KUC, 1974). It is impossible at this time to say whether these deposits are entirely preglacial or whether they accumulated during an early Quaternary Interglaciation. Whatever the case, they predate at least three full glacial-interglacial cycles (Table I).

Banks Glaciation

The oldest glacial event, whose extent is known on land (Fig. 6 and Table I) has been named the Banks Glaciation.

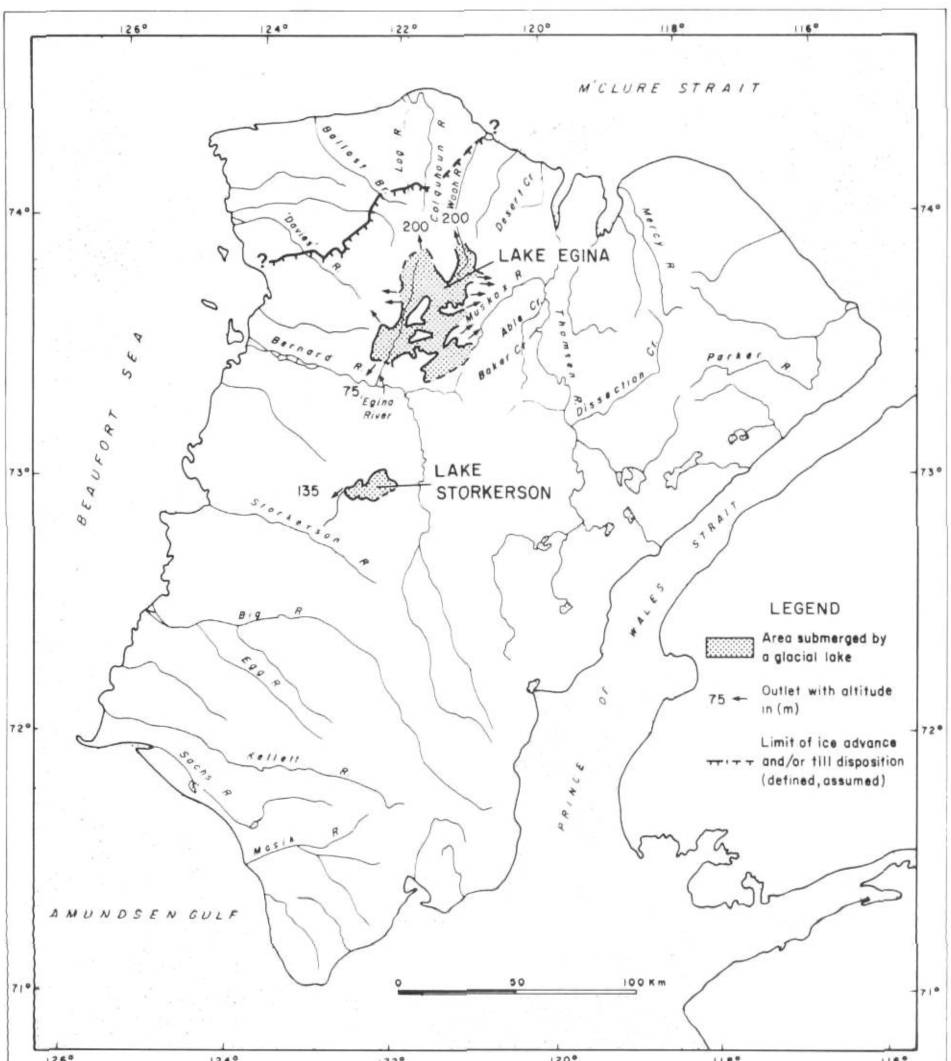


FIGURE 6. Paleogeographic map showing the glacial limit during Banks Glaciation as well as the areas submerged by glacial lakes Egina and Storkerson.

Carte paléogéographique montrant la limite de l'avancée glaciaire lors de la Glaciation de Banks ainsi que les surfaces recouvertes par les lacs glaciaires Egina et Storkerson.

PRE-BANKS SEA

Marine sediments below Bernard Till, in Duck Hawk Bluffs (Unit 6, Column C, Fig. 5) and in Morgan Bluffs (Unit 1, Column B, Fig. 5) could have been laid down just prior to the arrival of ice while the crust was undergoing depression by the approaching advance. Alternatively, they could be much older. The bodies of water in which the sediments were laid down on the west and east coasts are tentatively correlated and the sea is named the Pre-Banks Sea (Fig. 5 and Table I).

GLACIAL ADVANCE

The Banks Glacier flowed from an ice sheet, of mainland (Canadian Shield) origin, centred to the southeast of Banks Island. The Banks Glacier flowed northwestward, overriding in most places fine grained Cretaceous and Tertiary sediments (Fig. 2), until it reached the northwestern part of the island (Fig. 6). The limit of the ice is drawn at the limit of Bernard Till (Fig. 3) and is well marked by proglacial channels. The Banks Glaciation is by far the most extensive of the three recognized glaciations, since no other glaciations had ice sufficiently thick to override the high Durham Heights area in the extreme south and higher parts of the Devonian Plateau in the northeast.

The Bernard, Plateau and Durham Heights tills (Fig. 3) were deposited during this glaciation. These three tills are associated with the same glacial events not only because of their similar physical properties but because the ice that reached the northwestern portion of the island was also the only one thick enough to have covered the Durham Heights and Devonian Plateau areas. The Bernard Till is a black till with a low carbonate and a high montmorillonite content and with generally few stones (Table II). Also characteristic is its low Ca and Mg and high Ba, Al, Zn, and Mn trace element content. Like the Bernard Till, the Plateau Till is black and has a low Ca and Mg and a high Zn and Mn content. Some granitic, gneissic and metasedimentary erratics identified in the tills clearly came from distinct formations in the eastern portion of the District of Mackenzie. Bernard Till is rich in montmorillonite compared to Plateau Till because the glacier probably picked it up from the Cretaceous and Tertiary sediments it overrode.

GLACIAL RETREAT

When the Banks Glacier stood at its maximum, meltwater flowed toward the Beaufort Sea and M'Clure Strait across the unglaciated northwestern area. Ice retreat direction was towards the southeast as shown by the location of proglacial and lateral meltwater channels that dissect the Bernard or Plateau tills surfaces.

Two glacial lakes were formed during retreat. Glacial Lake Egina (Fig. 6) was impounded in the upper 'Egina''[1] River, between an ice front to the southeast and high ground forming a drainage divide to the north. Initial lake levels were controlled by outlets at about 200 m that permitted drainage of two small lakes towards M'Clure Strait via two tributaries of the Woon River. With further ice retreat, the two small lakes were joined and ten subsequent lake phases can be outlined each corresponding to different outlets. Lake levels lowered from *ca.* 200 m to *ca.* 100 m until glacial Lake Egina finally drained when the ice reached a position permitting flow into the Bernard River system. Glacial Lake Storkerson (Fig. 6) was dammed between high ground to the north and the ice front. The outlet was at *ca.* 135 m and water flowed towards the Beaufort Sea via a tributary of the Storkerson River. This short-lived lake finally drained into the Bernard River system. Following these events, ice retreat continued towards the southeast until the island was completely unglaciated.

POST-BANKS SEA

Evidence for a marine event associated with the deglaciation phase of the Banks Glaciation was found only in coastal bluffs since all coastal surfaces were either covered by ice during later glaciations or inundated during younger marine events. Marine sediments overlie Bernard Till, or till interpreted as having been laid down during the Banks Glaciation. This Post-Banks Sea is represented at Duck Hawk Bluffs (Unit 8, Column C, Fig. 5), at Morgan Bluffs (Unit 5, Column B, Fig. 5) and at sections east of the Nelson River (Unit 7, Column A, Fig. 5). The Post-Banks Sea sediments are indicative of a marine regressive phase, associated with isostatic uplift, which extended over the coastal areas of Banks Island following retreat of the Banks Glacier (Fig. 5 and Table I).

The absolute age of the Banks Glaciation is not known. It predates at least two full glaciations and two interglaciations prior to the present interglaciation (Table I).

Morgan Bluffs Interglaciation

Organic bearing perimarine sediments, which overlie marine and glacial sediments associated with the Banks Glaciation and underlie marine and glacial sediments associated with the Thomsen Glaciation, are found in the sections east of the Nelson River (Unit 8, Column A, Fig. 5) and at Morgan Bluffs (Unit 6, Column B, Fig. 5). Fluvial sediments with organics and paleosols

1. Geographical names in quotations are unofficial, but have been submitted to the Canadian Permanent Committee on Geographical Names.

TABLE II

Summary of till analyses

UNIT	Carpenter Till	Sachs Till	Jesse Till	Kange Till	Baker Till	Kellett Till	Plateau Till	Bernard Till
TEXTURE								
No. of samples	1	3	23	1	6	16	7	34
sand (%)	47	61	41	48	37	59	68	45
range	—	58-67	21-87	—	27-57	32-94	47-95	16-89
s[1]	—	—	15	—	11	18	16	17
silt (%)	32	22	37	37	40	28	21	33
range	—	14-27	10-50	—	36-45	4-45	4-35	6-52
s	—	—	9	—	3	10	10	10
clay (%)	21	17	22	15	24	14	11	22
range	—	14-19	3-33	—	7-31	2-33	2-18	5-39
s	—	—	8	—	9	9	7	10
CARBONATES								
No. of samples	1	3	23	1	6	16	7	34
Total (%)	22	22	39	40	22	33	16	17
range	—	13-38	27-63	—	6-32	21-46	2-26	6-33
s	—	—	9	—	10	10	7	8
CLAY MINERALOGY								
No. of samples	1	2	7	—	1	3	3	10
Illite (%)	63	35	49	—	41	43	38	27
range	—	30-40	35-55	—	—	31-52	34-42	12-43
s	—	—	7	—	—	—	4	10
Chlorite (%)	33	27	36	—	57	35	31	24
range	—	22-31	18-47	—	—	20-45	12-47	10-50
s	—	—	10	—	—	—	18	10
Kaolinite (%)	4	28	10	—	2	17	31	11
range	—	26-29	2-25	—	—	7-37	16-54	4-22
s	—	—	8	—	—	—	20	7
Montmorillonite (%)	—	11	5	—	—	4	—	38
range	—	0-22	0-34	—	—	0-12	—	0-71
s	—	—	—	—	—	—	—	20
HEAVY MINERALS								
No. of samples	1	2	7	—	1	3	3	10
Total (%)	2.1	1.0	0.6	—	0.7	0.5	0.9	0.4
range	—	0.9-1.1	0.2-1.3	—	—	—	0.5-1.4	0.3-0.7
s	—	—	0.4	—	—	—	0.5	0.2
Magnetics (%)	24.6	33.3	30.9	—	25.9	35.1	13	18.4
range	—	29.9-37.6	21.4-37.8	—	—	20.3-50.0	11.2-37.4	8.3-46.5
s	—	—	6.0	—	—	—	11	12.7

[1] = standard deviation

also occur in sections on the Thomsen and "Ivitaruk' rivers between Bernard and Baker tills (Table I). These various deposits are thought to have been laid down during an interglacial period called the Morgan Bluffs Interglaciation. Correlation of the sediments in the sections east of the Nelson River with those of the Morgan Bluffs is based on ratios of amino acids in fossil wood. D-aspartic/L-aspartic ratios in three samples from the sections east of Nelson River varied from 0.34 to 0.35 while those from two samples from the Morgan Bluffs were 0.32 (Table III).

In the organic sediments, plant macrofossils such as *Potamogeton filiformis* Pers., *Betula nana* L. or *Menyanthes trifoliata* L. and many species of Coleoptera from the Carabidae, Staphylinidae and Curculionidae families[2] were found. These plants and insects do not live on Banks Island today but rather they are restricted to the mainland near the tree line. On the basis of this it is possible to affirm that these sediments represent a climate which was slightly warmer that that of today's tundra.

The interstratified marine, fluvial and peat sequences (up to 10 m thick) were probably laid down in a perimarine environment over a relatively long period of time characterized by minor oscillation of sea level. Based on the actual height of the sediments, sea level must have stood 20-30 m higher than today. It is of interest that along the Bering Sea in Alaska, sea levels were about 20 m higher than today during the interglaciations that preceded the Sangamonian (HOPKINS, 1967). It is proposed therefore, that the Morgan Bluffs Interglaciation may be related to the Einahnuhtan or Kotzebuan transgressions discussed by Hopkins.

The absolute age of the Morgan Bluffs Interglaciation is not known. It is believed to predate at least two complete glacial cycles and the interglaciation preceding the present one.

Thomsen Glaciation

PRE-THOMSEN SEA

Marine sediments (Unit 7, Column B, Fig. 5) lying between Interglacial Morgan Bluffs perimarine sediments and Kellett Till, were investigated in the Morgan Bluffs. The body of water in which these sediments were deposited is named Pre-Thomsen Sea and is thought to have existed when the eastern coast was being depressed by the advancing Thomsen Glacier. In one section the upper Pre-Thomsen Sea sediments are clearly glaciomarine because they are interstratified with Kellett Till.

GLACIAL ADVANCE AND THE BIG SEA: WEST COAST

The Thomsen Glacier, like the Banks Glacier, flowed northwestward from an ice sheet of mainland (Canadian Shield) origin, centred to the southeast of Banks Island. It overrode large areas of southern and eastern Banks Island and the Thomsen River basin (Fig. 7) and deposited the pale, moderately stony and sandy Kellett, Baker and Kange tills (Fig. 3 and Table II).

In the south, ice just overtopped the drainage divide on the western slope of the island before being halted. At the extreme southwest, flow was blocked by the Durham Heights but penetrated to the west coast via the low areas centred on the Masik and Rufus River valleys. To the north the ice was blocked by the eastern and southern slopes of the Devonian Plateau and channelled down the Thomsen River valley. In the north, two small lobes on either side of an upland reached M'Clure Strait. The limit of this ice corresponds either to the limit of the correlated sandy tills or, particularly in the areas west of the Thomsen River and south of the Devonian Plateau, to spectacular terminal moraine systems.

When the Thomsen Glacier reached its maximum stand, meltwater in areas where the ice front did not abut the Big Sea either drained freely westward, deeply incising the nonglaciated areas, or was trapped in glacial lakes. Glacial Lake Parker (Fig. 7) inundated extensive nonglaciated areas of the southern and eastern Devonian Plateau. The initial outlet was at an altitude of *ca.* 245 m on the drainage divide between Thomsen and Parker River basins. The water probably drained into glacial Lake Dissection at *ca.* 170 m altitude, which was dammed in Dissection River valley by a lobe of ice in the Thomsen Valley. Drainage of the water from this area is not clear but it may have flowed to M'Clure Strait along the eastern margin of the lobe.

During Thomsen Glaciation, the Big Sea covered nonglaciated sectors of western and central Banks Island up to *ca.* 215 m elevation (Fig. 7). The limit of this shallow sea is chiefly marked by a well-defined trimline that separates washed from unwashed surfaces and by the presence of extensive outwash sand and gravels deposited in shallow marine embayments adjoining the ice front.

The Big Sea marks the depression caused by Thomsen Glaciation to the east and southeast. Isolines (Fig. 7), showing areas of equal marine emergence, progressively turn towards the southeast indicating the direction of the dominant ice mass. The stratigraphic position of the Big Sea and its related events can be lateral-

2. J.V. Matthews', Jr. unpublished GSC Plant Macrofossil Reports, Nos. 76-6 and 78-6; R.J. Mott's unpublished GSC Wood Identification Reports, Nos. 78-40, 78-41, and 78-42; L.D. Farley-Gill's unpublished GSC Wood Identification Reports, Nos. 77-30, 77-31, 77-32 and 77-33.

TABLE III

Amino acid ratios determined from fossil molluscs and wood collected on Banks Island

Ratios of the amino acids D-alloisoleucine to L-isoleucine in the free and combined (free & peptide bound) fractions in Hiatella arctica

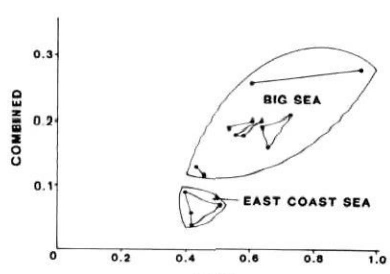
Geological Event	Sample No.	Laboratory No.	Allo-Iso ratio Free	Combined	Location	Comments
Schuyter Point Sea (Russell Stade of Amundsen Glaciation)	VH-77-103	AAL-533A	N.D.[1]	0.02	Coastal area 25 km south of Jesse Harbour; 72°02′15″N and 120°15′45″W.	In prelittoral sands at 21 m a.s.l. Shells from sample gave a radiocarbon age of 11,200 ± 100 (GSC-2545).
		AAL-533B	N.D.[1]	0.03		
		AAL-533C	N.D.[1]	0.02		
East Coast Sea (M'Clure Stade of Amundsen Glaciation)	VH-77-104	AAL-895A	0.42	0.04 & 0.06	Coastal area 25 km south of Jesse Harbour; 72°02′15″N and 120°16′30″W.	Shell fragments on surface of 36 m a.s.l. delta overlying Jesse Till.
		AAL-895B	0.51	0.07 & 0.07		
		AAL-895C	0.40	0.09 & 0.09		
Big Sea (Thomsen Glaciation)	VH-77-114	AAL-894A	1.31[2]	1.15[2]	Coastal area 27.5 km south of Jesse Harbour; 72°00′ 45″N and 120°21′W.	Shell fragments, ca. 100 m a.s.l., from section in marine delta underlying Jesse Till.
		AAL-894B	0.44	0.13		
		AAL-894C	0.46	0.12		
	VH-77-092	AAL-527A	0.64	0.19	Section on left bank of "Sarfarssuk" River; 73°05′ 30″N and 118°56′W.	Shells, ca. 90 m a.s.l., from section in fine marine sediments underlying Jesse Till.
		AAL-527B	0.66	0.16		
		AAL-527C	0.73	0.21		
	VH-77-065	AAL-535A	0.56	0.18	Surface 5.5 km northeast of mouth of Nelson River; 71° 15′30″N and 122°20′30″W.	Shell fragments, ca. 160 m a.s.l., from delta surface locally overlained by Jesse Till.
		AAL-535B	0.58	0.18		
		AAL-535C	0.64	0.20		
	VH-77-060	AAL-534A	0.54	0.19	Coastal bluff 7.5 km ENE of the mouth of Nelson River; 71°15′N and 122°15′30″W.	Shell fragments, ca. 25-32 m a.s.l., from section in marine delta underlying Jesse Till.
		AAL-534B	0.61	0.20		
		AAL-534C	0.70[2]	0.36[2]		
	VH-77-054	AAL-536A	0.61	0.26[2]	Section on the right bank of a stream 9 km northeast of the mouth of Nelson River; 71°16′30″N and 122°15′W.	Shell fragments, ca. 76 m a.s.l., from section in marine delta underlying Jesse Till.
		AAL-536B	0.95	0.28[2]		

Ratios of the amino acids D-aspartic to L-aspartic in Salix and Betula wood

Geological Event	Sample No.	Laboratory No.	No. of Runs	D/L ratio Average	Stand. Dev.	Location	Comments
Postglacial	VH-74-064	UA-582	2	0.14	0.00	Section in a gully 35 km ESE of Sea Otter Island and 7 km north of Big River; 72°31′N and 124°07′W.	Wood from same sample gave a radiocarbon age of 7800 ± 70 (GSC-2160).
Cape Collinson Interglacial	VH-81-066	UA-998	1	0.22	—	Left bank of a deep gully 4 km east of the mouth of the Nelson River. 71°14′20″N and 122°20′20″W.	Wood in peat from the Cape Collinson Formation (Unit 11 in column A, Fig. 5). Wood in same sample gave a radiocarbon age of > 61 000 (QL-1230).
Morgan Bluffs Interglacial	VH-77-023	UA-585	2	0.34	0.01	Left bank of a deep gully 4 km east of the mouth of the Nelson River. 71°14′20″N and 122°20′20″W.	Wood in peat from the Morgan Bluffs Formation (Unit 8 in column A, Fig. 5).
	VH-77-030	UA-586	2	0.35	0.01		
	VH-77-038	UA-587	2	0.34	0.01		
	VH-77-123	UA-588	2	0.32	0.01	Morgan Bluffs 13 km east of Jesse Harbour. 72°13′40″ N and 119°50′30″ W.	Wood in peat from the Morgan Bluffs Formation (Unit 6 in column B, Fig. 5).
	VH-77-132	UA-589	2	0.32	0.01		

[1] Not Detectable

[2] These shell fragments are most probably reworked from older units



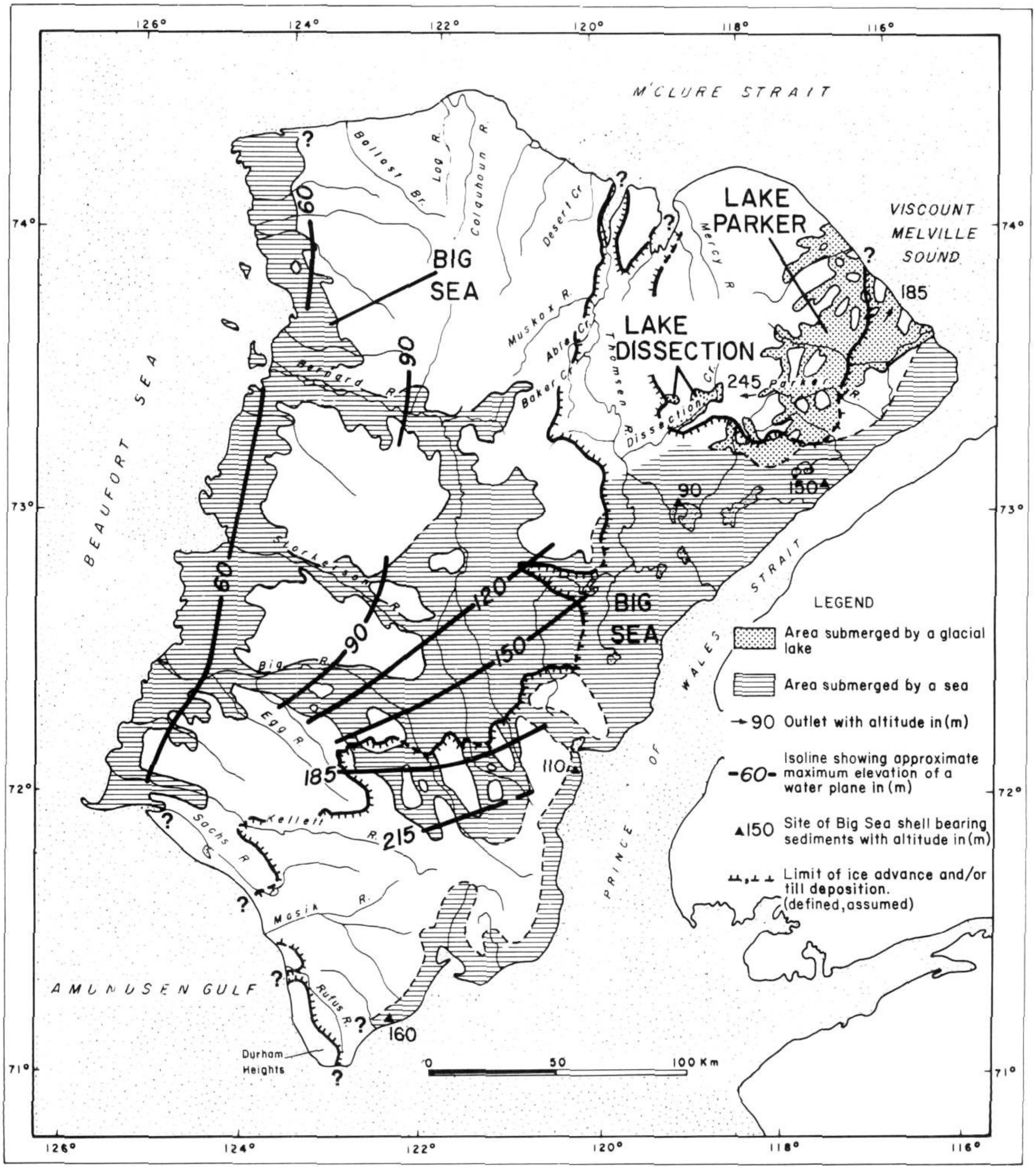


FIGURE 7. Paleogeographic map showing the glacial limit during Thomsen Glaciation as well as the areas submerged by glacial lakes Parker and Dissection and by the Big Sea.

Carte paléogéographique montrant la limite de l'avancée glaciaire lors de la Glaciation de Thomsen ainsi que les surfaces recouvertes par les lacs glaciaires Parker et Dissection et la mer Big.

ly inferred from simple stratigraphic relationships and it is clearly identifiable in numerous sections on the east coast. This sea locally reworked Bernard Till surfaces (Banks Glaciation) together with Kellett and Baker Till surfaces (Thomsen Glaciation). Some of these washed surfaces are in turn overlapped by Jesse Till in the southeast, Sachs Till in the southwest and Bar Harbour Till in the northwest, all deposited during Amundsen Glaciation. The Big Sea therefore inundated the island during the Thomsen Glaciation.

GLACIAL RETREAT AND THE BIG SEA: EAST COAST

The Thomsen ice generally retreated in a southeasterly and easterly direction from its maximum stand. Glacial Lake Parker abutted the retreating ice front and transgressed over newly deglaciated ground. The lowering altitude of the lake limit towards the east and the presence of glaciolacustrine deltas below the original outlet (245 m) indicate that later outlets permitted drainage into Viscount Melville Sound. Final drainage occurred when the coastal area was free of ice.

In the Thomsen River area the lobe of ice retreated from all sides towards the lower part of the valley as indicated by the pattern of end moraines and meltwater channels. In the Upper Thomsen River (Fig. 7) a small lobe of ice advanced westwards into the Big Sea building DeGeer or Kalixpinnmo (BESKOW, 1935) moraines. Over large areas of the southeast the ice front retreated in contact with the Big Sea.

Since the eastern slope of Banks Island was later covered by Amundsen Glaciation, it is not possible to trace the Thomsen deglaciation in that area. Nevertheless, numerous sections show that the Big Sea did inundate newly deglaciated eastern areas below *ca.* 200 m. The area covered by the sea, based on the location of subsurface sediments and their altitude, is shown in Figure 7. The sediments are mainly thick sequences of generally unfossiliferous (shells were found only in one section on the "Sarfarssuk" River) marine rhythmites which are capped, in areas where rivers flowed into the sea, by shell bearing deltaic sands and gravels. Amino acid ratios (Table III) obtained from shells permit tentative correlation of sections along the east coast. With deglaciation, the eastern coast gradually emerged. This emergence is well documented in coarsening upwards sequences of sediments observed in sections and in series of progressively lower deltas along many stream valleys.

The absolute age of the Thomsen Glaciation is not known. It preceded the Cape Collinson Interglaciation and postdates the Morgan Bluffs Interglaciation. Amino acid ratios of D-alloisoleucine to L-isoleucine (combined) obtained from *Hiatella arctica* shell fragments found in Big Sea deltaic sediments vary between 0.12 and 0.28 (Table III). Three of the five samples analyzed gave ratios around 0.19 but the others were either much younger or much older. The free ratios vary from 0.44 to 0.95. The scatter is quite large and more analyses are needed before results are conclusive. Nevertheless these ratios, if compared with other ratios obtained in the Arctic, are indicative of an event which certainly predates the last interglaciation (G.H. Miller, pers. comm.). The shell fragments found in the Big Sea deltaic sediments were common. Although some fragments are undoubtedly derived from older deposits (Table III), most are probably autochthonous since only extremely rare shell fragments have been found in older till and/or ice contact deposits.

Cape Collison Interglaciation

In one section east of Nelson River a 10-20 cm thick sequence of organic bearing sediments (Unit 11, Column A, Fig. 5) overlies Big Sea deltaic sands and gravels and underlies marine (Pre-Amundsen Sea) and glacial sediments (Jesse Till). The organic sediments, radiocarbon dated at >61 000 years (QL-1230), are believed to have accumulated in or close to a small tundra pond during an interglacial period, which followed emergence from the Big Sea and which is called the Cape Collinson Interglaciation. The D-aspartic/L-aspartic ratio on one wood sample from this unit was 0.22 (Table III).

The environment during this interval was tundra but it was distinctly warmer than today as indicated by the dominant presence of *Betula* including *B. nana* L and *B. glandulosa* Michx and a few species of Coleoptera from the Carabidae and Staphilinidae families[3], which are presently restricted to the mainland near the treeline. The sediments probably date from the last interglaciation.

Amundsen Glaciation

The Amundsen Glaciation was the last glaciation of Banks Island. Ice of Laurentide origin, advanced twice on the island, once during the earlier part of the glaciation (the M'Clure Stade, Fig. 8), and subsequently during the latter part of the glaciation (the Russell Stade, Fig. 9).

M'CLURE STADE

During the M'Clure Stade, lobes of ice situated to the south advanced in Thesiger Bay and Prince of Wales

3. J.V. Matthews's Jr. unpublished GSC Fossil Arthropod Report, No. 76-16 and unpublished GSC Macrofossil Report, No. 78-6; R.J. Mott's unpublished GSC Wood Identification Report, No. 75-23; L.D. Farley-Gill's unpublished GSC Wood Identification Report, No. 77-24; R.J. Mott's unpublished GSC Palynological Reports, Nos. 77-8 and 79-6.

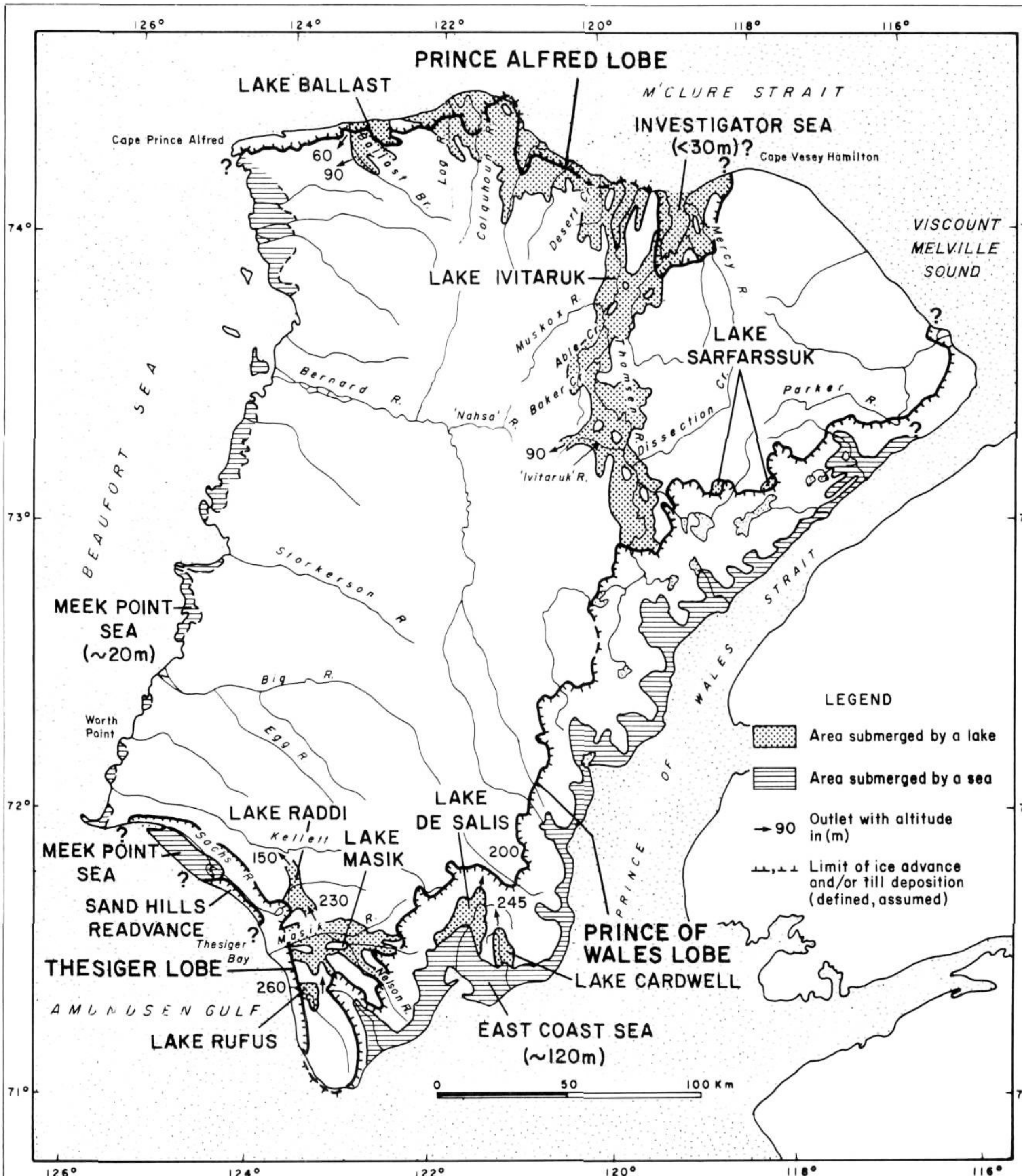


FIGURE 8. Paleogeographic map showing the glacial limit during M'Clure Stade of Amundsen Glaciation as well as areas submerged by glacial lakes Raddi, Masik, Rufus, Cardwell, De Salis, Sarfarssuk, Ballast and Ivitaruk and by the Meek Point and East Coast seas. The glacial limit of the Sand Hills Readvance is also shown.

Carte paléogéographique montrant la limite de l'avancée glaciaire lors du Stade de M'Clure de la Glaciation d'Amundsen ainsi que les surfaces recouvertes par les lacs glaciaires Raddi, Masik, Rufus, Cardwell, De Salis, Sarfarssuk, Ballast et Ivitaruk et par les mers de Meek Point et d'East Coast. La limite de l'avancée de Sand Hills est également indiquée.

Strait from Amundsen Gulf and Victoria Island, and in M'Clure Strait from Viscount Melville Sound. Each lobe is discussed separately.

Prince of Wales Lobe

The Prince of Wales Lobe impinged on the southern part of the island and flowed northeastward in Prince of Wales Strait overlapping the eastern coast of Banks Island (Fig. 8) and the northwestern coast of Victoria Island (FYLES, 1963, p. 14). As the ice advanced, Jesse Till (Figs. 3 and 4) characterized by its pinkish grey colour, its high carbonate content (Table II) and by a dense network of high centred polygons, was deposited. The limit of this lobe differs only in detail, except in the south, from the limit of "Wisconsinan" ice shown on the *Glacial Map of Canada* (PREST *et al.*, 1968).

Marine sands and gravels occur between the Cape Collinson Interglacial sediments and Jesse Till in a section east of Nelson River (Unit 12, Column A, Fig. 5). This indicates that a marine event, which has been called the Pre-Amundsen Sea, preceded the arrival of ice at the south coast.

The limit of the Prince of Wales Lobe is clearly that of the Jesse Till (Fig. 4). It is also marked in many areas by terminal moraines and spectacular outwash plains which extend onto nonglaciated areas. Generally, ice remained on the eastern coast of the island; the presence of very low hills being sufficient to divert or block ice-flow. The glacial limit decreases from *ca.* 400 m in the south to *ca.* 200 m in the northeast giving a gradient of *ca.* 1 m/km. When the ice was at its maximum stand, meltwaters were discharged towards the Beaufort Sea via tributaries of the Kellett, Big or Bernard rivers; were retained in the nonglaciated area in small glacial lakes such as Lake Sarfarssuk; or flowed into other glacial lakes such as lakes Rufus and Masik

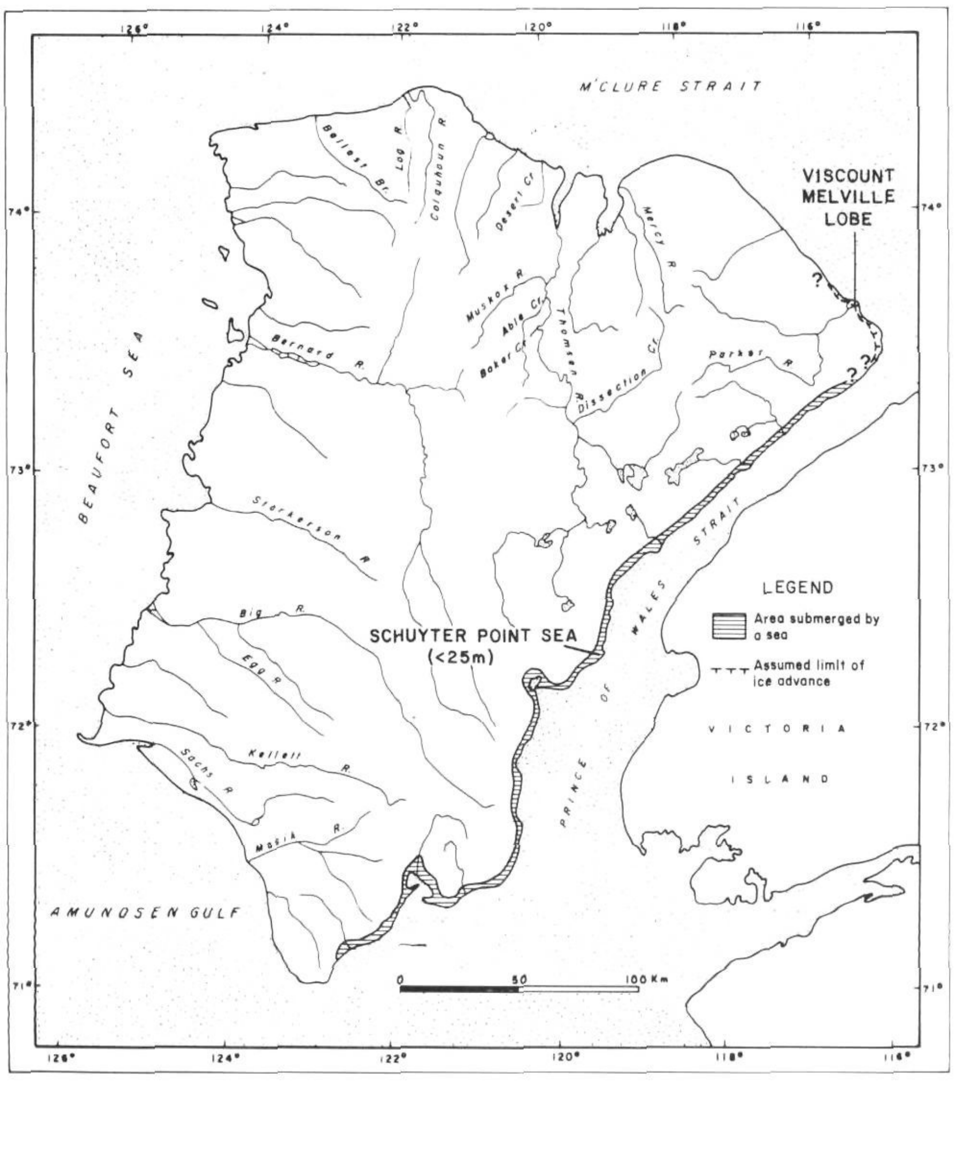


FIGURE 9. Paleogeographic map showing the glacial limit during Russell Stade of Amundsen Glaciation as well as areas submerged by the Schuyter Point Sea.

Carte paléogéographique montrant la limite de l'avancée glaciaire lors du Stade de Russell de la Glaciation d'Amundsen ainsi que les surfaces recouvertes par la mer de Schuyter Point.

retained by the Thesiger Lobe or Lake Ivitaruk retained by the Prince Alfred Lobe (Fig. 8).

The pattern of retreat of the Prince of Wales Lobe is well-documented by ice contact deposits such as end moraines and kames. In some areas, particularly in the higher southern regions, ice stagnated during deglaciation, forming large areas of hummocky moraines. As ice retreated down the island's eastern slope, glacial lakes were dammed in several valleys. Glacial Lake Cardwell (Fig. 8) drowned the upper Cardwell Brook and drained westward at an elevation of *ca.* 245 m into glacial Lake De Salis in the upper De Salis River. This last lake, standing at *ca.* 200 m, in turn drained north into the Big River drainage system.

In the course of deglaciation, the eastern coastal areas below *ca.* 120 m, were submerged by a body of marine water named the East Coast Sea. The trimline of this sea cuts into the Jesse Till and can be followed continuously over a distance of *ca.* 350 km from Nelson Head to the northeastern tip of the island (Fig. 8). The surfaces covered by the glacio-isostatic East Coast Sea are clearly washed but little sediment seems to have been deposited.

Only one sequence of deltaic sediments, built into a sea at *ca.* 36 m, was discovered and attributed to the East Coast Sea. Determinations of amino acid ratios of D-alloisoleucine to L-isoleucine (combined), obtained from 6 fragments of *Hiatella arctica* shells found in the delta, vary between 0.04-0.09 (Table III). The free ratios vary between 0.40 to 0.51. When plotted (Table III) it can be seen that ratios obtained from Big Sea or East Coast Sea are distinct one from the other. These ratios are different from those obtained in shells from the pre-last interglacial Big Sea (average of 0.19) and the Late Wisconsinan and Holocene Schuyter Point Sea (average of 0.02) and give an indication that the East Coast Sea (and the Prince of Wales Lobe which it immediately postdates) must predate the Late Wisconsinan.

Thesiger Lobe

The Thesiger Lobe impinged on the southwest coast after rounding the high southern tip of the island and flowed northwest into Thesiger Bay. Glacial deposits left by this lobe were first recognized by FYLES (1962, p. 10) and the limit of the ice advance is similar to the limit of "Wisconsinan" ice shown on the *Glacial Map of Canada* (PREST *et al.*, 1968). Sandy Sachs Till (Fig. 3 and Table II) was deposited by this lobe, the limit of which is clearly marked by the edge of the till sheet, by terminal moraines and by proglacial meltwater channels. The glacial limit decreases from more than 300 m in the south to *ca.* 100 m near Sachs Harbour giving a gradient of *ca.* 3 m/km. The northwestern extremity of the lobe lay against the Duck Hawk Bluffs.

While the ice stood at its limit, waters were dammed in the Rufus, Atitok, Masik and Sachs River basins. Glacial Lake Rufus (Fig. 8) inundated the lower Rufus River up to *ca.* 290 m and drained into glacial Lake Masik. When the Prince of Wales Lobe retreated from the area at the head of the Rufus River, Lake Rufus partly drained into the Nelson River system, where a lake may also have been dammed, via an outlet at 260 m. Glacial Lake Masik drowned the Masik and Atitok River basins up to *ca.* 200 m and drained into glacial Lake Raddi.

Deltas built into glacial Lake Masik, particularly along the Jeannette River at the mouth of glacial meltwater streams flowing from the Prince of Wales Lobe, prove that the ice was present both in Thesiger Bay and over eastern Banks Island at the same time. The shallow glacial Lake Raddi drowned the middle reaches of the Sachs River east of the modern Raddi Lake up to *ca.* 170 m. It drained into the Kellett River basin and thence into the Beaufort Sea.

The Thesiger Lobe retreated downslope towards the west leaving a series of end moraines. Glacial lakes Rufus, Masik and Raddi inundated newly deglaciated terrain as they followed the retreating ice. Final drainage of the lakes into lower Sachs River occurred when the ice front had sufficiently receded to permit an opening between the ice-front and higher ground to the east. These meltwaters deposited an extensive delta in a marine embayment between the ice front and a high scarp that extends southeast of Sachs Harbour. This delta, which now forms the Sachs Harbour Lowlands (Fig. 1), is graded to a former sea level at *ca.* 20 m a.s.l.

The marine embayment into which the 20 m delta was built is believed to be part of the Meek Point Sea which also submerged western Banks up to *ca.* 20 m. CRAIG and FYLES (1960) were the first to mention a low marine transgression on the west coast. The limit of the sea, most often marked by a low wave-cut cliff, can be traced over a distance of 250 km (Fig. 8). This features is named the Meek Point Sea and it necessarily postdates the Big Sea and the Thesiger Lobe since its trimline cuts into Sachs Till and hence it is considered to be the glacio-isostatic sea which submerged the west coast during the M'Clure Stade. The East Coast Sea and the Meek Point Sea are part of the same transgression (Table I). Since the ice-load which was responsible for the isostatic depression was located to the east and southeast of Banks Island, it is normal that the crust was depressed more to the east (*ca.* 120 m) than in the west (*ca.* 20 m). The tilt measured in various locations from east to west varies between 0.5 to 0.7 m/km. Shells of *Astarte* sp., collected on the west coast by D.M. Barnett in a raised spit 3-4 m a.s.l., gave a radiocarbon age of >19 000 (GSC-1478, LOWDON and BLAKE, 1973). The spit is in the large bay immediately south of Worth Point and at a higher elevation than a spit currently forming at the mouth of the bay during the present submergence phase of the west coast. The raised spit was likely constructed during the youngest transgression recognized on the west coast: the Meek Point Sea. This sea and the Thesiger Lobe, on the basis of the radiocarbon date on the shells from the spit, appear to predate the Late Wisconsinan.

Southeast of Sachs Harbour, the well developed Sand Hills Moraine extends along the coast of Thesiger Bay for a distance of 25 km (Fig. 8) and clearly overlaps Sachs Till surfaces at its southeastern extremity. This feature, which is made up of ice-contact deposits and the bouldery Carpenter Till (Fig. 3) may have been constructed by a local readvance (Sand Hills Readvance) of ice in Thesiger Bay following initial retreat of the Thesiger Lobe. Even though the morainic landscape is very "young looking" in comparison to the Sachs Till surfaces it is necessary to associate it with a local readvance of the Thesiger Lobe rather than with an entirely younger ice advance since no evidence of glacial overlap, postdating the Prince of Wales Lobe, has been found on the south coast. It is therefore unlikely that ice reached Thesiger Bay, building a morainic system on land, without having impinged on the south coast at the same time.

Prince Alfred Lobe

The Prince Alfred Lobe impinged on the north coast as it progressed into M'Clure Strait from Viscount Melville Sound. This body of ice is shown on the *Glacial Map of Canada* (PREST *et al.,* 1968) and was first reported by FYLES (1962 and 1969). East of Cape Vesey Hamilton, the lobe was contained in the marine channel by high sea cliffs whereas to the west ice overlapped the land. The lobe flowed into Mercy Bay where it deposited the Mercy Till (Fig. 3). West of there, the ice penetrated farther inland and deposited the sandy Bar Harbour Till (Fig. 3). The glacial limit corresponds to the extent of the tills and is clearly marked in a few areas by terminal moraines and meltwater channels. The glacial limit is at *ca.* 120 m in the Mercy Bay area, *ca.* 100 m between Castel Bay and Ballast Brook and decreases rapidly west of Ballast Brook to *ca.* 30 m at Cape Alfred at the northwestern tip of the island. The ice gradient is low at *ca.* 0.5 m/km. Depending on relative sea level and the extent of crustal depression, the Prince Alfred Lobe could have been floating locally in M'Clure Strait. It was, however, necessarily grounded on the present coastal areas since it held glacial lakes inland in the nonglaciated valleys.

As the ice stood in the coastal areas, waters were dammed in north sloping valleys. Glacial Lake Ivitaruk inundated extensive areas (up to *ca.* 90 m) between Cape Vesey Hamilton and the Log River and extended far inland in the low Thomsen River basin (Fig. 9). The drainage of the lake was towards the Bernard River and the Beaufort Sea. High ground covered by ice between the "Kaersok" and Log rivers on the north coast prevented contact between Lake Ivitaruk and glacial Lake Ballast which was impounded in the Ballast Brook and "Kaersok" River basins also up to *ca.* 90 m. The presence of a lake in this area was first established by FYLES (1969, p. 195) and discussed in more detail by FRENCH (1972). Initial drainage of Lake Ballast was toward Beaufort Sea via a 90 m high outlet on the west side of Ballast Brook. As the ice retreated northward, as indicated by end moraines paralleling the coast, a lower outlet at *ca.* 60 m was opened west of Ballast Brook, partly draining Lake Ballast. At about the same time, the high ice covered area separating lakes Ballast and Ivitaruk was deglaciated and the two lakes became joined. Waters of glacial Lake Ivitaruk were lowered by 30 m as the 60 m outlet of Lake Ballast could now be used. Final drainage of both lakes in M'Clure Strait occurred as the ice retreated to a sufficiently northerly position.

Evidence for a marine transgression on the north coast after the retreat of Prince Alfred Lobe has been recognized only in the Mercy Bay area. There, waters of the Investigator Sea washed Mercy Till surfaces up to *ca.* 30 m and may have extended 80 km inland up the Thomsen River. This sea, as shown on Table I, is probably correlative with the Meek Point Sea on the west coast and the East Coast Sea along Prince of Wales Strait.

At the extreme northwest corner of the island, the Bar Harbour Till is distinctly cut by the 20 m trimline of the Meek Point Sea, indicating that this sea, which postdates the Thesiger Lobe, also postdates the Prince Alfred Lobe. Since the Thesiger and Prince of Wales lobes were contemporaneous, as shown earlier, and since Lake Ivitaruk was not only held by the Prince Alfred Lobe standing in M'Clure Strait but also by the Prince of Wales Lobe in the Upper Thomsen River valley, the three lobes are contemporaneous.

The Prince Alfred Lobe is older than the Late Wisconsinan. In the "Kaersok" River valley, mosses collected by J.G. Fyles from an organic layer, which overlies silts and sands, deposited when M'Clure Strait was ice-filled, gave a radiocarbon age of >41 000 (GSC-1088). Peats, collected from fluvial sands and gravels near the mouth of Dissection River at *ca.* 45-50 m, by W. Blake Jr. and the author gave radiocarbon ages of >39 000 (GSC-2819) and 49 100 ± 980 (GSC-2375-2). The peats are likely associated with fluvial sediments laid down when sea level was higher than today. Since the Investigator Sea is the last sea to have drowned the Thomsen River basin in pre-Late Wisconsinan time, the determination may provide a minimum age for the retreat of the Prince Alfred Lobe and the drainage of Lake Ivitaruk which preceded the sea in question.

Age of the M'Clure Stade

On the *Glacial Map of Canada* (PREST *et al.*, 1968) an ice limit approximately corresponding to the limit of the Prince of Wales, Thesiger and Prince Alfred lobes (Fig. 8) is shown as "Classical Wisconsinan" (Late Wisconsinan). Four lines of evidence were presented above to show that the M'Clure Stade predates the Late Wisconsinan. Amino acid ratios, on shell fragments from the East Coast Sea which postdates Prince of Wales Lobe, and, old radiocarbon age determinations, on shells from a spit built into the Meek Point Sea which postdates the Thesiger Lobe and on organic matter, in the "Kaersok" and Dissection River valleys, which postdates the Prince Alfred Lobe, all gave results that demonstrate a pre-Late Wisconsinan age (if not a pre-Middle Wisconsinan age) for the three ice lobes.

Three other lines of evidence can be added. First, organic matter from the base of a core was collected by J.C. Ritchie, in a lake in southern Banks Island situated in a channel cut by glacial meltwaters flowing from the Prince of Wales Lobe. This sample gave an age of 26 800 ± 1560 (GSC-2780, J.C. Ritchie, pers. comm.). The sample may be contaminated by coal, which would account for the older age, but pollen spectra from the core may extend, according to Ritchie, into the early part of the Late Wisconinan though the data are not conclusive. This would imply an age older than the Late Wisconsinan for the Prince of Wales Lobe. Second, as described below, it is possible to define a younger ice limit than that of the Thesiger, Prince of Wales and Prince Albert lobes. This limit lies for the most part to the east and southeast of Banks Island. The limit of the lobes on Banks Island must necessarily be much older than the limit on Victoria Island and elsewhere unless a major phase of ice retreat was closely followed in time by a major readvance. Finally, as also described below, the eastern coast of Banks Island was inundated in the Late Wisconsinan-Holocene by the Schuyter Point Sea. This sea, from which a trimline distinctly cuts into surfaces previously covered by the East Coast Sea (Fig. 4), is considered to have resulted from the isostatic depression of the crust in an area lying outside the zone covered by ice in Late Wisconsinan time. Two glacial stades of the Amundsen Glaciation are therefore represented, the oldest by the Prince of Wales, Thesiger and Prince Alfred lobes and the East Coast and Meek Point seas, the youngest by ice standing to the east on Victoria Island and the Schuyter Point Sea. Since the younger stade is Late Wisconsinan in age, the older predates this period.

From the above discussion, it is seen that much evidence tends to show that the M'Clure Stade predates the Late Wisconsinan. Nevertheless, the possibility remains that the M'Clure and Russell stades followed each other over a relatively short period during the Late Wisconsinan. In this hypothesis, most of Victoria Island would have had to have been deglaciated and then recovered again in the same stade. One of the means of definitely solving this problem would be to find and date organic material lying in between glacial sediments associated with the two Wisconsinan stades. Until this is accomplished, the question of the absolute age of the two stades will not be resolved.

RUSSELL STADE

During the Russell Stade (Table I), the extreme northeast tip of Banks Island was covered by the Viscount Melville Lobe that flowed from Viscount Melville Sound (Fig. 9). The evidence for this is a ridge of glacially deformed fine marine sediments that overlies Jesse Till between Parker and Passage points. Shells, collected by D.M. Barnett at *ca.* 85 m in ice-pushed marine sediments located 16 km north-northwest of Parker Point, were dated at 10 600 ± 270 (GSC-1437, LOWDON and BLAKE, 1973). These shells give a maximum age for this ice advance.

Along the east coast below *ca.* 25 m (Fig. 9), prelittoral and littoral sediments, locally shell-bearing, have been deposited in the Schuyter Point Sea. This sea, on the basis of radiocarbon dates on the shells, is Late Wisconsinan-Holocene in age. Five dates indicate a progressive lowering of relative sea level from *ca.* 21 m to *ca.* 8 m between 11 200 (GSC-2545) and 10 200 BP (GSC-2099) (VINCENT, 1978c). Except for the Viscount Melville Lobe in the northeastern tip, the Schuyter Point Sea did not abut an ice margin on Banks Island but it marks a marginally depressed area lying to the west of the Laurentide ice sheet.

THE LIMITS OF ICE ADVANCE DURING THE LAST GLACIATION IN THE SOUTHWESTERN CANADIAN ARCTIC ARCHIPELAGO

Many have attempted to portray on maps the overall limit of Laurentide Ice in Arctic Canada during the last glaciation (HOBBS, 1945; JENNESS, 1952; CRAIG and FYLES, 1960; PREST *et al.*, 1968; PREST, 1969, and HUGHES *et al.*, 1977). During the last decade, MILLER and DYKE (1974) and IVES (1978), DYKE (1978), and FYLES *et al.* (1972) respectively drew the limit in the northeast, the north centre and the mainland portion of the northwest. The southwestern part of the Archipelago has received little attention since the work of Fyles. As

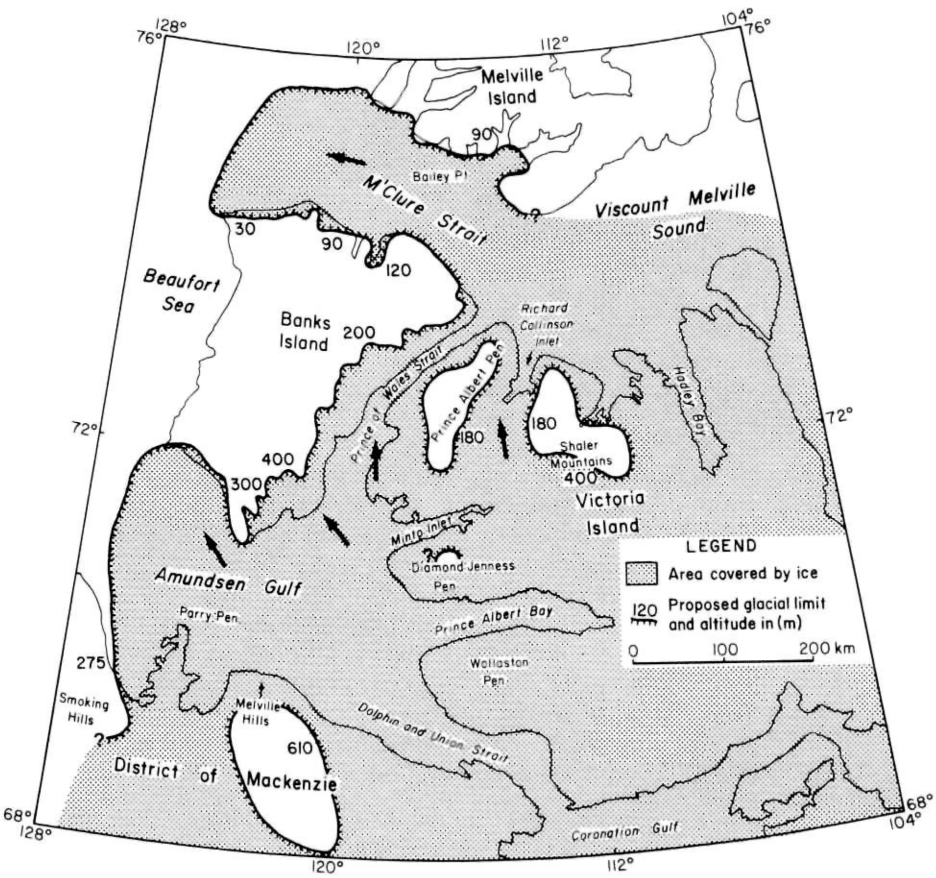


FIGURE 10. Map of the southwestern portion of Canadian Arctic Archipelago showing the proposed glacial limit in the Early Wisconsinan.

Carte du sud-ouest de l'archipel Arctique canadien montrant la limite proposée de l'avancée glaciaire au Wisconsinien inférieur.

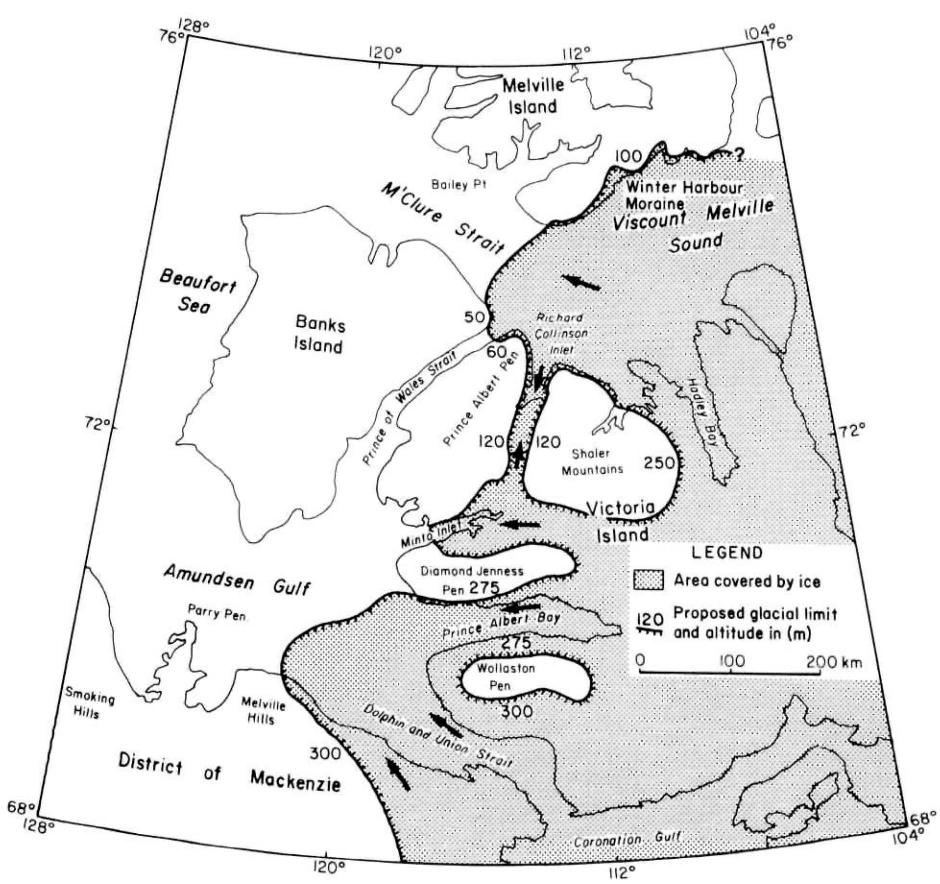


FIGURE 11. Map of the southern portion of Canadian Arctic Archipelago showing the proposed glacial limit in the Late Wisconsinan.

Carte du sud-ouest de l'archipel Arctique montrant la limite proposée de l'avancée glaciaire au Wisconsinien supérieur.

described above, two glacial limits related to the last (Amundsen) glaciation, are drawn on Banks Island. In both cases, ice flowed from the Keewatin dispersal centre of the Laurentide ice sheet. The two limits should also be found in surrounding areas. Two maps, one for the earlier advance (Fig. 10), and the other for the probable limit during the Late Wisconsinan (Fig. 11) have been drawn. These maps were constructed on the basis of airphoto interpretation using criteria to differentiate the till sheets similar to those described at the beginning of this paper, and on field work by FYLES (1963) and the author on Victoria Island.

Figure 10 shows the limit of ice advance during the early part of the last glaciation. On Banks Island this corresponds to the limit of the Thesiger, Prince of Wales and Prince Alfred lobes during the M'Clure Stade. On Melville Island the limit is made to coincide with that of glacial deposits at low altitude (>50 m, <90 m) along the southern coast particularly in the Bailey Point and Cape Hoar area. These are thought to have been deposited along the northern border of the Prince Albert Lobe. On the mainland, the corresponding limit is set at the upper limit of a morainic belt along the flanks of the Melville Hills (FULTON and KLASSEN, 1969) and high areas to the south of these. The belt reaches an elevation of *ca.* 600 m a.s.l. and lies below rubble strewn hills devoid of apparent glacial features. The limit in the Smoking Hills area is the one FYLES *et al.* (1972) consider as being the limit of the "maximum extent of the Laurentide Glaciation". On Victoria Island, the recognition of the limits of individual till sheets indicate that a portion of Prince Albert and Diamond Jenness peninsulas and of the Shaler Mountains escaped glaciation. Altitudes of the till limit indicate that the gradient was low and that it progressively decreased in height towards the northwest.

Figure 11 shows the provisional limit of ice during the latter part of the last glaciation. On Banks Island this corresponds to the limit of the Viscount Melville Lobe during the Russell Stade. On Melville Island, the limit is that of the Winter Harbour morainic belt (FYLES, 1967). On the mainland, in the area south of the Melville Hills, the limit corresponds to that of the till sheet (<300 m) which clearly cuts into the older and higher (<600 m >300 m) more subdued till sheet mentioned above. On Victoria Island, the pre-Late Wisconsinan till sheets appear on the air photographs to be clearly cut by younger till sheets. Large areas of Prince Albert, Diamond Jenness and Wollaston peninsulas and of the Shaler Mountains were not covered during this latest advance. Ice flow was controlled by low-lying areas centred on Dolphin and Union Strait, Prince Albert Sound and Minto and Richard Collinson inlets.

CONCLUSION

An attempt has been made to provide a framework for Quaternary events on Banks Island. Some of the contributions and implications of the study will now be mentioned.

Firstly, at the scale of the entire island, it has been shown that continental ice reached and covered part of the study area during three distinct glacial stages (the Banks, Thomsen and Amundsen glaciations), and that each of these stages was separated by interglaciations. It has been demonstrated that transgressive marine events, resulting from the buildup of ice, preceded each glacial overlap of the island, and that marine regressive events related to glacio-isostatic recovery of the crust occurred during the subsequent retreat of each glacier. This model is similar to the one proposed by MILLER *et al.* (1977) for the Clyde Foreland area of eastern Baffin Island. Most of the glacial, marine and glaciolacustrine events are recognized for the first time and permit an understanding of the geological events responsible for the landscape of a substantial area in the southwestern Canadian Arctic Archipelago.

Secondly, the Banks Island reconstruction provides some insight into possible style of glaciation and related events that may also have occurred on other islands of the Arctic Archipelago. The oldest observed glaciation, the Banks Glaciation, is the one that covered the most extensive area and the highest ground on the island. It is probable that it is this glaciation which was responsible for the deposition of till and erratics of mainland origin on the higher areas of the Central and Western Queen Elizabeth Islands. On Banks Island, during the younger Thomsen and Amundsen glaciations, ice was not as extensive. During these intervals it is probable that continental (mainland) ice would only have been strong enough to impinge on the southern coastal fringe of the Queen Elizabeth Islands.

Thirdly, this study provides new insight into the behavior of the continental ice sheets since the style of glaciation was the same during the Banks and Thomsen glaciations as well as during the two stades of the Amundsen Glaciation. In each case ice flowed from the southeast suggesting a common dispersal centre situated to the northwest of Hudson Bay. This, coupled with the fact that each successive glaciation was less extensive than the one immediately preceding it, provides a pattern for the behaviour of the continental ice sheets in the northwest. This pattern can be compared with that of other portions of the ice sheet. Evidence has also been put forward to show that the limit of Laurentide ice in the northwest, up till now considered to be Late-Wisconsinan, could in fact predate this time. The present work suggests that the Late Wisconsinan limit lay well to the east and southeast of Banks Island.

This new information will have to be taken into account when modelling the Laurentide ice sheet.

Finally, the terrestrial stratigraphic record reported on Banks Island goes back further than any yet known in the Arctic Archipelago and, together with those of southern Alberta and the Yukon, is one of the longest records available in Canada. As such, it has the potential of becoming one of the reference stratigraphic series for glaciated North America.

ACKNOWLEDGEMENTS

This paper is part of the reporting process for Project 740065 (Surficial geology inventory, Banks Island) of the Geological Survey of Canada. Field logistics in 1974, 1975 and 1977 were very efficiently handled by the Polar Continental Shelf Project.

Dr. J.G. Fyles of the Geological Survey of Canada was the first to investigate the Quaternary history of Banks Island. Discussions I had with him were extremely useful. Many colleagues at the Survey examined fossil material found in various samples. Dr. J.V. Matthews, Jr. identified arthropods and plant macrofossils. Mr. R.J. Mott and Mrs. L.D. Farley-Gill contributed to the identification of wood and pollen. Radiocarbon dates were provided by the G.S.C. laboratory under Dr. W. Blake, Jr. and the University of Washington laboratory under Dr. M. Stuiver. Dr. G.H. Miller of the University of Colorado and Dr. N.W. Rutter of the University of Alberta respectively provided amino acid ratios on shells and wood. I would like to thank all these persons for their extremely valuable collaboration.

Drafts of this paper greatly benefited from critical reading by my colleagues A.S. Dyke, J. England and D.A. Hodgson. Mr. E. Bélec drafted the illustrations.

REFERENCES

BESKOW, G. (1935): Praktiska och kvartärgeologiska resultat av grusinventeringen i Norrbottens län, *Geol. Föreningens I Stockholm Förhandl.*, bd 57, h. 1, p. 120-123.

BURNS, B.M. (1973): *The climate of the Mackenzie Valley-Beaufort Sea*, Toronto Environment Canada, Climatol. Stu., No. 24, Vol. 1, 277 p.

CRAIG, B.G. and FYLES, J.G. (1960): *Pleistocene geology of Arctic Canada,* Geol. Surv. Can., Pap. 60-10, 21 p.

—— (1965): Quaternary of Arctic Canada, *in Anthropegen period in Arctic and Subarctic*, Trans. Scientific Research Inst. of the Geology of the Arctic, State Geol. Committee, Moscow, Vol. 143, p. 5-33 (in Russian with English summary).

DYKE, A.S. (1978): Glacial history of and marine limits on southern Somerset Island, District of Franklin, in *Current Research*, Part B, Geol. Surv. Can., Pap. 78-1B, p. 218-223.

FRENCH, H.M. (1972): The proglacial drainage of northwest Banks Island, *The Musk-Ox*, Publ. No. 10, p. 26-31.

FULTON, R.J. and KLASSEN, R.W. (1969): Quaternary geology, Northwest District of Mackenzie, in *Report of Activities*, Part A, Geol. Surv. Can., Pap. 69-1A, p. 193-194.

FYLES, J.G. (1962): Physiography, in Banks, Victoria and Stefansson Islands, Arctic Archipelago, *Geol. Surv. Can*, Mem. 330, p. 8-17.

—— (1963): Surficial geology of Victoria and Stefansson Islands, District of Franklin, *Geol. Surv Can.*, Bull. 101, 38 p.

—— (1967): Winter Harbour Moraine, Melville Island, in *Report of Activities*, Part A, Geol. Surv. Can., Pap. 69-1A, p. 194-195.

—— (1969): Northwestern Banks Island, District of Franklin, in *Report of Activities*, Part A, Geol. Surv. Can., Pap. 69-1A, p. 194-195.

FYLES, J.G., HEGINBOTTOM, J.A. and RAMPTON, V.N. (1972): *Quaternary geology and Geomorphology, Mackenzie Delta to Hudson Bay*, XXIV Intern. Geol. Congr., Guidebook A-30, 23 p.

HOBBS, W.H. (1945): The boundary of the latest glaciation in Arctic Canada, *Science*, Vol. 101, No. 2631, p. 549-551.

HOPKINS, D.M. (1967): Quaternary marine transgressions in Alaska, *in The Bering Land Bridge*, D.M. Hopkins, ed., Stanford, Stanford Univ. Press, p. 47-90.

HUGHES, T., DENTON, G.H. and GROSSWALD, M.G. (1977): Was there a Late-Würm Arctic ice sheet?, *Nature,* Vol. 266, p. 596-602.

IVES, J.D. (1978): The maximum extent of the Laurentide ice sheet along the east coast of North America during the last glaciation, *Arctic*, Vol. 31, No. 1, p. 24-53.

JENNESS, J.L. (1952): Problem of glaciation in the western islands of Arctic Canada, *Bull. Geol. Soc. Amer.,* Vol. 63, No. 9, p. 939-952.

KUC, M. (1974): The interglacial flora of Worth Point, western Banks Islands, *in Report of Activities*, Part B, Geol. Surv. Can., Pap. 74-1B, p. 227-231.

LOWDON, J.A. and BLAKE, W. Jr., (1973): *Geological Survey of Canada radiocarbon dates XIII*, Geol. Surv. Can., Pap. 73-7, 61 p.

MANNING, T.H. (1956): Narrative of a second Defence Research Board expedition to Banks Island, with notes on the country and its history, *Arctic*, Vol. 9, Nos. 1-2, p. 2-77.

MIALL, A.D. (1976): *Proterozoic and Paleozoic geology of Banks Island, Arctic Canada*, Geol. Surv. Can., Bull. 258, 77 p.

—— (1979): *Mesozoic and Tertiary geology of Banks Island, Arctic Canada: the history of an unstable craton margin*, Geol. Surv. Can., Mem. 387, 235 p.

MILLER, G.H., ANDREWS, J.T. and SHORT, S.K. (1977): The last interglacial cycle, Clyde foreland, Baffin Island, N.W.T.: stratigraphy, biostratigraphy, and chronology, *Can. Journ. Earth Sc.*, Vol. 14, No. 12, p. 2824-2857.

MILLER, G.H. and DYKE, A.S. (1974): Proposed extent of Late Wisconsin Laurentide ice on Eastern Baffin Island, *Geology*, Vol. 2, No. 3, p. 125-130.

MORRIS, W.A. and VINCENT J.-S. (1979): Magnetostratigraphy of Pleistocene sediments of Banks Island, Northwest Territories: a feasibility study, in *Current Research,* Part B, Geol. Surv Can., Pap 79-1B, p. 301-306.

PISSART, A., VINCENT, J.-S. and EDLUND, S.A. (1977): Dépôts et phénomènes éoliens sur l'île de Banks, Territoires du Nord-Ouest, Canada, *Can. Journ. Earth Sc.*, Vol. 14, No. 11, p. 2462-2480.

PORSILD, A.E. (1950): A biological exploration of Banks and Victoria Islands, *Arctic*, Vol. 3, No. 1, p. 45-54.

PREST, V.K. (1969): *Retreat of Wisconsin and Recent ice in North America*, Geol. Surv. Can., Map 1257A.

PREST, V.K., GRANT, D.R. and RAMPTON, V.N. (1968): *Glacial map of Canada*, Geol. Surv. Can., Map 1253A.

TAYLOR, A.E. and JUDGE, A.S. (1974): *Canadian geothermal data collection — Northern wells, 1955 to February 1974,* Earth Physics Branch, Dept. of Energy, Mines and Resources, Geothermal Ser., No. 1, 171 p.

VINCENT, J.-S. (1978a): Lithostratigraphy of the Quaternary sediments east of Jesse Bay, Banks Island, District of Franklin, in *Current Research*, Part A, Geol. Surv. Can., Pap. 78-1A, p. 189-193.

——— (1978b): *Surficial Geology of Banks Island. District of Franklin, N.W.T.,* Geol. Surv. Can., Open File 577 (NTS map areas 97G, H, 98A-F, part 88B-D).

——— (1978c): Limits of ice advance, glacial lakes, and marine transgressions on Banks Island, District of Franklin: a preliminary interpretation, in *Current Research*, Part C, Geol. Surv. Can., Pap. 78-1C, p. 53-62.

——— (1978d): Glacial limits on Banks Island with special emphasis on the Wisconsinan limit and events, Abstracts with program, Vol. 10, No., 7, *Geol. Soc. Amer., 1978 Joint Annual Meeting*, Toronto 1978, p. 509-510.

——— (1980a): *Les glaciations quaternaires de l'île de Banks, Arctique canadien,* thèse de D. Sc., Univ. de Bruxelles, 248 p. (unpubl.)

——— (1980b): *Surficial Geology — Banks Island, Northwest Territories*, Geol. Surv. Can., Maps 16-1979 (North half) and 17-1979 (South half).

——— (in press): *La géologie du Quaternaire et la géomorphologie de l'île de Banks, Arctique canadien*, Comm. géol. Can., Mémoire 405.

VINCENT J.-S. and EDLUND, S.A. (1978): *Extended legend to accompany preliminary surficial geology maps of Banks Island*, Geol. Surv. Can., Open File 577.

WASHBURN, A.L. (1947): *Reconnaissance geology of portions of Victoria Island and adjacent regions, Arctic Canada*, Geol. Soc. Amer., Memoir 22, 142 p.

WILSON, J.T. *et al.* (1958): *Glacial map of Canada*, Geol. Ass. Can.

FIGURE 5. Stratigraphic correlation of composite sections.

Corrélation stratigraphique des coupes composites.